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FORESTS: BETWEEN ENERGY DEMAND AND ECOSYSTEM SERVICES. AN EMERGY ASSESSMENT OF FORESTRY STOCKS AS THE MAIN SOURCE OF THERMAL FUEL IN THE MARA RIVER WATERSHED, MARAMUREȘ COUNTY, ROMANIA

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Abstract: Nature builds resilience through storages of energy and one of the most iconic elements encompassing this capacity is represented by forests. Biomass in general and forests in particular are known to be one of the vast global reservoirs of carbon and energy and are described as forms of renewable natural capital that managed until the second half of the ninetieth century to globally sustain human communities as the major source of energy. Forests actively contribute to the functionality of a territorial system through a series of attributes such as water retention capacity, soil and slope stability, primary production capacity, all termed ecosystem services, benefits that communities take for granted. In more remote rural areas around the world, such as the Carpathian Mara River watershed, local communities still rely on forestry wood as the main supplier of thermal energy. The dependency relation also represents the community's level of perception towards natural resources, the landmarks and image of the entire Land of Maramureş as *„the wood civilisation"*, for example, being a cultural construct build through this energetic resource. In a time of pressure over energetic resources and following the premises of Emergy Theory and methodology, in this paper we propose an alternative approach in assessing natural resources in order to better understand that the exploitable energetic value of forests comes second when compared with the value of the provided ecosystem services.

Key words: Emergy assessment method, watershed, forests, stocks, primary production capacity, ecosystem services,

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INTRODUCTION

Forests, like any other ecological system, process energy coming from the Sun, matter (carbon) and information, covering the Earth with life and controling the Geobiosphere (Odum, 2007). For the temporal window on our lifetime, biomass in standing forests is considered to be a

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renewable natural resource, mainly due to the fact that primordial forests covered almost the entire continental surfaces with the exception of the Artics and could sustain humans since the dawn of history (Sundberg et al., 1994, in Odum, 1996). Wood as a supplier of energy represents a brief syntagm that can describe the motivations driving its frantic exploitation around the world. Today, the global fuel demand is too great to be supported on wood, but, faced with fossil fuels shortages, the continuous pressure on forests constitutes a major concern. This effect is experienced also in the relatively small Mara River Watershed, were local communities rely totally on wood as the main supplier of thermal energy and raw material powering their pseudo wooden industry.

Forests as forms of natural capital

The natural capital can be defined as the world's stocks of natural resources, from geology to soils, waters and biological organisms that form ecological systems. The definition comes in relation with a paradigm that enforces the idea that the economy is supported not only by the products and services associated with human productivity (traditional economics), but mainly by the products and associated essential services provided by nature (environmental economics).

This new approach derives from the Malthusian premises following observations made on the ninetieth century classical economics, stating that the geographical space, in the virtue of its finite spatiality (implicitly, finite natural resources), cannot sustain a constant economic development for a population with propensity to exponential growth. These new ideas pushed forward a new way of thinking over the relations humans have with the surrounding environment. Of course, Malthus's ideas can be proven wrong if the technological progress is taken into account. The exegetists of neo-classical economics in the 1950's for example have emphasized exactly this statement, judging that an economically wise management can sustain an endless growth in terms of human life standards. Starting with the seventh decade of twentieth century, the human-environment relations re-enter in their attention following the first major oil crisis from 1973 (Alpanda et al., 2010; Balassa, 1985; Gozner, 2010; Herman, 2009; Rosecrance, 1973). The newly formed ecological economics studies the relations humans have with the environment in the process of building their living standard by producing their goods and services (Common et al., 2005).

Bio-economy represents another philosophical concept worth mentioning. It belongs to Romanian scientist Georgescu-Roegen, who in his book, *"The entropy law and the economic process"* (Georgescu-Roegen, 1971), emphasized the importance of the entropy law when considerring the apparent antagonism environment-economic growth. The effects of his ideas towards human-environment relationships are felt in today's economic and environmental policies oriented towards sustainable exploitation of natural resources as means of reducing or delaying entropy.

Forests as a form of natural capital represent an ecological, social and economic liability and have a critical role in the ecology, aesthetics and socio-economic development of a community (Wu et al., 2010). The stocks over exploitation without encouraging it to naturally recover, can lead to productivity and resilience decline. This systemic effects can have negative consequences, not just on ecosystems but on human communities also, by firstly exposing the territory to hazardous phenomena such as flooding, soil erosion or droughts and secondly, by exposing communities themselves to economical risks.

Forests as providers of ecosystem services

The sum of all the benefits humans enjoy from the environment are collectively known as ecosystem services and understanding this concept requires a strong background in Ecology or Geography. The concept was popularized by the UN backed Millennium Ecosystem Assessment (2005) that managed to bring together environmental scientists from around the world in order to scientifically assess ecosystems and resulted with dramatic conclusion concerning the human impact on the environment. Extrapolating from the same document, one can identify crucial services that the Mara Watershed's forests provide to the local communities and that can be segregated on the following categories (after the Millenium Ecosystem Assessment, 2005):

- supporting services - *"that are necessary for the production of all others"* (De Groot el al, 2002; Millenium Ecosystem assessment, 2005, p. 40), including nutrient recycling, primary production and contributions to soil formation;

- provisioning services - products obtained from the forests, such as raw materials and fuels, wild foods, game. Wood as raw material and thermal fuel represents the most exploitable form in which communities benefit financially from forests;

- regulating services - in the form of carbon sequestration, purification and water retention or soil protection against erosion. On small and medium sized watersheds, protection against soil erosion represents the most visible form in which the forest contribute to a community's well-being.

