Natural Resources, Biodiversity, Integrated Management and Regulation: general considerations and discussion.

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Abstract

To attenuate the loss of biodiversity, more knowledge on the subject is needed. In most cases, local biodiversity is represented by resources such as food, medicine, lumber and construction, fodder, and esthetics and frequently the assessment and protection of biodiversity is based on the knowledge and traditions of the local population. What is experienced as useful has less probability of being destroyed. The destruction of biodiversity is due largely to the limited knowledge currently available and the lack of knowledge concerning its potential value as resource. Most local knowledge of plants and animals is based on their use as edible resources by the population. If local knowledge of species as resources is obliterated, the potential exchange of villagers versus local or distant markets will decrease and resources use will disappear. Local knowledge concerning biodiversity, therefore, needs to be promoted, extended and disseminated outside of the villages and local communities.

By protecting local cultures, biodiversity can also be protected. This knowledge has to be transferred to other units of society, both in the same areas and outside of them in order for them to become a source of local income and potential of sustainable life for villagers. Educational programs should be developed locally and local markets have to be promoted. To really improve the landscape quality in Western civilization, as in the tropics, more knowledge and information is needed regarding the species and their use and interest. More emphasis has to be given to local knowledge, its maintenance and transfer.

Introduction

Most civilizations eradicated their bases for sustainability and collapsed in 30-60 generations [1, 2]. In the past 2000 years, some societies have destroyed their topsoil

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and soil fertility through soil erosion, salinization, loss of organic matter and nutrients, plus the destruction of native biodiversity. For instance, "Mesopotamia… hosts today less than one-fourth as many peoples as it supported during the reign of Hammurabi nearly four thousand years ago" [1]. On these assumptions, pessimistic views suggest that it is far from possible to deal with an exponentially increasing human population and that the quality of life is constantly subjected to decrease with constraints including wars, migrations, famine and epidemics that could be linked or exacerbated by climate change and "religious" movements [3].

Natural resources, and biodiversity in particular, are limited in space and time, and the capability of human populations to carry out sustainable management strategies are linked to different limits, which include among the most notable: management experience, knowledge and tradition of local situations, economic pressure for short-term results, property strategies, policies and behaviors of social groups and leadership, appropriate ethics and political rules [4].

In particular, environmental resources need time to be properly understood and properly managed to avoid their loss or devastation. Impacts, such as fire, are associated to human colonization and most types of agriculture. For instance, the first consistent presence of carbon residues in Central American soils in Panama 11,200 years BP, are associated with the arrival of the first humans [5]. As well, the killing and destruction of 24 genera of North American mammal macro-fauna (reported as overkill) was apparently caused by the first groups of hunters around 12,000 years B.P. [6, 7] who invaded the North American Continent and was a consequence of their inexperience in dealing in a sustainable way with resources new to them (large mammals). In fact, it has been suggested that the collapse of species due to human migrations is part of the lack of knowledge. In Africa, a similar loss of species has not occurred, perhaps due to a better and longer co-evolution of humans and the macro-fauna [7, 8]. These losses of biodiversity affected plants as well. For instance, it has been observed that in Central America large fruits could not be disseminated as a consequence of the destruction of these large mammal browsers. In addition, the loss of spider monkeys in the Brazilian Amazon affected the dissemination of the plants that produced their preferred fruits. For instance, it has been observed that abandoned fields and previously rural areas caused the loss of species of birds and invertebrates [9, 10] and, in the same way, intensively cultivated areas can reduce most biodiversity [11]. But, at the same time if properly managed, both agricultural and/or agroforestry activities can provide sufficient food and shelter for the inhabitants and protect biodiversity or manage it at a higher level [12, 13, 14].

This paper attempts to indicate actions that may be taken to reduce the decline of natural resources and promote sustainability as a follow-up to the discussions and documents resulting from the Johannesburg 2002 convention, which are the consequence of the previous output of Rio 1992, Cartagena 2000 and Montreal 2001, promoted by the United Nations.

Biodiversity is an attractive subject but: how many species live on the planet and what is our current knowledge of them?

