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THE POSITION OF AGRICULTURAL ECOSYSTEMS AMONG THE ECOSYSTEMS OF CONTEMPORARY BIOSPHERE AND THEIR PRODUCTIVITY

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Abstract

I.PUIA,V.SORAN, I.ROTAR, E.CHIRCA, 1995, The position of agricultural ecosystems among the ecosystems of contemporary biosphere and their productivity.(In English). Not.Bot. Hort. Agrobot. Cluj, XXIV-XXV. The authors divide the ecosystems of contemporary biosphere into two great series: A) the series of natural ecosystems and B) the series of man-made ecosystems (see fig.1). Among these series, four distinctive groups (see fig.1) may be separated according to the amount of energy that may circulate through (the so called energy flux). Natural ecosystems may have a lower or a higher energy flux. Man-made ecosystems have a comparatively higher energy flux, but some of them (some silvosystems, agro-ecosystems and water ecosystems controlled by man) are productive from a biological point of view whereas others (the ones in villages, towns, as well as other kinds of systems built up by man) are great consumers of organic substances and other natural ressources.

A classification of agro-ecosystems according to the output/input ratio of "cultural energy" is evinced (see fig.2). The authors distinuish three groups of agro-ecosystems,namely: I) Industrial agro-ecosystems; II) Intensive agro-ecosystems; III) Extensive agro-ecosystems.

Key words: ecosystem, man-made ecosystem, agro-ecosystem, classification, cultural energy.

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Man's interference with the environment has been manifest on multiple planes. It is absolutely compulsory, since no living system can subsist without a permanent substance, energy and information exchange with the environment containing the natural resources of its existence.

The nature and proportion of man's interference with the environment have ever been changing along history in accordance with man's social and biological needs, with the means of production employed in his exploration of the environment.

To cut a long story short, man's interference with the environment , particularly in the biosphere, may historically be divided into a few ages, such as:

a) the age of man's thorough integration into the structural and functional order of natural ecosystems, during which man is an element of the trophic network of natural ecosystems interwoven into its texture so as to fill a certain position or ecological niche of a certain size. Man's action in the environment is prevalently reduced to his getting food (by harvesting and hunting), to minor, insignificant changes of the environment and - to a lesser extent - his exploration and exploitation of certain resources necessary for the making of tools. Within the respective age, the most significant changes occured between 1oo,ooo and 3o,ooo years B.C. in an interval of about 7o,ooo years, during which Neanderthaloid hominids cleared, or set on fire large forest areas, subsequently replaced by savannas, pampas and steppes through the expansion of Gramineae. It may, therefore, be stated, that during this early age, the most significant changes wrought by man in the biosphere consisted in the replacing of arborescent plant formations (tropical forests with falling leaves during the droughty season) by herbages (in savannas, pampas and steppes) as well as in a drastic numerical reduction verging on the extinction of certain herbivors by hunters towards the end of the Palaeolithic (I.Puia and V.Soran, 1984);

b) the age of great ecological transitions of 10 millenia ago, bound up with an essential change in the way of getting food through the cultivation of plants and the taming of animals. By quitting the position he held in natural ecosystems and following their pattern, man was able to make new ecosystems (preeminently agro-ecosystems), whose simplified structure as compared to the complex mechanism of nowadays trophic chain he could easily keep under control. Started at a local level, man's action in the environment was carried on at a regional and finally reached the global plane. It mainly consisted in the dislocation of natural ecosystems by means of clearing and fallowing lands more or less cut off from the natural circuit of matter;

c) the age of oikumen extention, i.e. of extending men's specific habitat, by means of founding rural and urban settlements, lines of communication and other great enterprises;

d) the age of intensifying men's action upon the environment to the point where it becomes a force of an intensity similar to that in the course of time have acted upon the planetary environment. This last stage brought about by the scientific and technical revolution of the XIXth and XXth centuries includes both man's undeliberate and his deliberate interferences with the progress of the great biochemical cycles on earth. This ultimately implies an ecological administration at both global and local level so that man may organize his activity in such a way as to protect his life on all possible planes.