- cultural services - nonmaterial benefits people gain from forests such as building cultural and spiritual capital (wood civilization in Maramureş) or recreational experiences.

Geographical markers of the study area

This paper highlights the current distribution of forestry areas and incorporated energy stocks (and associated emergy) into a Carpathian, medium sized, third order watershed. The methodological approach incorporates systems and thermodynamic principles, introducing watersheds as energy systems on the premises that river basins represent one of the most intelligible forms of natural hierarchical organization. The forestry cover represents a production system within the watershed.

The Mara River drains an area of over 41.000 hectares, and it's a tributary to the river Iza, a main contributor to the Tisa river, the major denudational axis of historical Maramureş, found today in two countries, Romania and Ukraine.

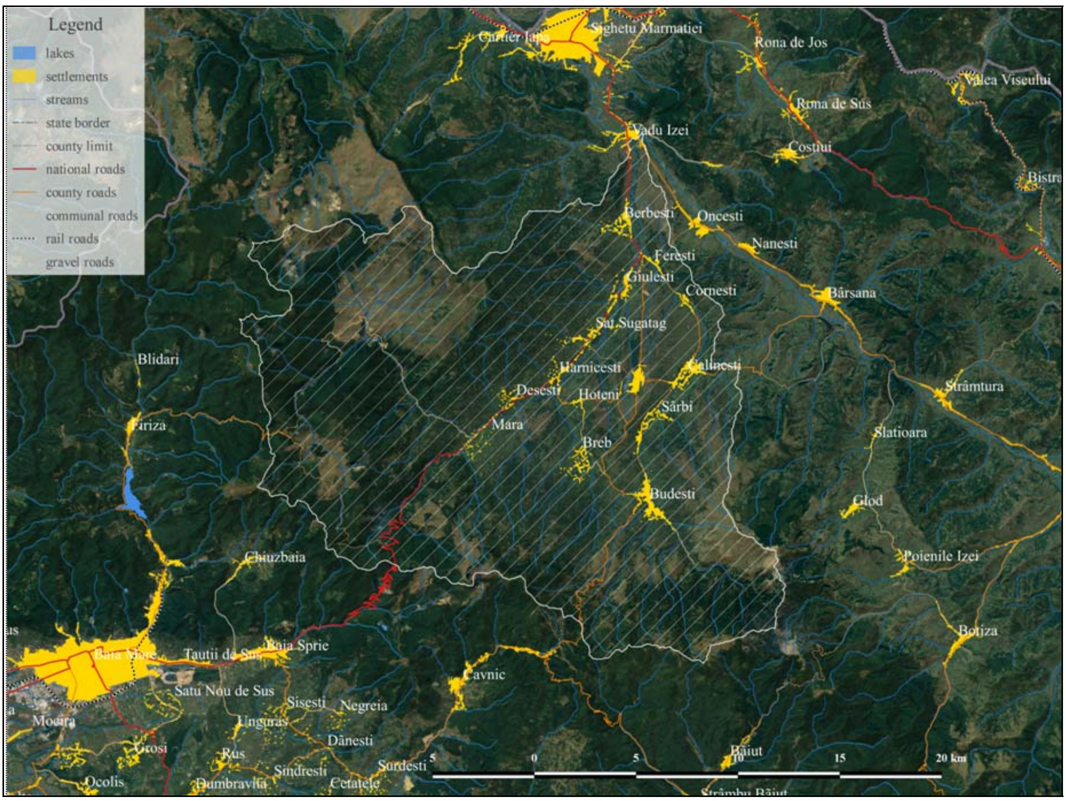

Figure 1. The Mara Watershed - a spatial reference
(Source: satellite imagery – Google Satellite via Quantum GIS 2.2.0)

The relief characteristics of the drainage basin subscribes to a denudational pattern. The mountain relief is represented by degraded, rezidual vulcanic structures with a relief energy reaching values of up to 350 m only in the area of Mara gorge, where the Mara River has penetrated the Neogene eruptive lavas (Ujvari, 1972, in Ilieș, 2007) of Igniș Plateau, a tabular vulcanic structure affected by neotectonic faulting. Similar values are recorded in the petrographic sector at the eastern edge of Igniș Plateau, on a line of geological discontinuity, forming a spectacular 200 meters steep.

The compact depressionary sector is characterized by a moderate divide and presents a low relief energy of up to 40 to 50 meters, especially along lithological discontinuities, bearing the markers of fluvial erosion. The main hydrographical network comprises two major streamflows - Mara and Cosău rivers - and represents the last phase of stream evolution since their initiation at the end of Pliocene.

The primary denudational function has been doubled by the implementation of a centuries old rural habitational infrastructure, comprising today a network of 15 villages, organised into 6 communes. In the year 2012, the Mara Basin's stable population comprised approximately 15.000 people that have a build infrastructure of around 5.500 households. [1] The initial hydrological flow has become the main adjuster of matter, energy and information within the watershed, balancing the natural and anthropic inflows and outflows.

Historically speaking, such as the Land of Maramureș itself, or other areas around the Carphatians, no matter the criteria of spatial delineation, the Mara Basin suffered spatial changes, transforming from a heavily forested area into an agro-forestry land. The transition followed a slow, centuries old process of continuous dwelling, a process assumed through natural resource exploitation and harnessing.