Various observers have pointed out that Rio and Cartagena have made little or no substantial improvement in attenuating the loss of biodiversity and/or loss of species, not to mention the transformation of land use, at Johannesburg it was indicated that (World Summit on Sustainable Development art 42): "... by 2010 a significant reduction in the current rate of loss of biological diversity". Perhaps the problem is still to account for the species, all species, the foodwebs, recognize them and appropriately monitor and possibly use them in a sustainable way. This is a key problem involving education, local preservation, maintenance of knowledge, the possibility given to the local cultures to “sell” their “use of biodiversity” to other people that are interested in using or appreciating them. The major problem, again is educational, to make the local knowledge in the tropics available and acceptable outside of the local villages and to extend it to potential other consumers. People living in towns, that could buy local production, do not have this knowledge and do not like species from “outside the boundary of their knowledge”. In addition, some key species from the wild can be subjected to rapid decline if the demand from towns creates pressure on the villagers for hunting, collecting or farming of just a few targeted species. Modern Agriculture tends to focus on only 15 species of plants and 8 species of livestock and these organisms provide between 80% to 90% of the world’s food supply [15]. The core problem is to open the panorama of species we normally consider as edible in order to include the ones we do not know!

The number of species living on our planet is still a major question of debate and the answer is far from being resolved, as documented in the literature. For instance, the total number of species described is around 1,8 million. However, the number of species forecasted, dominated by small sized invertebrates, is 7,2-82 million [16, 17, 13, 18].

The problem is that science in general and, in particular, taxonomy, the branch dealing with the description of animals and plants, have been traditionally focused on a few groups, such as, mammals, birds, large plants and butterflies, and that most inconspicuous organisms such as mites, most tiny inconspicuous insects, earthworms, microorganisms, etc., have been nearly ignored. What is the reason of this? Reading the chronicle of Alfred Russel Wallace, a foremost Explorer and Naturalist traveling in the Amazon and the Far East Indonesian Archipelago in the XIX century, it is interesting to note that, in essence, the kind of creatures he collected especially were large insects, birds, mammals and reptiles - the colorful or conspicuous ones - that could be sold by his very active agent in London, Mr. Samuel Stevens [19] to museums and that where attractive to private amateurs and collectors. Possibly today knowledge is still influenced by peoples' limitation in appreciating and accounting for diversity of biota. Simplification is always the main road of performance of common people. For instance, for most students, earthworm is a name for just one species or a few - two or three - for people that like line fishing. For the Ye'Kuana living in the Alto Orinoco, earthworms receive at least 16 ethnonames and at least two species are eaten and considered a gourmet food [20]. All these species have not a scientific name yet. For taxonomists, there are at least 5,000 earthworm species living on the planet, but most people in developed countries, even if well-educated, believe that only "one species " covers this category of invertebrates.

These differences in people's current knowledge and "rational knowledge" make the tragedy of the limited protection of biodiversity even more problematic. It is difficult to protect or even notice plants and animals that are not known, used or considered of any use. In some cases, the idea tout curt of interdiction from hot spot areas of humans can be the only way to maintain biodiversity, however much knowledge coped with local inhabitants is going lost with the local illiterate cultures loss.

For instance, the Yanomamo living in the forests of Amazonas, Venezuela consider edible about 392 (out of the 521 they normally recognize currently with ethnonames) species they hunt, trap, collect or cultivate in their forest gardens (Tab. I).

Therefore, the essential local knowledge is based on species that are or are not useful, but this oral knowledge is based on direct experience of using these resources

[20]. For instance, the Yanomamo eat 25 different types of caterpillars but currently, only one species has a defined scientific name: *Omoposhi* (Table II and Fig. 7) just one example of the incredible difference between local and scientific knowledge. The Yanomamo as well know and name many different caterpillars being for them"poisoning"

Do we eat all of the species available on the planet? Is what we eat a reasonable picture of biodiversity?

Diamond, 2002, has suggested that most species that have been domesticated, especially the ones we know today, cereals as well as animals, such as cows, goats, sheep and hogs, are the "only ones" that were easier to transform (domesticate) and to be kept in artificial conditions developed in the new environments called agroecosystems. Seven areas of major domestication processes of animals and plants have been described thus far [21, 22].

Is he true? Key species adopted by humans are no more than 20 that supply up to 85% of world's food base. About 5,000 plants have agronomic interest but around 20,000 plants (of a total of 250,000 described) and possibly 6,000 animals, more currently, are estimated to be used as food in some part of the world [15, 23, 24, 25, 26, 27], all representing the diversity known by humans. But, in our opinion, the proportion of the few most-used species of the 1.8 million already described on the planet is still inappropriate.

It has been argued that insects, together with other small invertebrates, represent alone about 85% of all described species. But at least 10 million species of insects have prudently been forecasted as living on the planet, ten time the number of those described [28]. Some projections have given numbers ranging between 30 and 82 million insect species [18, 28].

Then, again, the number of species is far larger than the few species selected to be accommodated in our domestic desk dominated by species domesticated in the Fertile Crescent and, in most cases, local food and more diverse food is not less nutritious or healthy than Western food found in on supermarket shelves [29, 26, 30, 31, 32, 33].