Such an administration of our environment in its entirely would require proper knowledge of the main types of ecosystems nowadays extant on Terra and of the degree to which man's interfering with them could have benefic or malefic effects.

The ecosystems nowadays extant in the biosphere may be divided into two large groups: 1) natural ecosystems and 2) man-made ecosystems (managed or improved by him).

As the result of a long evolutionary process, natural ecosystems were formed in the biosphere. Some of their most common features are: a high degree of spontaneous self-organization carried on in accordance with the general laws of the evolution of matter; stability achieved by means of ecofeedback; an unperturbed, steady progress at the level of biogeoche-

mical cycles; and a clear-cut structural diversity (marked among other things by a very large number of component species).

Unlike natural ecosystems man-made ones have no spontaneous self-organization; their stability is low because of the few ecofeed-backs they stir; their biogeochemical cycles are controlled altered, even revoked by man and their ecological diversity (the number of component species) is very small.

In spite of the mentioned differences, the structure and functions of man-made ecosystems are generally similar to those of natural ones. Human settlements, especially those of the urban type seem to be an exception from the rule. Since in towns plants rarely play a trophic part (they are seldom meant to feed the human population of this ecosystem) the proportion of primary producers can only be low. For the majority of the natural resources on which they feed, urban settlements are highly dependant upon extra-urban environments (agro-ecosystems, natural ecosystems, fuel and ore deposits). From a trophic point of view they vaguely resemble such minor natural ecosystems (devoid of primary producers) as the dependant or incomplete ones from underground environments, or ocean abysses, where sunlight doesn't penetrate.

By analyzing from an energetic standpoint the ecosystems nowadays extant in the biosphere of the earth, we should be able to classofy them on the ground of input energy as well as of potentially accumulated chemical energy. From the outset we have separated the series of natural from that of man-made ecosystems (fig.1.).

The former are important for life on earth as a whole, including the life of the human species. All their chemical elements pertain to the structure of living systems and are periodically recycled. Their oxygen production is of about 160 billion metric tons per annum, and the quantity of water regenerated in them through respiration is comparable with that of oxygen. The primary net production achieved in natural ecosystems is estimated to circa 163 billions metric tons dry matter per annum. Consequently, life on earth depends on the functions fulfilled by natural ecosystems: the production of organic substance and the inclusion in its structures of radiant solar energy accumulated as potential chemical energy; oxygen out-put, and