Forestry areas in the Mara Watershed

Forestry represents an indispensable resource for the Mara Basin's communities. Over the centuries, people used wood as the main construction material, developing a distinct wood culture, recognisable all over the world through distinct religious and traditional housing architecture and adhorning details. Currently, forestry represents the main source of thermal fuel. As a unitary block, the forestry cover mainly occupies the higher, mountainous areas of the basin, in alternation with secondary pastures. Towards the depressionary sector, the forestry cover is represented through a complex landscape fusion of forest patches in combination with agricultural fields, pastures and shrublands.

METHODS

The methodological approach presented in this paper falls into a greater scientific paradigm that imagines existence as a universal system controlled by energy and matter and where everything is connected to everything else (Odum el al. 2001). All systems, no matter their spatial (micro or macro systems) or temporal extension use matter flows (the materialization of energy) to build a structure and store energy in various forms. Energy represents the potential to do work with release of heat, either that we speak about a mechanical process, or a biochemical process such as photosynthesis. This type of system conceptualization is strongly anchored in the first two thermodynamic principles. Therefore, a forest can be imagined as an energetic system capable of exchanging energy, matter and information with the surrounding systems and also of building stocks through its primary production capacity.

In relation to this aspect an energy flow is defined as the energy transfer rate per surface unit / per time, as a measure of intensity and its capacity of doing work (Bumbak, 2016). According to the system's principles, energy flowing through a system passes through a series of transformations processes that diminish its actual quantity, increasing its quality instead.

[1] *http://www.recensamantromania.ro/wp-content/uploads/2012/08/TS2.pdf*

Therefore, with reference to forestry systems, building biological stocks is the the result of solar energy's transformation throughout climatic and biological processes.

Solar energy, the primordial form of energy, can be stored in various forms. For example, either as geopotential energy of rainwater and rivers, either as chemical energy stored in water vapour within the atmosphere or as energy stored by biological organisms (Bumbak, 2016).

The Emergy evaluation method that is proposed here derives from Howard Odum's observations regarding the study of energy's qualitative variations within ecological systems (Odum, 1987, 1988, 1996, 1998, 2001 in Bumbak, 2016). The mentioned author stresses the fact that energies flowing through a system have different capacities of doing work, therefore must register variations both in quantity and quality, further suggesting complex methodologies for the process of quantifying them. One method though was emphasized more, mainly due to its versatility and ability to evaluate disparate energy resources both as flows and stocks using a common denominator - the solar Joule.

Emergy is the energy used directly and indirectly in the past to create a product or deliver a service (Voora et al., 2010 in Bumbak, 2016). It can be defined also as the energy incorporated and used as a tool to measure the cumulative actions of energies operating in a chain (Ianoş, 2000). The researchers in the field of Environmental Sciences for example, that have used this method in various studies (Ascione et al., 2009, 2011; Brown et al., 2001, 2012; Franzese et al., 2009, 2013; Mellino et al., 2014, 2015; Odum, 1988, 1994, 1996, 2000, 2001, 2007; Pulselli et al., 2008, 2010, 2011; Raugei et al., 2014; Ulgiati et al., 2011; Viglia et al., 2011; etc.) are emergy supportive, saying that it presents itself as an appropriate method in the evaluation process of ecosystem *„goods and services”*, representing the essential amenities used by a community from the surrounding environment in order to function properly (Bumbak, 2016).

Establishing an emergy value for the forestry cover means that the researcher can assess the amount of energy Nature has invested in creating that forest up to the moment of the study. The emergy value incorporated in that stock represents not the exergy (available energy quantifiable through SI metrics) but the energy Nature uses in order to deliver useful ecosystem services. In a financial assessment, these services can value more than the exergy of the forestry stocks, therefore, the stocks bring added value to a territory not by being exploited through deforestation, but by their capacity of providing essensial amenities for the people.

A very important aspect regarding the evaluation procedure concerns the spatial and temporal reference frame. Ussualy, emergy flows are expressed spatio-temporal as value / hectare / year, while stocks are expressed as value / hectare. If the stocks are subjected to depletion actions, then the quantity of outgoing energy is expressed as value / ha / year or simply as value / year. The emergy assessment of forestry stocks and its primary production capacity follows the next methodological framework:

- diagramming forestry as a system - represents the first step of the procedure and implies literally drawing up a system diagram according to energy systems diagramming rules (see Odum, 1996, p. 73). In its initial phase, the diagram represents a qualitative interpretation of the system's boundaries, essential variables (sources of energy, stocks of energy, production systems, consumers), relations and functions;

- creating a standard table for evaluating the system (see Odum, 1996, p. 79);

- evaluating the incorporated exergy (available energy) / mass of each item, using specific algebric algorithms. The quantities are expressed according to the nature of the evaluated item using the metrics accepted by the International Systems of Units. In this paper, only the energy incorporated into the forestry stocks and the one incorporated into the yearly primary production capacity was assessed. The energy is expressed in the usual SI metric - Joules for energy content or grams for mass content;

- finding or calculating the solar transformity (UEV). Transformity is defined after the main unit of measure for emergy as the quantity of solar emergy necesary to produce one Joule of usable energy empowered within a flow, good or a service. It represents the relation between the quantity of emergy necesary to produce it and its energetic or material content (Odum, 1996). It is expressed as emJoule / Joule (seJ/J) or emJoule / gram (seJ/g), the latter being known as specific emergy (Bumbak, 2016). Transformities can be directly calculated or extracted from relevant bibliography. In this paper, standard transformities for wood were used based on bibliographical sources on emergy evaluation (Mellino et al, 2014).

