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ABSTRACT

HANPP calculated from land cover as indicator of ecological sustainability

Josep A. Garí

This is the inaugural paper that introduced a new indicator of sustainability, which the author coins HANPP: *Human Appropriation of Net Primary Production*. This indicator estimates the extent of human use of ecological and land resources, contributing to the nascent ecological-footprint movement in the 1990s. The paper describes the concept of HANPP and provides a set of rudimentary algorithms and metrics for measuring it, mainly through data on land cover and land use. It also provides a preliminary, comparative estimation of HANPP in two socially and ecologically dissimilar countries – Ecuador and the Netherlands – and offers a brief discussion on the potential role of HANPP in assessing sustainability issues, from biodiversity conservation to land use management. In effect, after this paper, HANPP started to be used and further developed in the field of ecological economics, becoming a practical tool to assess and guide land-use policy and management. This paper illustrates the humble beginnings of an indicator that has contributed to building the robust network of metrics now available to assess and advance socio-economic pathways to sustainable development.

JEL Classification: Q00, Q01, R14

Keywords: HANPP, Land Use, Ecological Economics, Sustainability Indicators, Ecological Footprint

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HANPP CALCULATED FROM LAND COVER AS INDICATOR OF ECOLOGICAL SUSTAINABILITY

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Abstract. In this paper we discuss the human appropriation of net primary production (HANPP) as indicator of ecological sustainability based mainly on land-cover statistics. After introducing the concepts of NPP and HANPP (section I), we discuss globally from land cover the meaning of NPP and HANPP in world terrestrial ecosystems (section II). Later, we develop a group of indicators based on the notion of HANPP (section III). Finally, we discuss briefly the meaning of HANPP (section IV).

Keywords: Sustainability, Net Primary Production, Land Cover, Human Ecology.

I. INTRODUCTION

The sun is the main energy source for life. Light energy (sunlight) arriving to the ecosystems is converted into chemical energy (organic matter) by primary producers, mostly plants, through the process of photosynthesis. The total amount of chemical energy that primary producers fix from light energy is called the gross primary production (GPP). Part of the GPP is released by the process of respiration (R), that supplies energy for the metabolic activities of the primary producer. The remainder energy, named net primary production (NPP), is the chemical energy used for synthesizing new plant biomass, which will be the organic matter available to the rest of the trophic levels (the heterotrophs). This essential biological process of energy conversion and flow from sunlight to heterotrophs can be expressed as follows:

Light energy (Sunlight) ----> Chemical energy (GPP) ----> R + NPP

NPP ----> Biomass (primary producers) ----> Heterotrophs

In sum, the net primary production (NPP) is the amount of energy that primary producers, mostly plants, leave to the life of the rest of the species, the heterotrophs (Vitousek et al., 1986). NPP is stored as biomass, mostly plant biomass in terrestrial ecosystems, and it is the energy source for the heterotrophs and, as *green* matter, before being used by heterotrophs it is the biological substratum for more chemical energy (NPP) obtention.

The net primary production of the biosphere supports the life of humankind and all heterotrophic species. That's why a reasonable share of net primary production is so essential: on NPP rely the life of ecosystems, the existence of biological diversity, and the human life.

Humankind needs to appropriate some NPP for its life and development, given that NPP is the source of food and some materials. However, this appropriation should not become excessive, given that all the remaining heterotrophs rely on the same flow of NPP. The energy flow is open, so the NPP appropriated once cannot be used again. This essential aspect of energy flow in biosphere, based on the laws of thermodynamics, requires a sustainable human appropriation of NPP. A NPP constraint goes together with a biodiversity constraint (Smith, 1996).

Demographic growth and global inequalities, among other factors, cause a large and increasing human appropriation of NPP, taking it away from the rest of the species. According to some global calculations, nearly 40% of potential terrestrial NPP is appropriated

because of human activities (Vitousek et al., 1986). This much quoted calculation reflects the high proportion of terrestrial biological resources appropriated by the human species, and at the same time it indicates a small proportion of biological resources available for all the remaining species. It is obvious that a high human appropriation of NPP involves a low supply of chemical energy for the remaining heterotrophic species, and consequently a loss of biological diversity is expected, at both genetic and ecological levels.

We propose to discuss HANPP. We do not consider HANPP the only or necessarily the best indicator of sustainability. Our interest lies rather in the development of a battery of indicators (HANPP, MIPS, Energy Cost of Obtaining Energy), and in the conflict that arises when one indicator improves, MIPS perhaps, while other indicators deteriorate, HANPP most probably (Martínez-Alier et al., 1996).