But when we inquire about the number of species known and considered edible, the situation is quite disarming, also among "specialists", such as Biology students (Table III). In addition, when we examine the five most-cited species, three always appear - tomatoes, carrots and cherries or apples - all red in color! Apparently, our ability in recording edible species is determined by color?

Is it possible to think about alternative resources coming from the biodiversity to improve the environmental conditions of the landscape?

The approach toward resources can be pessimistic or optimistic:

Are the species that we use (mostly in the Western culture) the right ones, the only ones available that have just been domesticated and spread everywhere? The case is wheat, rice, corn, sorghum, barley, oats, soybeans, potatoes and so they have been spread everywhere and dominate cultures like China, Australia, Europe and Africa. The same for animals - the large animals - cows, hogs, sheep, goats, horses, chickens, ducks, salmons and trout that have dominated most of the world panorama [34]. Another view suggests much more diversity based on the many different species adopted in areas with high biodiversity and based on local knowledge and experience, linked to thousands of species not currently found in our supermarkets but locally considered as food and a considerable resource but not appreciated enough outside of their small range of attention and use [30, 31, 32, 33, 4, 35, 36].

Perhaps a few examples can clarify the current situation.

A - strange spinach.

During the Vietnam war, under the pressure of bombing paddy rice fields, many communities in the area of Hue survived by eating an Asiatic sister species of the sweet potato, the water spinach or water cabbage (*Ipomoea aquatica*) that thrives as a sort of hydroponic culture on channels, ponds and small lakes and has a very short life cycle (Personal communication, 1996 in Hue); and the plant is still largely cultivated in Vietnam and China, both in aquatic and terrestrial environments [37] (Fig. 1).

B - Vietnamese minorities.

In Vietnam, over 50 different minorities live in the country. Some live in the mountane-forested areas. In general, the King Vietnamese, based on lowland paddy rice culture, believe that the mountainous minorities are undernourished due to lack of paddy rice for several months in the year being their dry rice less productive [38]. This is partially true since some minorities consistently use natural resources, non-conventional food that they collect in wild areas (by hunting, trapping and gathering) but, in general, these activities are not allowed or even tolerated or regarded as being unimportant by most observers belonging to the paddy rice culture or to the Western culture (linked to the Fertile Crescent species).

Once, in a local primary school, at Thuong Lo, of Katu peoples in the mountains near Hue, one of us (MGP) asked the pupils, using an interpreter, if they where eating insects: everybody was looking at him as if he were a “stupid provocative man”. He insisted, asking if they had tasted the small creamy legless bug (possibly three genera of Curculionidae live inside bamboo following dr. C O’Brien: *Otidocephalus*, *Cyrtotrachelus*, and *Macrocheirus*) inside the bamboo shoots in the field margins and forest close to the village: everybody was now waving their arms enthusiastically, saying that it was a very good raw snack. Have been asked many people living in the town at Hue and even school teachers, food scientists and agronomists and nobody could mention this local use (fig. 2).

C. – Wild weeds adopted as healthy traditional food in the Creta

Cretans use olive oil, but, less known is their high consumption of up 26 wild plants including (*Portulaca oleracea*, Portulacaceae) very rich in F2 vitamin (alpha-linolenic acid, one essential polyunsaturated fatty acid) in wich the average Westerners suffers a deficiency [35]. Most epidemiologic studies have shown the superior health profile of inhabitants of Creta [39].

If people in towns do not become acquainted with their rural landscape they risk an increased monotony and the species diversity declines. Promoting diversity is a culture that accepts quite a different combination of species as food, accepts to support income of rural areas and for the rural communities, and helps to maintain diversity by appreciating the diversity of food in time and space. Commercialization needs standard production: products easily harvested, transported and stored. Maintaining biodiversity in rural or forest areas or savannas needs a kind of exchange with consumers that is different and more varied during the year and in different seasons. Food (vegetables and fruits) with minor blemishes, size and color differences and variability have to be accepted so that the farmer does not have to opt for the exaggerated use of pesticides [40, 41]. Links and joint projects are needed among local communities and people living in large towns in order to exchange knowledge and improve understanding. In most cases, local food, including small unconventional invertebrates, has nutritional value attributes and, for many reasons, is similar to the conventional food (Table IV).