RESULTS AND DISCUSSIONS

Diagramming forestry as a primary production system within the Mara Watershed

In the process of establishing the main energetic components that affcect forestry inside the Mara watershed as a system, defining morpho-hydrographic, climatic and socio-economic features of the watershed were taken into consideration. The focus of this particular diagram is on all variables found in relation with the forests. The structural, tectonic and fluviatile relief supporting the system has been conceptualized as a massive stock of energy that actively supports forestry landcover. Soils, products of synthesis considered as non-renewable resources, are another major control variable taken into consideration and represented on the diagram as stocks of energy that actively support forestry landcover. The entire anthropic suprastructure, comprising a network of 15 rural settlements organised into six communes, has been represented simply as a subsystem that is supported partially by forest wood, especially as a source of thermal fuels and as raw material for timber processing. The human-made capital as a form of energy build-up inside the subsystem, is represented in principal by the habitable infrastructure, that partially incorporates wood in its structure.

The paper's main focus rests on forestry as primary production subsystems in the Mara watershed, evaluating its stock and its yearly regeneration capacity.

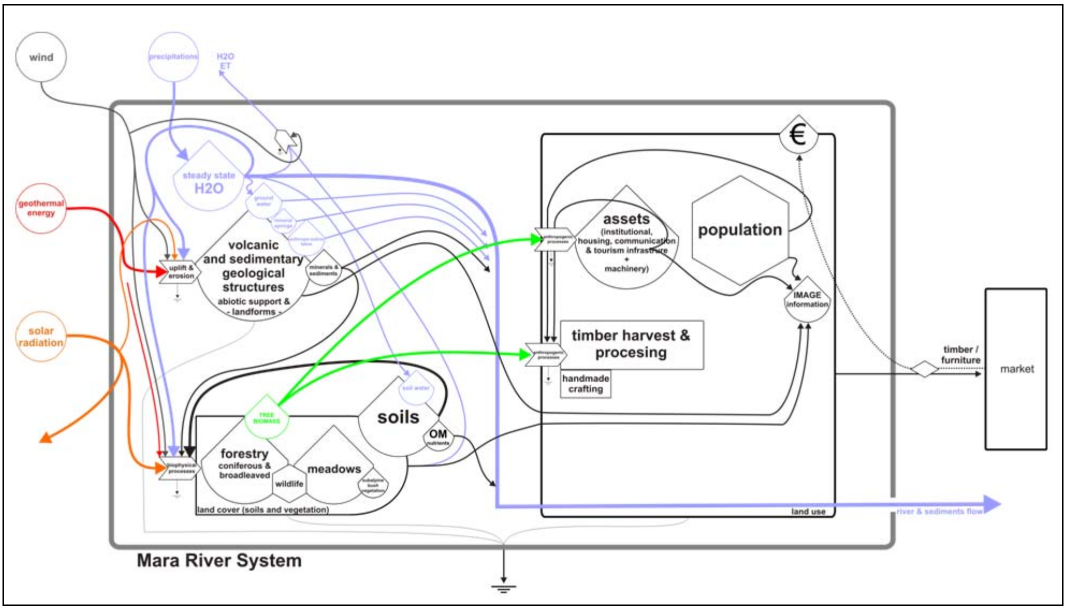

Figure 2. Forestry land-cover as production subsystem in the Mara River System

Statistics, dynamics and spatial distribution of forests in the Mara Watershed

Even though at a european level the statistics speak about a low but ascendant trend with respect to the growth of forested areas, the situation in the Mara Watershed, reflected through the spatial dynamics of forestry cover along a period of 22 years (1990 - 2012) point out a constant cover retreat which states the fact that the forests annual growth capacity cannot overcome deforestation and that the forests are a threatened natural resource. [2]

At present, compact forested areas can be found in the mountainous upper sector of the watershed, and sporadically, in the depression sector. The most forested areas are found on the glacis sector, at the base of Igniş Plateau's steep. The forest strip extends to the north-east at the base of the northern sector of Mara Piedmont. The Gutâi and Văratec mountains contain extensive forested areas.

Table 1. Shares from total LandCorine 2012 cover types in the Mara Watershed
(Data source: LandCorine vector data 1990, 2000, 2006 şi 2012)

vegetation class	S = ha (2012)	share (%)
CLC 311 – deciduous forests (compact)	**8821**	**21.5**
CLC 312 – coniferous forests (compact)	**856**	**2.4**
CLC 313 – mixed forests (compact)	**3325**	**7.9**
CLC 324 – transitional woodland-shrubland	5740	14
CLC 231 / 321 – secondary pastures	10618.2	25.9
CLC 222 – agricultural fields with orchards	179.8	0.4
CLC 242 – complex cultivation patterns	4368	10.6
CLC 243 / 211 – surfaces occupyed mainly by agricultural fields	1907.8	4.6
CLC 131 – quaries	82.4	0.2

A centrifugal, transitional forest strip can be observed at the base of Igniş and Gutâi mountains and represents the sector of maximum anthropic interventions. The forest patches decrease as we approach the two main valleys of the watershed, comprising dominant agricultural surfaces such as orchards and pastures. The future total brush removal will equate with the formation of a stable pasture cover (Ilieş, 2007).