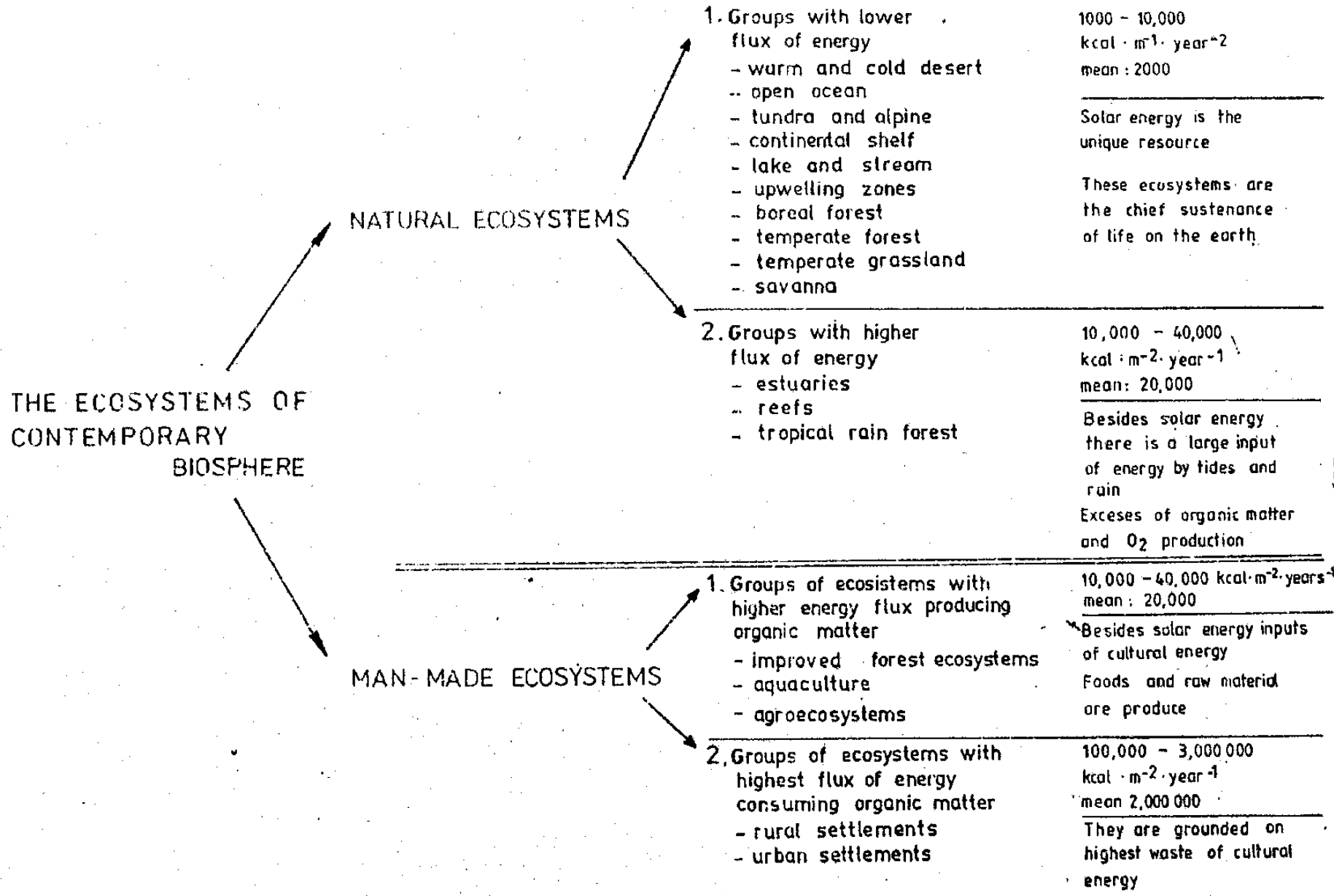

Fig 1. Classification of contemporary biosphere ecosystems depending on energetical fluxes

water regeneration. These processes are carried out in cycles of differing duration. The quantity of free water extant on the Earth is completely regenerated by the biosphere every 2 million yeers; the oxygen in the atmosphere is regenerated through photosynthesis by land and water vegetation every 2,000 years; the whole quantity of CO_2 extant in the biosphere is included in organic substance through a cycle lasting for about 300 years.

Man-made ecosystems participate to a far lesser extent in the completion of the great biogeochemical cycles on Terra. The contribution of agro-ecosystems to the net primary production of the biosphere is of circa 9-10 billions metric tons dry matter **par** annum. The oxygen and water production of these ecosystems merely represents circa 5-6 % of the amount achieved through photosynthesis and respiration on a biospheric scale. The main function of man-made ecosystems is, however, not to keep life going on in the biosphere, but to provide the human species with food, raw material and an oikumen corresponding to its material and spiritual needs.

We should mention the fact that attempts at classifying ecosystems extant on Terra were also made by E.P.ODUM (in 1975), as well as by K.I.LUKASEV and I.K.VADKOVSKAIA (in 1976). Like us, E.P.ODUM distinguished four ecosystem types, whereas the other two authors acknowledged only three basic groups of ecosystems, namely: 1) of the urban and industrial 2) of the agricultural and 3) of the natural type. In our opinion, the arrangement of the four basic groups into two distinct series (of natural and man-made ecosystems) best corresponds to objective reality. Of course, there are some cases in which the choice for inclusion in one group or another is difficult to make. For instance, a hay field or a forest are more frequently and to a greater extent endowed with the specific features of a natural ecosystem than with those of a man-made one. Man's control over the entity at hand comes to nothing but a few improvements (such as his sowing of highly productive grasses; utilization of manure and mineral fertilizers; parcelling; clearing of shrubbery).