We focus on terrestrial ecosystems because human life relies mainly on terrestrial ecosystems, as illustrated by the fact that land-based agriculture supplies 97% of human food (Pimentel and Hall, 1989), and because the ecological relationships between humankind and terrestrial ecosystems are so close and interdependent that our focusing on terrestrial ecosystems results justified.

II. GLOBAL VIEW ON THE HUMAN APPROPRIATION OF NET PRIMARY PRODUCTION (HANPP)

In this paper, the human appropriation of net primary production (HANPP) as indicator of sustainability will be mainly developed on the basis of land cover. Nearly the only current source at world level for a satisfactory calculation of HANPP is the data on land cover supplied by the Food and Agriculture Organization (FAO). Moreover, the use of land cover will be even more suitable in future because of the capability of the Geographical Information Systems (GIS).

We consider five main types of land cover: croplands, permanent pastures, forests, other natural ecosystems, and human-occupied or -degraded lands.

1. Croplands

Croplands, which include both arable lands and lands under permanent crops, are ecosystems wholly appropriated by human societies since the net primary production of the ecosystem is mostly appropriated by the human species in the harvest.

Although part of crop NPP is not usually consumed by the human species or by human-supporting species (livestock), such as the roots in cereal crops or the leaves in tuber crops, this remaining NPP is hardly available for other major heterotrophs. We also consider the remaining biomass after the harvesting as HANPP.

Examining an agricultural ecosystem from the point of view of a naturalist it is evident the poor presence and the scarce diversity of species other than the human species, a fact that supports the idea of human appropriation of all crop NPP. In fact, many croplands work as *natural factories* that convert light energy into chemical energy (NPP), and supply a large part of the latter to the human species or to human-supporting species.

2. Permanent pastures

A permanent pasture is land used permanently, five years or more, for herbaceous forage crops, either cultivated or growing wild (FAO, 1994a). True permanent pastures are human-controlled grazing ecosystems (Vitousek et al., 1986), that is, ecosystems basically for feeding livestock, and consequently ecosystems mostly for human profit. According to this, permanent pastures, as ecosystems appropriated by livestock, are consequently human-appropriated ecosystems, in a situation analogous to the case of croplands. In essence, NPP of pastures is HANPP via livestock. However, a controversial discussion appears when considering natural ecosystems, such as a savanna, that are subsidiarily used as grazing lands. In these cases, the term *permanent pastures* does not fit well, but one part of NPP in these ecosystems is HANPP.

3. Forests

Forests and woodlands may be in principle ecosystems free of human appropriation; however, to some extent, they are not. We distinguish two main ways of human appropriation of forest biological resources:

1. Partial and limited appropriation of wood in managed forests, in which the wood resources obtained are biomass that counts as HANPP.

2. Appropriation of whole forest biomass in deforesting practices. All forest biomass of the deforested area is HANPP.

In deforestation, but also in wood production in managed forests, the human appropriation does not include only the annual NPP, as in crop harvest, but also biomass accumulated during previous years. Unlike crop harvest and pasture exploitation, this appropriation is not exactly a harvest because the forest is just once appropriated and it remains degraded for several decades or almost for ever.

Using a model from economics, deforestation may be described as the appropriation of both the profit and the capital; where the profit is the NPP in a given period of time, and the capital is all the forest biomass present at a given time. We define plant biomass as the natural capital of the ecosystem because it is the basis for future NPP obtention. In croplands and permanent pastures, HANPP is limited to the biomass profit of the period of time between two consecutive harvests (harvest time). In contrast, the appropriation of natural capital (all biomass) in deforestation makes of it an unsustainable practice, given that it implies the destruction of the biological basis for chemical energy production in the ecosystem.

4. Other natural ecosystems

Natural ecosystems other than the above referred to, are included in this heterogeneous land-cover category. It includes ecosystems in principle not appropriated by humankind. Inside this category we find mainly the following biomes: savanna, shrubland and chaparral, temperate grasslands, tundra and alpine, and desert.

5. Human-occupied lands and human-caused ecosystem degradation

Human lands are both human-occupied lands, such as built-up areas, and human-degraded lands, that is barren and desert land because of human activity. NPP of human lands is obviously HANPP. The NPP of human lands is from human-occupied spaces like gardens and urban parks. Human-degraded land usually has a low NPP, but under this category we may include the loss of potential NPP.