Table 2. Dynamics of forestry landcover classes between 1990 and 2012
(Data source: LandCorine vector data 1990, 2000, 2006 şi 2012)

vegetation class	dynamic 1990 - 2000		surface 2000	dynamic 2000-2006		surface 2006	dynamic 2006 - 2012		surface 2012
	+	-	ha	+	-	ha	+	-	ha
CLC 311 deciduous forest	102.3	53	10432	-	1611	8821	-	-	8821
CLC 312 coniferous forest	-	34.9	407.2	454.8	-	862	-	6	855.9
CLC 313 mixed forest	-	-	2994	331	-	3325	-	-	3325
CLC 324 transitional woodland-shrubland	-	-	9638	3898	-	5740	-	-	5740

The human intervention have a centrifugal pattern, an unbiased observant being able to differentiate areas with a strong anthropic impact at the base of the habitational core along the river valleys, comprising a mosaicated land-use pattern composed of arable surfaces, orchards, pastures and isolated forest patches. As a visual marker of ownership, narrow strips of trees separate the agricultural fields. The centrifugal belt is extending towards the mountainous sector at a rate of about 160 hectares per year. A remnand item of the former secular forest that covered the entire Mara Basin is the protected Crăiasca Forest, found in the vecinity of Ocna Sugătag, a former salt miner establishement, nowdays a balneary resort of local interest. By far, the interval between the year 2000 and 2006 represented the summit of deforestations in the Mara Basin, at least in

[2] *http://ec.europa.eu/eurostat/statistics-explained/index.php/Forestry_statistics_in_detail*

contemporary times. The broad leaved forest cover was the most affected and suffered a 1600 hectares retreat. It is true though that the deforestation meant forest rarefaction not total eradication, but, according to the LandCorine methodology, the rarefaction was at a level that the rezulted patches were introduces into distinct vegetation classes.

One graphic example is represented by the compact deciduous forests that covered the entire Mara Piedmont at the begining of 1990's, that through constant human interventions has passed from CLC 311 vegetation class into the CLC 324 at the begining of the year 2000. This spatial dynamic was followed by yet another class change, and in just six years, the same sector was declared as CLC 242 – surfaces occupyed by complex cultivation patterns, were the forestry biomass represents just above 15 %. Overall, in that period of time, the most affected areas by deforestation were the surfaces found at the base of the Mara and Gutâi piedmonts.

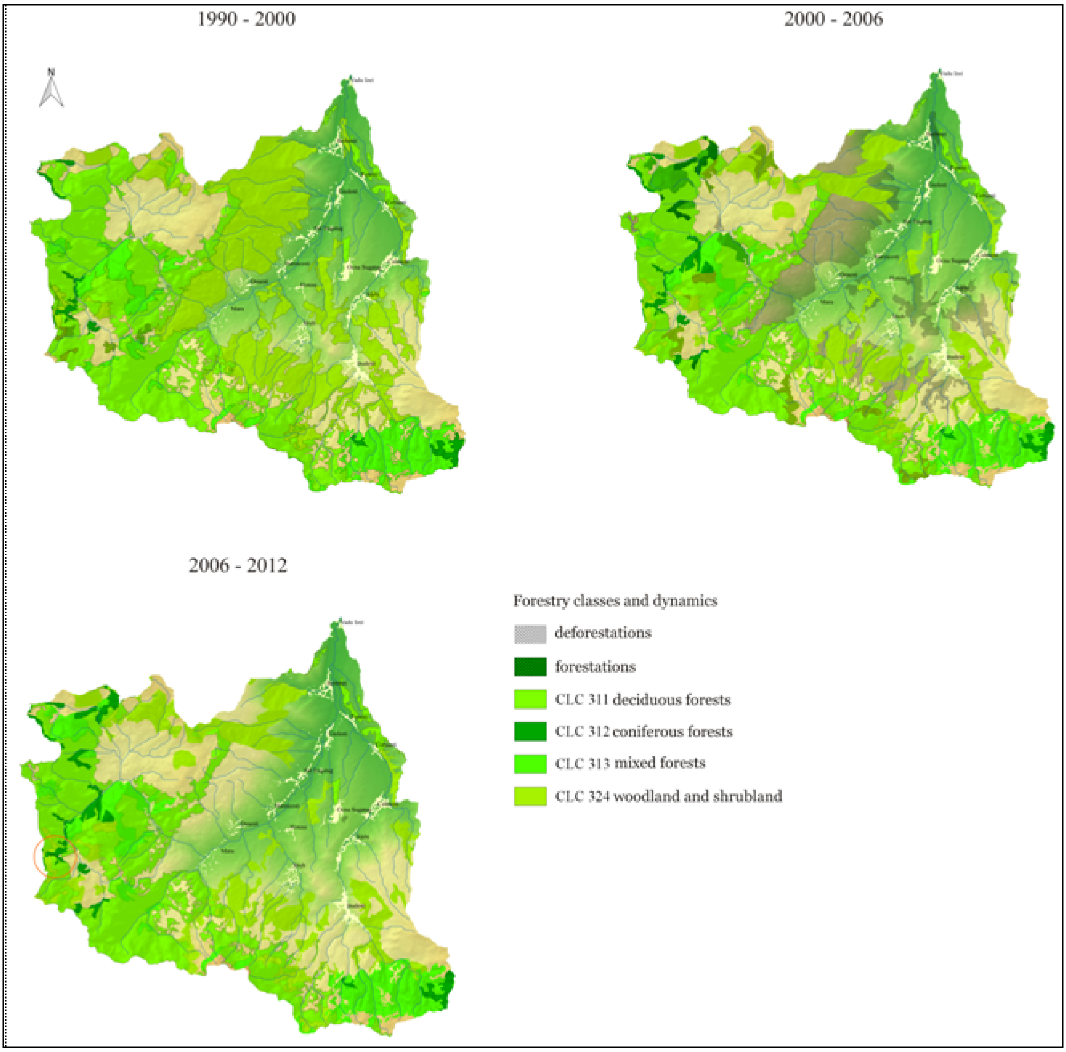

Figure 3. Spatial dynamics of forestry CLC classes in the Mara Watershed
(Source: surface vector data – LandCorine 2000, 2006, 2012)