It was only the close study of agro-ecosystems that

actually revealed the importance of man's part in understanding ecosystems and his exertion of a permanent control over them.

A possible classification of agro-ecosystems based upo the supplementary (cultural) energy introduced into ecosystems by man's control over them is presented in fig.2., reproduced from a recent work by I.PUIA and V.SORAN (printed in 1984). Depending on the two mentioned parameters, agro-ecosystems may be divided into 3 groups, namely: 1) industrial agro-ecosystems; 2) intensive agro-ecosystems and 3) extensive agro-ecosystems.

The classification of agricultural ecosystems presented in fig.2 offers a lot of information concerning ecosystem energetics, which in the particular case of agro-ecosystems is strictly dependant upon the energy input of the system. The main source of energy which maintains the structure and life of ecosystems is radiant solar energy.

Besides, solar energy a quantity of energy - derived from it - can also enter in natural and agro-ecosystems. It is the case of tide energy released in the area of estuaries and coral-reefs; of rain energy released in the case of tropical rain forests; and of "cultural energy" introduced by man into agro-ecosystems [x]. The larger the quantity of the

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x) The sintagma "cultural energy" was used in agro-ecology by W.G.COX and M.D. ATKINS (in 1979) to designate the non-solar energy introduced under various aspects into agro-ecosystems so as to stimulate biological production in the direction of large crops. It represents the sum total of biological energy (man + animal work) and of technological energy (energy invested in agricultural work done with mechanical equipment + energy of chemicals used in agriculture + energy invested in the fabrication of agricultural machinery and chemicals) spent on agro-ecosystems.