HANPP because of deforestation and ecosystem degradation show an irreversible ecological impact. It is obvious in complex ecosystems, such as a forest, where deforestation is the appropriation or destruction of all or nearly all forest biomass, and consequently the reconstruction of the ecosystem, if possible, is extremely long. Ecosystem degradation does not happen exclusively in deforestation, but also as a consequence of other human practices: the urbanization of natural areas and the desertization of cropland because of an unsustainable agriculture are examples of ecosystem degradation. The human-caused degradation of ecosystems implies a loss of NPP, because the new ecosystem has less NPP than the former. For example, the human conversion of a forest into a grassland involves a loss of NPP (forest NPP minus grassland NPP), which is HANPP. Also, some unsustainable agricultural practices imply a decrease in crop NPP; this decrease or loss of NPP is HANPP.

6. Time and HANPP

In any calculation of HANPP during a long, or historical, period of time, a controversial question arises. On the one hand, human appropriated lands have some NPP, all of which is HANPP; on the other hand, some land uses owe their origin to a loss of NPP because of the change of the former ecosystem, and this loss remains while the land is human-occupied. For instance, many European lands were deforested in the past. Such loss of NPP is not included in today's HANPP's accounts, while deforestation today in Ecuador (for instance) would be included.

III. HANPP AS INDICATOR OF ECOLOGICAL SUSTAINABILITY

1. NPP

From land-cover categories and a few more elements we develop, in the steps of Vitousek et al. (1986), the proposed biological indicator of sustainability we call HANPP. The ecosystems of a given region, through the process of photosynthesis carried out by their primary producers, obtain from light energy some chemical energy for its life. The input of energy in a given period of time, based on land-cover categories, may be expressed by the following equation:

$$NPP = C + P + F + OE + HL \qquad [1]$$

where

NPP: Total net primary production (dry organic matter).

C, P, F, OE, HL: NPP of croplands, permanent pastures, forests, other natural ecosystems, and human lands, respectively.

2. HANPP

NPP is the input of energy in a given period of time. This energy is stored in the ecosystems as plant biomass and in this state it is available for the heterotrophs. The human species, which is one among millions of species of heterotrophs, appropriates some NPP, that we name HANPP. HANPP is the amount of plant biomass (NPP) that flows from the primary producers to the human species. The main sources of HANPP are expressed in the following equation:

$$HANPP = C + P + MF + DF + HL + L \quad [2]$$

where

HANPP: Human appropriated net primary production (dry organic matter).

C: NPP of croplands, which is mostly HANPP through harvesting.

P: NPP of pasturelands, which is mostly HANPP via livestock.

MF: NPP appropriated by the human species from managed forests; mainly wood.

DF: NPP appropriated by the human species due to deforestation.

HL: NPP of human-occupied lands.

L: NPP lost because of human activity.

HANPP expressed as an amount of organic matter indicates little in itself about ecological sustainability. However, it is the key element for developing indicators, which follow.

3. HANPP as a percentage

Considering that a region, in a given period of time, receives an input of energy (NPP) and have outputs of energy (NPP consumed by the heterotrophs), we can assess the importance of the HANPP, which is the human output of energy, contrasting it with the energy input:

$$HANPP\ [\%] = (\ HANPP\ /\ NPP\ )\ x\ 100 \quad [3]$$

where

HANPP [%]: Relation between the input (NPP) and the human output (HANPP) of chemical energy in a given period of time.

HANPP: Human appropriated net primary production (human-caused output).

NPP: Total net primary production (input).

4. HANPP per person

The HANPP may be expressed according to demographic conditions:

$$\text{HANPP [per person]} = \text{HANPP} / \text{Population} \quad [4]$$

5. Irreversible HANPP (iHANPP)

HANPP because of deforestation and ecosystem degradation involve the loss of the ecosystem, and for such cases we propose an indicator of irreversible human appropriation of net primary production (iHANPP). It can be expressed by the following equation:

$$\text{iHANPP} = (\text{DF} + \text{L}) / \text{HANPP} \quad [5]$$

where DF is HANPP because of deforestation, and L is HANPP because of human-induced loss of NPP through ecosystem degradation. In relation to deforestation, this practice is both a human appropriation of biomass (this is reflected in DF) and a human-caused loss of NPP (this can account for L) given that the new ecosystem, a grassland for example, has less NPP than the former forest.