In general, the state authorities manage the forestry stocks and decide upon the level of exploitation it can sustain. The exploitation rights are awarded to certified timber processors through a series of exploitaion licences. The land appropriation reform from the early 2000 saw a huge number of people regaining their historical rights of ownership over large parts of the country's forests. This fact can represent a potential explanation for the gained exploitation momentum between 2000 and 2006. Also, another causal relation can be found in a qualitative manner: as globalization affects even the most remote areas on Earth, it is possible that the wood has lost its empowered ancestral significance for the people of the Mara watershed, changing its status as a natural resource that secured survival to a natural resource that can secure fast and easy enrichment for forest owners. The main issue concerning forest exploitation resides not in assuring the necessary quantity of thermal fuels for the local households, but by selling it raw to third parties at a price under its potential.

For a long time, the wood biomass has been considered a renewable resource because of its steady natural regeneration capacity over the period of several decades. An alert exploitation pace, that overcomes forests's natural ability to recover, transform this resource into a nonrenewable one. The fact that in the Mara Basin forests lose over a hundred hectares a year, means that this scenario can apply here to.

Energy and emergy value of forestry stocks

In direct relation with the vegetation category and according spatial extention, the main energy reservoir is represented by the incorporated energy of deciduous forests, build up of trees belonging to the beech, oak, ash, sycamore maple and birch species.

Table 3. Calculated mass, energy content and incorporated emergy of forestry stocks in the Mara Watershed (Data source: surface – LandCorine 2012 / green wood density – Shmulsky et al., 2011 / volume – romsilva.ro / transformity for forest wood (UEV) – Mellino et al., 2014)

item	standar d units	raw data	energy J	UEV sej /J	emergy seJ
CLC 311- deciduous forests stock (+60% of CLC 324 + 32.5% of CLC 242 + 2% of CLC 243)	g	3.97E+12	7.48E+16	4.11E+03	3.07E+20
surface 2012**	ha	1.60E+04	-	-	-
average green wood density**	g/m3	1.14E+06	-	-	-
average estimated volume**	m3/ha	2.17E+02	-	-	-
specific average caloric content	Kcal/g	4.5E+00	-	-	-
specific average energy content	J/g	1.88E+04	-	-	-
CLC 312 – coniferous forests stock	g	1.57E+11	2.96E+15	4.11E+03	1.21E+19
surface 2012	ha	8.92E+02	-	-	-
average green wood density	g/m3	8.13E+05	-	-	-
average estimated volume	m3/ha	2.17E+02	-	-	-
CLC 313 – mixed forests stock	g	7.04E+11	1.33E+16	4.11E+03	5.46E+19
surface 2012	ha	3.33E+03	-	-	-
average green wood density	g/m3	9.76E+05	-	-	-
average estimated volume	m3/ha	2.17E+02	-	-	-
TOTAL forestry surface	ha	2.03E+04	-	-	-
TOTAL available energy / emergy	g	4.83E+12	9.10E+16	4.11E+03	3.74E+20

In the process of energetic evaluation of standing forest stocks of biomass, patches of forest vegetation found in other CLC classes were taken into consideration. These resources managed for centuries to supply locals with the necessary quantities of thermal fuels.

In order to express the energy content amassed in green forestry wood, several parameters have to be taken into account. On one hand, spatial attributes of the forestry patches have to be extracted. The surface values were extracted using the CLC seamless vector data for the year 2012 that were processed using GIS software. On the other hand, in order to express quantity in mass units (grams) and energy, physical parameters such as density, average volume, average caloric content and average energy content in forest wood were extracted from credited bibliographical sources. The incorporated emergy was obtained by multiplying the energy content, expressed in Joules, to the equivalent transformity, as calculated by Mellino (Mellino et al, 2014).

Due to its physical properties, the tree species forming the deciduous forest cover have a higher energy and emergy content. The average emergy of deciduous forest is around 1.92 E+16 seJ /ha, with over 30% higher than the emergy incorporated in a hectare of coniferous forest. The age of the forest is also an influencial factor, the secular deciduous forests represented by a denser matter have a higher transformity coefficient (Odum, 1996) than for example, a forest plantation made up of similar species. Even with a 160 hectare per year backlash, the forestry biomass stock amasses immense quantities of energy capable of doing ecological work, comparable with the flows of renewable energies in the entire Mara watershed (see Bumbak, 2016).

Table 4. Average incorporated emergy of forestry stocks in the Mara Watershed
(Data source: surface – LandCorine 2012)

vegetation class	S = ha 2012	emergy seJ	seJ/ ha
CLC 311 – deciduous forests TOTAL	1.60E+04	**3.07E+20**	1.92E+16
CLC 312 – coniferous forests	8.92E+02	**1.21E+19**	1.36E+16
CLC 313 – mixed forests	3.33E+03	**5.46E+19**	1.64E+16

Primary production capacity

As it was mentioned before, wood represents the main thermal fuel resource for the local population. Unfortunately, the thermal output of traditional heating stoves present in the majority of the Mara Basin's households, render just above 40% of the caloric potential of wood, the rest being released to the atmosphere in the form of degraded heat, meaning that people have to surmount low efficiency by increasing quantity. Technological devices that can improve efficiency are constly and are implemented remotely, according to each household's budget. [3]

Following the energetic calculus, the paper presents the Mara Basin's forest total yearly primary production capacity and the energy yelds that can be obtained in order to assess the potential of natural regeneration as means of reducing human impact through deforestation. The estimated annual growth was estimated at around 5.6 cubic meters per hectare, according to the last invetory made in 1985. [4]

The natural regrowth capacity is proportionally dependend on forest's cover extension. Constant deforestation means that the presently available stocks will produce fewer new trees. The estimation was made on the total patches of deciduous forests that were present in classes CLC 311, CLC 324, CLC 242 and CLC 243, with surfaces estimated for the year 2012.