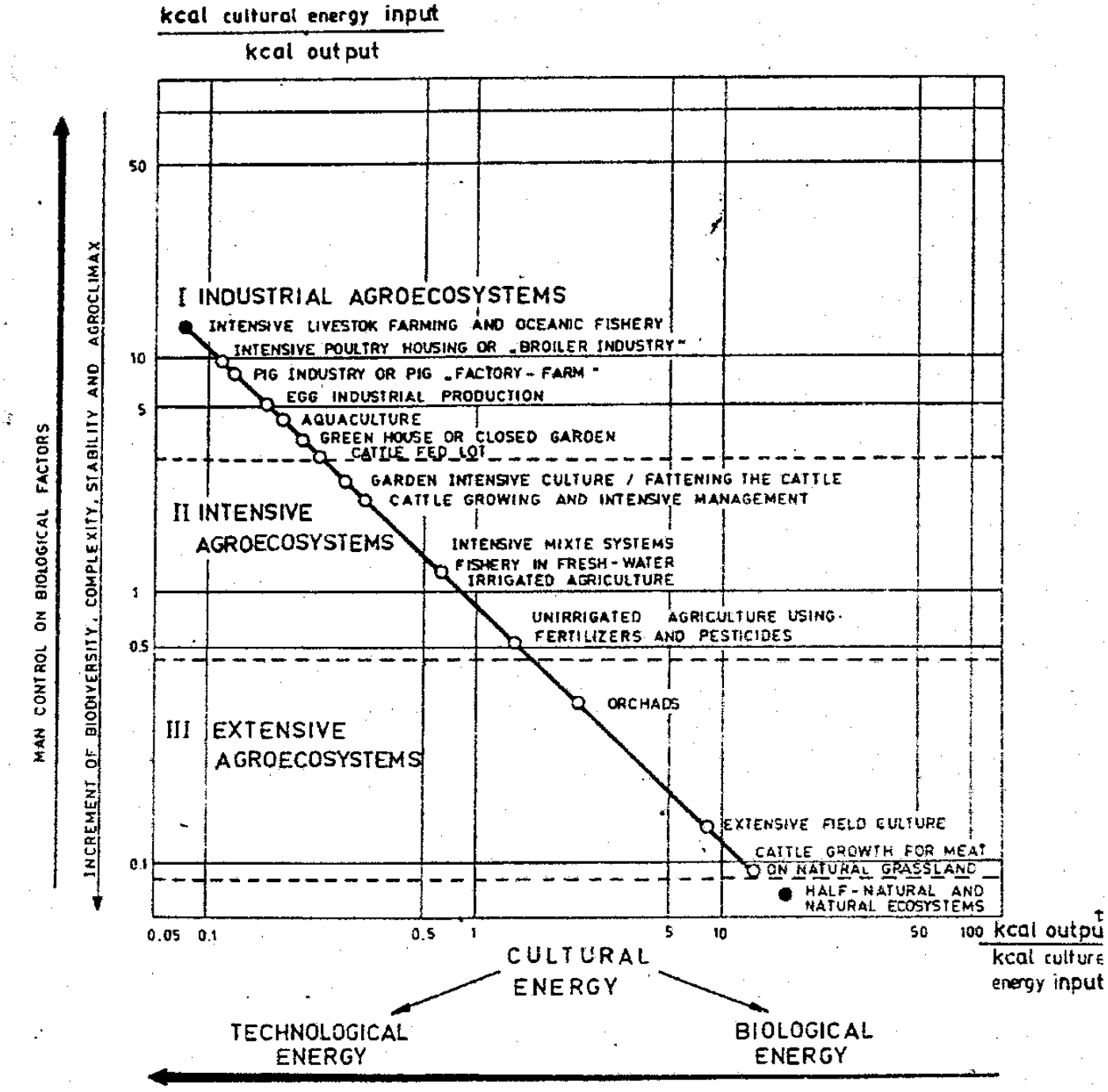

Fig 2 Classification on categories and types of agroecosystems according to the input of cultural energy quantity and other criteria

non-solar energy input, the larger the output of solar energy fixed in organic compounds, i.e. as potential chemical energy of an ecosystem. The log-log scale in fig.2, shows the cultural energy input/output ratio to be linear in agro-ecosystems. An essential difference between natural ecosystems and agro-ecosystems is evident on the structural and functional plane. As E.P. ODUM remarked (way back in 1969) large quantities of organic substance yielded in estuaries, coral-reefs and tropical rain forests on the one hand, and agro-ecosystems on the other hand are the outcome of two different ecological strategies. The energy input of the above mentioned natural ecosystems is allotted through many channels to a large series of species. The share held by each population in the production of organic substance is rather small, but on the whole the great variety of species extant in the ecosystem secures its high productivity. The same coefficient is low, however, in agro-ecosystems, whose component species are either few, or one only (in the frequent case of the monoculture system). Consequantly, in an agro-ecosystem, the energy input focused on a single channel results in a large quantity of organic substance. According to the data provided in fig.2 the highest productivity is reached in agro-ecosystems, which are ultimately nothing but a hypertrophic link of the food chain in an extensive ecosystem of "traditional" agriculture.

In conclusion, we'd like to back up the thesis according to which both natural and man-made ecosystems are enrooted in structures and functions of a similar kind. An argument pro consists in the fact (evinced in fig.1) that in both ecosystem series there is a group, whose high production of organic substance would depended on the energy input of the system.

Rezumat

Autorii împart ecosistemele biosferei contemporane în două mari serii: A) seria ecosistemelor naturale şi seria ecosistemelor construite de om (vezi fig.1). In cadrul acestor două serii se pot separa patru grupe distincte (câte două în

fiecare serie) după cantitatea de energie care circulă în interiorul lor (aşa numitul flux energetic). Ecosistemele naturale pot fi caracterizate printr-un flux scăzut de energie (o grupă), sau printr-un flux energetic ridicat (altă grupă). Ecosistemele construite de om se caracterizează - comparativ - printr-un flux energetic mai ridicat. Dintre acestea, agro-

ecosistemele sunt clasificate de autori după intensitatea fluxului de energie culturală (vezi fig.2.) în agroecosisteme industriale, egroecosisteme intensive şi agroecosisteme extensive.

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