6. HANPP and the concept of ecospace

Ecospace is the environmental space that a given human group uses or appropriates (Opschoor, 1995). In our terminology, it is the space that provides HANPP for a given human group. Ecospace requires the introduction of flows of NPP, because some human groups appropriate foreign NPP or export NPP; for example, they import forest NPP. The HANPP indicator as related to ecospace is expressed by the following equation:

$$\text{HANPP [ecospace]} = \text{C} + \text{P} + \text{MF} + \text{DF} + \text{HL} + \text{L} + \text{CM} - \text{CX} \quad [6]$$

where CM would be imported biomass and CX exported biomass (see equation 2 for the rest of abbreviations).

This indicator remains to be developed, when adequate data on commercial flows of NPP are available.

Table 1. Net primary productivity and plant biomass of major land-cover categories and its related terrestrial biomes.

Land-cover category and related biomes	*Net primary productivity* ($g/m^2/yr$)	*Biomass* (g/m^2)
Cropland	700	--
Permanent pasture	600	1,600
Forest and woodlands		
Tropical rain forest	2,200	45,000
Tropical seasonal forest	1,600	35,000
Temperate forest	1,300	35,000
Boreal forest	800	20,000
Other natural ecosystems		
Desert	3	20
Tundra and alpine	140	600
Temperate grassland	600	1,600
Shrubland and chaparral	700	6,000
Savanna	900	4,000
Human land		
Human-occupied land	200	--
Human-degraded land	--	--

Notes and sources:

1. Net primary productivity and biomass data are expressed as dry organic matter.
2. Data are world mean data; some variation exists.
3. Cropland net primary productivity is an estimation of the author; see text: Appendix, 2.
4. Data of permanent pasture is adapted from data of temperate grassland because of the similitudes between both ecosystems.
5. Data of forests and other natural ecosystems are based on Whittaker and Likens (1975).
6. Human-occupied land net primary productivity is deduced from Ajtay et al. (1979), cited in Vitousek et al. (1986). This estimate may be high, but not out of line with other estimates.

7. Calculation of NPP and HANPP

From land-cover statistics and additional data on wood production and human degradation of ecosystems, the components of the indicator can be calculated. A discussion on some of the difficulties that arise and on some methods required is to be found in the appendix.

NPP for each land-cover category and biome is calculated by the following equation:

$$NPP = NPP\ (productivity) \times Area \quad [7]$$

where

NPP: Net primary production (the total production of a given land-cover category).

NPP (productivity): Net primary productivity (the production rate, in $g/m^2/yr$; see Table 1 for world mean data).

Area: Area of the land-cover category or biome.

Equation 7 can be applied for calculating C, P, F, OE, and HL. However, in the calculations many difficulties arise, some of which are discussed in the appendix. Among them it stands out the necessity of calculating specifically for each country or region its crop NPP (Appendix, 2), and the fact that data on permanent pastures refer to diverse ecological situations (Appendix, 3).

HANPP in forests (MF and DF) may be calculated as follows:

$$MF = Wood\ production \times 0.6\ (g/cm^3) \quad [8]$$

where MF is HANPP in managed forests; wood production data is available in FAO's forest products yearbooks; and 0.6 (g/cm^3) is wood density according to Armentano and Ralston (1980).

Deforestation NPP (DF) is calculated as follows:

$$DF = Forest\ biomass \times Deforested\ area \quad [9]$$

where

$$Deforested\ area = (Forest\ area\ T1 - Forest\ area\ T2) \ / \ (T2 - T1) \quad [10]$$

being T1 and T2 two years of reference.

Finally, in relation to loss of NPP (L):

$$L = (\text{Former ecosystem NPP} - \text{Degraded ecosystem NPP}) \times \text{Area} \quad [12]$$

8. An example of HANPP

Table 2 shows HANPP calculations for two countries, Netherlands and Ecuador.

Table 2. HANPP in Netherlands and Ecuador

In this calculation of HANPP there are excluded commercial flows of NPP (CM and CX), and losses from degraded land (L).