The total surface of deciduous forest in the Mara watershed was estimated at around 16000 hectares. The numbers regarding the average yearly consumption of forest wood as thermal fuel was obtained by multitplying the average quantity of wood used (ap. 20 m3/household/year) to the total number of households in the Mara Watershed (5.500 households). The numbers obtained in table 5 point out a surprinsing fact. Considering an yearly average consumption pattern of around

[3] *ftp://ftp.fao.org/docrep/fao /010/i0139e/i0139e04.pdf*
[4] *http://www.fao.org/docrep/w3722e/w3722e23.htm*

20 cubic meters of wood per each household, a quantity rawfully optimal in assuring the thermal confort during the winter time, the wood demand overcomes the forest primary production capacity estimated at around 90.000 cubic meters per year. The internal demand for wood fuel is estimated at around 123.000 cubic meters per year. This fact empirically assumes that the entire quantity of wood resulted through annual deforestations in the Mara Watershed, estimated at around 23.000 cubic meters, are used completely in meeting the internal demand. Moreover, the population is expected to resort to wood imports from ouside the basin. Of course, the administrative boundaries do not totally overlap the watershed boundaries, therefore, the forest encompassed within the administrative limits increase the amount of wood available as thermal fuels, decresing the import pressure.

Table 5. Comparison between estimated mass, energy content and incorporated emergy of various wood hypostasis
(Data source: surface – LandCorine 2012 / green wood density – Shmulsky et al., 2011 / volume – romsilva.ro / transformity for forest wood (UEV) – Mellino et al., 2014)

item	standard units	raw data	energy units	energy J	UEV sej /J	emergy seJ
CLC 311 – deciduous forest stock	g	3.97E+12	J	7.48E+16	4.11E+03	3.07E+20
surface 2012	ha	1.60E+04	-	-	-	-
average estimated green wood density	g/m3	1.14E+06	-	-	-	-
average estimated volume	m3/ha	2.17E+02	-	-	-	-
average specific energy content	J/g	1.88E+04	-	-	-	-
primary production capacity	g/yr	1.02E+11	J/yr	1.92E+15	4.11E+03	7.90E+18
-	m3/ha/yr	5.60E+00	-	-	-	-
-	g/ha/yr	6.38E+06	-	-	-	-
rate of household wood consumption	g/yr	1.40E+11	J/yr	2.63E+15	4.11E+03	1.08E+19
-	m3/unit /yr	1.23E+05				
deforestation rate	g/yr	2.65E+10	J/yr	4.99E+14	4.11E+03	2.05E+18
-	ha/yr	1.07E+02	-	-	-	-
-	m3/yr	2.33E+04	-	-	-	-

With a scenario in which the deforestation rate reaches around 107 hectares a year, the wood cannot be considered an export resource for the Mara Basin communities. The deforestation rate was calculated in GIS by comparing the spatial vector data representing forested areas between the year 2000 and 2012, according to Land Corine 2000 and 2012. The registered difference was divided at the time interval of 15 years, on the basis that the stagnation trend in deforestations for 2006-2012 was maintained at least until the year 2015.

CONCLUSIONS

After decades of constant over exploitation and harvesting that surpassed the Annual Allowable Cut act, the risk awerness on the part of administrative stakeholders, academia and civil society towards the deficient forest management around the country, conservative practices are gaining momentum again. This in itself can set a positive trend and as long as this trend is maintained, forests can have the an optimistic future.

The paper highlights statistical facts and spatio-temporal dynamics about the forestry cover in a small mountainous watershed and makes a plea towards a better understanding of their importance to societies by applying an original scientific method that can emphasize the resource's energetic potential used in providing crucial amenities to societies. The emergy values obtained through calculations points out that forests are more valuable to the people of the watershed, and to all of us, if they remain on site, providing ecosystem services, free of charge. The emergy value incorporated within the forestry stock puts a number on the forerst's capacity of doing ecological work through provided ecosystem services.

The population dependence on forestry wood calls for integrated efforts in changing lasting mentalities and implementing new concepts and technologies that can harness different energy sources or produce different fuels in order to obtain thermal energy. This will reduce preassure on forests as sole providers of thermal fuel.

REFERENCES

Alpanda S., Peralta-Alva A. (2010*), Oil crisis, energy-saving technological change and the stock market crach of 1973-74*, Review of Economic Dynamics, vol. 13, issue 4, p. 824-842.

Ascione M., Bargigli Silvia, Campanella L., Ulgiati S. (2011), *Exploring an urban system's dependence on the environment as a source and a sink: The city of Rome (Italy) across space and time scales*, ChemSusChem, 4, p. 613-627.

Ascione M., Campanella L., Cherubini Fr., Ulgiati S. (2009), *Environmental driving forces of urban growth and development. An emergy-based assessment of the city of Rome, Italy*, Landscape and Urban Planning, 93, 238-249;

Balassa B. (1985), *Exports, policy choices, and economic growth in developing countries after the 1973 oil shock*, Journal of Development Economics, vol. 18, issue 1, p. 23-35.