Management strategies and improvement of education

Reducing the environmental impact is an issue of sustainable farming systems, that is: reducing erosion, soil loss, loss of diversity of biota, maintenance of landscape diversity and harmony and energy conservation. This process is complicated by the destination of products and their commercialization constraints. Making consumers more aware of the links in product strategies, environment quality, and fate, under different options of production could be essential. Educational programs in local villages, house gardens, farms, natural environments and in urbanized areas are quite important to encourage the use of new goods. Good communication is needed as well as appropriate educational frameworks, among different actors. Citizen consumers need to improve their knowledge of biodiversity and the use of different foods. In addition producers, ecologists, sociologists, economists, and psychologists must to be involved in the educational program over a period of time, to encourage the use of biodiversity in the food system [11].

The constraints of science-scientists and communication

The transfer of knowledge is a complex operation within human communities and its development is essential to an evolutionary patrimony of human communities. Biodiversity recognition among different human groups is not well-known and the amount of knowledge in different groups is, as well, poorly understood especially in the non-literate societies.

One can argue that experience accumulated in an environment over generations can improve with time and is based on trials, collection, hunting, failures and positive results. As well, the domestication processes that have provided humans with major crops and livestock are based on a limited number - seven main areas on the planet and are based on a limited number of species [21, 34]. However, it is not true that among millions of species on the planet, there are not further materials that can be considered as potential new crops or livestock [26, 36]. These unknown resources are, in most cases, in the hands of local people.

There is need to develop and stimulate local semi-domestication processes. For instance, some mini-livestock, such as rodents, can be attractive for their tasty meat (Fig.

3). Presently they are hunted in the wild of South America but could be domesticated [42]. The local use and the maintenance of non-written knowledge about species has to be increased and reinforced. Valuable plants have never been utilized outside of very localized areas. A good example could be the *Yara Yara* – a delicious fruit as large as an orange, (Fig. 4) from Alto Orinoco or several cousins of the tomato; *Tupiro* and *Tupirillo*, growing in the Amazon [43] (Fig. 5) or berries and small fruits, rich in vitamins (Fig. 6).

The educational programs have to transfer knowledge from local communities to large "civilized" communities, not only "vice versa". Educational programs and small-project support has to be provided for local activities through Non-Governmental Organizations (NGO) dealing with these objectives, and providing knowledge of such species outside of the local villages.

Very few projects try to maintain and improve local knowledge, increase it and disseminate it to "the markets" in the large neighboring communities.

One example could be some fruits that have never been adopted, even in the nearest Indian markets, which are not collected because no one asked for them (Fig 4-10). Aromatic (Fig. 10), medicinal, and wood- fuel plants should be developed.

Knowledge of biodiversity and the sustainable domestication of plants and animals have to be continuous processes in local villages [44, 45, 46].

Without these transfers, a new trend in considering local knowledge, experience and resources related to biodiversity will be exceedingly difficult. The most important focus for planners, experts and teachers is to modestly learn from the local people.

Conclusions

Everyone traveling in the tropics has found large projects, centrally or locally directed, that have provided cars, computers and buildings to some groups of people focused on investigating biodiversity. In general bureaucrats, sometimes heads of some local organization are leading the studies. In most cases, these projects do not encourage the exchange of knowledge available locally to different groups of people to help maintain their knowledge and generate new knowledge in order to improve a sustainable development of biodiversity. In most cases, only the package of species known by "experts" in the projects are suggested as resources, and little attention is being paid to local biodiversity resources and their use.

Encouraging local knowledge in schools, maintaining ethnonames, and transcending the boundary of each village with the “local” knowledge are mechanisms to develop appropriate management strategies to produce sustainable use of local resources.

Efforts are needed to encourage local cultures and maintain their knowledge alive and, where possible, export of some biodiversity resources. Ecotourism and export agreements can help but risk submerging small illiterate communities has to be properly managed.

Westerners, as well, need an improved educational framework in order to better incorporate biodiversity knowledge, their use and their potential also as food, medicine, and forestry systems.

Plants, animals and microbe with medicinal, pesticidal and aromatic properties provide many opportunities for people in all nations. Reasonable laws are needed to protect national resources and prevent the introduction of pest species.

Equitable strategies to develop and manage different species using local knowledge have to be implemented and sustained.

Notes: In most cases, “new non-conventional food” plants and animals have been reported here with only their local ethnic names to give credit of their biodiversity to local communities [4].

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Table I. Potential knowledge of species ethnonames by a 11-year old Yanomamo in Amazonas, Venezuela. Column I lists the total species potentially known in different categories, column II lists the edible species, column III lists ethnonames collected by a missionary during many years of contact with villagers in Alto Orinoco. Columns I and II were obtained by a group of seven Yanomamo of different villages; they listed the species "by memory".