Country	HANPP [10^{12} g]	HANPP [%]	HANPP [10^5g/person]	iHANPP [%]
Netherlands	24.3	78.6	16.3	--
Ecuador	180.6	63.8	168.1	76
Ecuador (without DF)	43.3	15.3	40.3	--

Notes and sources:

1. The above data have been calculated from the following statistics (10^{12} g):

Country	C	P	F	OE	HL	MF	DF	NPP	HANPP
Netherlands	15.9	6.6	3.9	3.5	1	0.8	-	30.9	24.3
Ecuador	13.6	29.6	226.6	13.2	0.1	*	137.3	283.1	180.6

2. For abbreviations, see equations 1 to 5.
3. MF in Ecuador (*) is not calculated because wood production is mainly from DF (see: Appendix, 4).
4. Ecuador HANPP is also calculated excluding deforestation as a way of taking into account time effects, given that Netherlands deforested in the past but this HANPP is not included in today's accounts (see text: II, 6).
4. Data of Netherlands (1990/1991) is estimated from *Europe's Environment: Statistical Compendium for the Dobris Assessment* (Eurostat, 1995).
5. Data of Ecuador (1992) is estimated from *1993 FAO Production Yearbook* (FAO, 1994a), *1992 FAO Forest Products Yearbook* (FAO, 1994b), and *1992 Demographic Yearbook* (UN, 1994).

IV. BRIEF DISCUSSION

Land use change. The effects of land use change are felt on all levels of organization, from genetic to global (Vitousek, 1994). Deforestation, expansion of croplands, conversion of natural ecosystems into intensive permanent pastures, urbanization, and desertization because of unsustainable agricultural practices are examples of human-induced changes in land use. They have important effects on biological diversity, mainly because these ecological changes are not due to the natural dynamics of ecological systems but due to human appropriation or degradation of such ecosystems. Such effects may be captured through the calculation of HANPP.

On conservation of biological diversity. Biological diversity, at both genetic and ecological levels, depends on a source of NPP, which is the energy that keeps alive biological systems. A decrease in human-non-appropriated NPP because of HANPP involves some constraint to the conservation of some biological diversity. The human-appropriated NPP is energy (or biomass) not available for the rest of the heterotrophs. Moreover, HANPP involving ecosystem degradation (which we defined as iHANPP) has other effects on biological diversity because it implies loss of natural habitat. The relationships between loss of natural habitat and loss of species is clear (Swanson, 1991).

Global Environmental Change. Apart from the effects on biodiversity, the human control over a high proportion of world NPP involves the alteration of global bio-geo-chemical cycles. Vitousek (1994) reports that converting all Amazonian forest to pasture would increase temperature, decrease precipitation, and alter patterns of atmospheric circulation.

Sustainability without HANPP decrease. The reduction of HANPP is not in all cases the only way of sustainability. Some management and developmental strategies could improve sustainability without necessarily reducing HANPP. For example, the *sustainable* development of agroforestal systems, the subsidiary use of savannas and grasslands as pastures, but not their conversion into pastures by a massive introduction of livestock, and a rigorously sustainable forest management may perhaps be practices that increase HANPP without a decrease in biodiversity.

HANPP as a technology-independent indicator of sustainability? HANPP is one indicator that may be added to other physical indicators of sustainability already developed: e.g. MIPS, Energy Cost of Obtaining Energy. HANPP is specifically a biological indicator of sustainability. The fact that HANPP is not technology-dependent, while the other indicators

are, probably could mean that some indicators improve because of some technological developments, while HANPP keeps at the same level or even worse. However, the development of genetic engineering and biotechnologies could in the future afect HANPP.

Improving crop NPP. Some controversy arises when discussing the future possibilities of improving substantially crop NPP. It is clear that the increase in crop NPP, suppossing that population does not increases, would allow less cropland for feeding humankind, or at least it would not require the extension of croplands. However, this idea does not always work. The *Green Revolution,* which was a project of crop improvement, although has allowed some crop improvement, at the same time has shown its ecological unsustainability in many cases. Current advances in genetic engineering, or what we may call *Genetic Revolution,* although it can be of great value, at the same time it may have a grave effect on the sustainability of ecological systems.

On data availability. Many difficulties appear in the calculation of HANPP. For instance, data on human degradation of lands or data on true pastures not including other subsidiarily grazing ecosystems are not usually available. The proposed indicator will be increasingly valid with data from Geographical Information Systems (GIS). However, the need to count commercial flows of NPP and the difficulty in estimating losses in NPP over periods of time, remain.

Historic trends. Human impact on biosphere is obvious from an historic point of view: human land use and land cover change has transformed one-third to one-half of Earth's ice-free surface (Vitousek, 1994). One main use of HANPP would be in reconstructing such historical and geographical trends.