Brown M., Raugei M., Ulgiati S. (2012), *On boundaries and 'investments' in Emergy Synthesis an LCA: A case study on thermal vs. photovoltaic electricity*, Ecological Indicators, 15, p. 227-235.

Brown M., Ulgiati S. (2001), *Emergy measures of carring capacity to evaluate economic investments*, Population and Environment: A Journal of Interdisciplinary Studies, vol. 22, no. 5, p. 471-501.

Bumbak S. (2016), *Spatial assessment of renewable energy flows in the agrarian Mara River watershed (Maramureş Land, Romania) as a potential tool for local and regional resource management policies*, GeoJournal of Tourism and Geosites, vol. 18, no. 2, p. 201-220.

Common M., Stagl S. (2005), *Ecological Economics: An Introduction*, Cambridge University Press, Cambridge, UK.

De Groot R., Wilson M., Bouman R. (2002), *A typology for the classification, description and valuation of ecosystem functions, goods and services*, Ecological Economics, 41, p. 393-408.

Franzese P., Cavalett O., Häynä Tiina, D'Angelo S. (2013), *Integrated Environmental assessment of agricultural and farming production systems in the Toledo River Basin (Brasil)*, United Nations Educational, Scientific and Cultural Organisation.

Franzese P., Rydberg T., Russo G.F., Ulgiati S. (2009), *Sustainable biomass production: A comparison between Gross Energy Requirement and Emergy Synthesis methods*, Ecological Indicators, 9, p. 959-970.

Georgescu-Roegen N. (1971), *Entropy and the Economic Process*, Harvard University Press, Cambridge, Massachusetts, USA.

Gozner Maria (2010), *Turismul în sistemul teritorial Albac - Arieşeni şi impactul acestuia asupra mediului*, în Analele Universităţii din Oradea, Fascicula Construcţii şi Instalaţii Hidroedilitare, 3(2), Editura Universităţii din Oradea.

Herman Grigore Vasile (2009), *Omul şi modificările antropice din Câmpia Someşului / The man and anthropogenic changes in Somes Plain*, Editura Universității din Oradea, 227 pag., ISBN 978-973-759-981-0, Oradea.

Ilieş Gabriela (2007), *Ţara Maramureşului - Studiu de Geografie Regională*, Editura Presa Universitară Clujeană, Cluj Napoca, Romania.

Mellino S., Buonocore Elvira, Ulgiati S. (2015), *The worth of land use: A GIS-emergy evaluation of natural and human-made capital*, Science of the Total Environment, 506-507, p. 137-148.

Millenium Ecosystem Assessment (2005), *Ecosystems and human well-being*: *Synthesis*, Island Press, USA.

Odum H. T. (1988), *Self organization, transformity and information*, Science 242: 1132-1139.

Odum H. T. (1994), *Ecological and General Systems*, University Press of Colorado, USA.

Odum H. T. (1996), *Environmental Accounting: Emergy and Environmental Decision Making*, John Wiley and Sons, New York.

Odum H. T. (2000), *Handbook of Emergy Evaluation Folio 2: Emergy of Global Processes*, Centre for Environmental Policy, University of Florida, Gainesville.

Odum H. T. (2007), *Environment, Power and Society for the Twenty-First Century: The Hierarchy of Energy*, Columbia University Press, USA.

Odum H.T. (2001), *A prosperous way down. Principles and Policies*, University Press of Colorado, USA.

Pulselli F.M., Patrizi Nicoletta, Focardi Silvia (2011), *Calculation of the unit emergy value of water in an Italian watershed*, Ecological Modelling 222, p. 2929-2938.

Pulselli R.M., Pulselli F.M., Rustici M. (2008), *Emergy accounting of the Province of Siena: Towards a thermodynamic geography for regional studies*, Journal of Environmental Management, 86, p. 342-353.

Pulselli, R.M., (2010) *Integrating emergy evaluation and geographic information systems for monitoring resource use in the Abruzzo Region (Italy)*, Journal of Environmental Management, 91, p.2349-2357.

Raugei M., Rugani B., Benetto En., Ingwersen W. (2014*), Integrating emergy into LCA: Potential added value and lingering obstacles*, Ecological Modelling, 271, p. 4-9.

Rosecrance R.N. (1986), *The Rise of trading state:Commerce and conquest in the modern world*, Basic Books, USA.

Shmulsky R., Jones P.D. (2011), *Forest products and wood science – An introduction*, Willey-Blackwell, UK.

Sundberg U., Lindergren J., Odum H.T., Doherty S. (1994), *Forest EMERGY basis for Swedish power in the 17th century*, Scandinavian Journal of Forest Research, Suppl. p. 1-50.

Ulgiati S., Ascione M., Zucaro A., Campanella L. (2011), *Emergy-based complexity measures in natural and social systems*, Ecological Indicators, 11, p. 1185-1190.

Viglia S., Franzese P.P., Zucaro Amalia Blackstock, Kirsty L., Matthews K.B., Ulgiati S. (2011), Ecological Questions, vol.15, no.1, p. 57-69.

Wu S., Hou Y., Yuan G. (2010), *Valuation of forest ecosystem goods and services and forest natural capital of Beijing municipality, China*, Unasylva, 234/235, vol.61.

*** LandCorine vector data 1990, 2000, 2006 and 2012.

http://www.recensamantromania.ro/wp-content/uploads/2012/08/TS2.pdf

http://ec.europa.eu/eurostat/statistics-explained/index.php/Forestry_statistics_in_detail

ftp://ftp.fao.org/docrep/fao /010/i0139e/i0139e04.pdf

http://www.fao.org/docrep/w3722e/w3722e23.htm

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