THE BIODIVERSITY KNOWLEDGE OF THE YANOMAMI
tentative, very prudential, assessment

ORGANISMS	TOTAL	eaten	Finkers, 1986
Plants conuco ICARI	22	19	40 ???
MEDICINAL-DGS	15	?	7 (yopo)
MAGIC, ORNAMENT	?	?	16
For fishing (barbasco And making traps)	5	0	
Mushrooms- edible	15	12	11
Trees in the forest	59	0	
Palms	13	13	
Trees bearing fruits	66	66	136 (fruits and roots)
Mammals	44	44	64
Birds	98	95	240
Fishes	47	47	122 (incl 6 which are not edible)
Reptiles, lizards	11	4	
Snakes	21	11	41
Anurans	13	6	37 (incl. 19 which are not edible)
Insects	**72**	**65**	**143 ? (incl. 6 which are not edible)**
Spiders	**7**	**5**	**2**
Gastropods	**4**	**1 (aquatic)**	
Crustaceans	**4**	**4**	**6**
Miriapods	**5**	**no**	
TOTAL	**521**	**392 (75.73)**	**865 (?)**

Table II.

Caterpillar consumption and knowledge among the Yanomamo July 1997

Caterpillars (Lepidoptera) (25 species)	**host plants**	
MAGNA (the same as the Piaroa)	HUMISCI	
IROKIRI	MOKHE	
WAGIO WAGIO	***WAGIOWAGIO NATO behuco**	
CASHA	KANAIIHA	HAWARI behuco?
PARIMA	TAHINANI mata	
MAMO CORI CINA	CANAININI mata	
IRO KRUKUIU	ATARI HAHI mata	
PASCOU	TOHO TOTO behuc	
WERO WERO	SCAWARA CURIMI mata	
OPO MOSHI	PENAHE’	OHATA WACO mata
PENAHE NOSI	***PEENA PEENA**	CURATASCI COTE mata
WATEOMA	WARAPAHI mata	
PARURI HESIKAKI	?	
HEWAKEMA	?	
NIYÃ	?	
KIRAKIRAMI UMO	?	
SHAKUKUMI	?	
KRAYA	?	
MAYA	?	
YAKURETO	KUMICIHENATI mata	
MAPAYAWA	***MAPAYAWA HENA mata**	
HEWEKEWEKEMOREWE	PITAHAMU mata	
WAWA HENA	MAECOTOMA mata	
SHIYAHUMI	ATARIHIA mata	
PORE MAPUUSIKI	PITAHA mata	

Table III. Estimated (maximum) number of species known and consumed as food by western civilized peoples and forest- and savanna-dwelling peoples in Amazonas (Venezuela). Interviews were performed by university personnel (1995-1996) using forms filled out in class; oral interviews were carried out in Amerindian villages located near Puerto Ayacucho, Amazonas (1997).

Population	Plants	Mammals	Fish	Birds	Insects	Total
Students at Padova University.	**48**	**10**	**12**	**5**	**0**	**75**
Guajibo Amerindians	**38**	**22**	**18**	**18**	**31**	**127**
Curripaco Amerindians	**46**	**18**	**32**	**25**	**11**	**132**
Piaroa Amerindians	**68**	**24**	**18**	**38**	**28**	**182**
Yanomamo Amerindians	**125**	**52**	**56**	**96**	**89**	**418***

Note

The university students were attending animal ecology courses in their third year at the University of Padova, for their degree in Natural History.

The Guajibo live in the savannas near P. Ayacucho, Amazonas, Venezuela.

The Curripaco are an expert river margin-dwelling group living near P. Ayacucho, Amazona, Venezuela. The Piaroa and Yanomamo are more strictly forest-living Amerindians in the Alto Orinoco, Amazonas, Venezuela. The Yanomamo maintain strong links with the forest for their survival.

*Based on different sources and evaluations, the total number could be around 1400 species.

Table IV. Nutritional value of some insects consumed in tropical South America compared with other animal foods. Composition per 100 g edible portion (from Dufour and Sanders, 1999).

FOOD	**MOISTURE %**	**ENERGY kcal**	**PROTEIN**	**FAT**

female ant *Atta sexdens*	6.1	628	39.7	34.7
female ant *Atta cephalotess*	6.9	580	48.1	25.8
Soldiers termite *Syntermes* sp.	10.3	467	58.9	4.9
Palmworm *Rhynchophorus palmarum*	13.7	661	24.3	55
Caterpillars various (smoke dried)	11.6	425	52.6	15.4
River fish (smoke dried)	10.5	312	43.4	7
Tapir (smoke dried)	10.3	516	75.4	11.9