APPENDIX: APPROACH TO THE CALCULATION OF HANPP

The proposed group of biological indicators of sustainability, based on the notion of HANPP, have been presented conceptually, but their real application does not proceed directly. In the calculation of HANPP difficulties appear, mainly in relation to the availability of data and the validity of the estimated parameters. This section is a discussion of some of the difficulties that arise in the calculations.

1. Distinction between production and productivity

The concepts of production (net primary production) and productivity (net primary productivity) are used in different ways in the literature. In some cases, however, no difference is made. In this paper, productivity is understood as the rate of fixation of chemical energy, and production is the total amount of chemical energy obtained in a given period of time (often 1 year). The relationship between both concepts is for us the following:

$$\text{Net primary production} = \text{Net primary productivity} \times \text{Area} \qquad [13]$$

Because of the close relationship between both concepts we abbreviate them *NPP*. If required, we indicate specifically net primary productivity as *NPP (productivity)*.

2. About crop NPP (C)

Crop NPP, which is HANPP, depends on several factors, mainly on the following ones:

1. The species cultivated: e.g. sugar cane NPP is higher than wheat NPP.
2. Environmental constraints: temperature, water, light and soil, among others.
3. Additional human inputs: e.g. technology, fertilization and use of pesticides.

These factors, and specially the latter, are the causes of a high variation in crop NPP (productivity) worldwide, which may range from 100 g/m^2/yr to 4,000 g/m^2/yr, with a world mean of 650 g/m^2/yr (Whittaker and Likens, 1975). This high variation in NPP of crops is in a large part because of differences in agricultural practices (human inputs) between human societies. In fact, in present world we find from traditional to highly technological agricultural practices, and consequently a high variation in crop NPP exists from one region to another. Therefore, an specific estimation of crop NPP for each region or country studied is strongly required in order to avoid important errors. Information about crop yield, which is available in many world and local sources, will be an appropriate basis for estimating crop NPP in a given region. The conversion of yield data (which usually is referred to nutritive matter) into NPP data (which is the whole crop NPP in the harvest time) may be achieved by the following equation:

$$\text{Crop net primary productivity} = \text{Conversion factor} \times \text{Yield} \qquad [14]$$

Sharpe (1975) has discussed different conversion factors, and from his discussions and examples we estimate as appropriate for our approach a conversion factor of 2.5. In relation to yield data, for making easier the calculations of cropland NPP, we propose to use only cereal yield data, given that cereal is the most important crop. However, and specially if in a given region cereal crops are not the main ones, the calculation can be adapted for other crops, using a proportional calculation for each crop. From the proposed way of estimating crop NPP we estimate world mean crop NPP in 1992, having been the cereal yield of 280 g/m^2 (FAO, 1994a), in 700 g/m^2:

$$\text{Crop NPP (World, 1992)} = 2.5 \times 280 = 700 \text{ g/m}^2 \qquad [15]$$

This estimation is similar to the world mean NPP estimated by Whittaker and Likens (1975), which was of 650 g/m^2 per year. Our estimation is a little higher than that of Whittaker and Likens probably indicating an expected increase in crop productivity in the last years.

3. The problem of data on permanent pastures

FAO's data on permanent pastures are not as reliable as expected because of the fact that under the category of permanent pastures there are not exclusively ecosystems for feeding livestock. In some cases, natural areas used subsidiarily as pastures but that are not whole permanent pastures, and ecosystems such as savannas and shrublands (FAO, 1994a) are considered under the global and heterogeneous FAO category of *permanent meadows and pastures*. Obviously, HANPP in true pastures is much higher than in ecosystems used in a subsidiary way as grazing land. In the former cases, which is land that we specifically consider as permanent pastures, the NPP of the ecosystem is HANPP because it is a wholly human-appropriated ecosystem. In the latter cases, HANPP is just a little part of the NPP of the ecosystem, and even if were not considered no significative variation may result. Geographical Information Systems may be useful for a right distintion between whole permanent pastures and ecosystems of some HANPP when used for grazing. These facts should be taken into account while no more specific data on pasturelands are available.

4. Calculation of HANPP in forests (MF and DF)

In countries and regions where deforestation is a large practice, the main source of wood is deforestation, but not managed forests. Therefore, for countries where deforestation exists, MF data is in principle not included, because a large part or, perhaps, the whole wood production comes from deforestation activities, but not from hypothetical managed forests. So if DF is great, wood production data (MF) from statistical series such as FAO yearbooks should not be taken into account. MF data will be only counted where DF data is small or does not exist. This methodological consideration is for avoiding to count twice wood appropriation.

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