Energy Ecology of Disasters of Various Genesis

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Abstract. In recent decades, the United Nations has come up with a number of new concepts and programs for global, regional and national development. They are characterized by an attempt to consider the global development process as a whole, from all sides — economic, social and natural ones. Practice has revealed a need to integrate a huge variety of ideas about the essence, forms, ways and patterns of the global system development. They are interpreted differently by different groups and forces. However, there is a great interest in integrating the concepts of development, since the progress and well-being of future generations depend on them to a certain extent. In some cases, attention is paid to poorly defined fundamental natural and historical laws that underlie the sustainable development. Without this consideration, it will be difficult to justify the objectivity of the selected criteria. The sustainable development of territories is influenced by various risks, threats and disasters that deteriorate the sustainability and sustainable development of territories. There are no justified criteria for assessing consequences of disasters of different origins, as well as for assessing the sustainable development of territories. In this regard, the paper raises the question of the need to develop a methodology for assessing consequences of disasters of different origins and their effects on the sustainable development of territories.

1. Problem Statement

1.1. Consequences of Disasters of Different Origins
Disasters are discontinuous changes that occur as a spontaneous response of a system to smooth environmental changes [1].

The balance of disasters represented by emergencies of different origins is shown in Figure 1.
Figure 1. Schematic representation of the Society’s life in cooperation with the Nature, with a view to emergencies of different origins (A — the path to degradation or biosphere instability; B — the path to sustainable development).

Note: \(N\) — total power; \(P\) — useful power; \(G\) — lost power; \(P_{em}\) — power of a natural or man-made emergency.

The schematic representation of the Society’s life in cooperation with the Nature, with a view to emergencies of different origins (A — the path to degradation or biosphere unsustainability; B — the path to sustainable development), shown in Fig. 1, implies that:

1) Man-made emergencies are caused by the Society (people) and, in turn, affect the Society and the Nature;
2) Natural emergencies are caused by the Nature and, in turn, affect the Society and Anthroposphere;
3) Man-made and natural emergencies affect each other — natural emergencies can cause man-made emergencies, and vice versa;
4) The human-induced load on the Nature and the Society, adjusted for the emergency power load, should not exceed 70 kW/km\(^2\) [2]. In the case shown in Fig. 1, the human-induced load, adjusted for the power of emergencies of different origins, exceeds 70 kW/km\(^2\). Therefore, the energy ecology balance of emergencies is disrupted. The path to degradation and biosphere unsustainability of the Nature and the Society is preserved.

In case of emergencies of different origins (B — the path to sustainable development) (Fig. 1), the human-induced load that affect the Nature and the Society, adjusted for the emergency power load, does not exceed 70 kW/km\(^2\). Therefore, the energy ecology balance of emergencies is not disrupted. The path to sustainable development of the Nature and the Society is preserved.

The energy ecology balance of disasters of different origins is important for understanding and determining the sustainability of socio-economic systems. The sustainability is the ability of the system to maintain its current state when subjected to external forces. If the current state is not maintained, the system is called unsustainable. Disasters of different origins, which cause the unsustainability of socio-economic systems, act as external influencing factors. A number of disasters,
such as devastating nationwide earthquakes, hurricanes, tsunamis, wars, and nuclear power plant accidents, may completely destroy the national socio-economic system of the country and lead to absolute unsustainability. Less significant (in scale and consequences) disasters of different origins violate the sustainability of socio-economic systems without leading to their complete destruction (a kind of convective instability). Therefore, in the context of what has been said about the effects of disasters on socio-economic systems, the following pattern can be identified: 1) disasters affect the sustainability of socio-economic systems by reducing the sustainability either to extremely low values (destruction of the system) or to certain limits; 2) the sustainable development of socio-economic systems is associated with changes in the power of disasters. Therefore, the sustainable development of socio-economic systems will be observed in cases where the power of disasters decreases continuously over time. A continuous decrease in the power of disasters is a requirement for the sustainable development of socio-economic systems.

One of axioms of science is the existence of the real world that is in continuous motion, i.e., it preserves itself and changes at the same time. It should be also noted that considering the sustainable development of society in isolation from the fundamental laws of the real world is completely unacceptable and discredit the very idea of sustainable development.

This problem can be solved using a special technique [3]. Before addressing this technique, we will consider the requirements for parameters of sustainable development assessment and parameters of disasters of different origins. Based on the analysis of measures, indicators, indices, parameters and ratings for sustainable development, all measures can be divided into several classes [4]:

- dimensionless estimates (percent, shares, points). Zero dimension of these estimates is conditional, since they use either heterogeneous quantities or artificial scales that cannot measure real natural and social processes.

- cost (monetary) estimates, unstable measures closely related to the economic principle of monetary accounting for environmental changes.

- estimates in physical units (hectares, tonnes). A variety of heterogeneous natural units of measurement cannot be used for an integrated assessment of the system as a whole. There can be as many measures as there are product names.

- universal stable measures. A measure is universal if it is expressed in terms of spatial and temporal quantities. A measure is stable if it is an invariant in a dedicated class of systems.

Thus, the sustainable development assessment for territories can include from several to dozens of indicators. Most studies and methods do not guarantee the necessity and sufficiency of selected parameters, thereby increasing risks and reducing the validity of decisions.

In order to eliminate the identified shortcomings, the Scientific School of Sustainable Development developed requirements for socio-economic indicators necessary for the effective design and management of sustainable development:

- Requirement 1: sustainable development should be designed on the basis of measurable quantities reduced to a single measure (unit of measurement) for systems which are open at the input and output in terms of energy (power) flows.

- Requirement 2: sustainable development should be designed according to the power conservation law and the principle (criterion) of sustainable development, expressed in terms of measurable quantities [4, 5].

When assessing consequences of disasters of different origins, the author has found that, if there is no single legal foundation, then neither the number of parameters taken into account, nor the careful selection of experts, nor the complexity of mathematical formulas can provide an objective assessment of consequences of disasters for sustainable development purposes in terms of measurable quantities.

In order to eliminate the identified shortcomings, we formulated requirements for assessing and predicting consequences of disasters of different origins and their effects on sustainable development of socio-economic systems (world, country, region):
• Requirement 1: consequences of disasters of different origins should be assessed on the basis of measurable quantities reduced to a single measure (unit of measurement) for systems which are open at the input and output in terms of energy (power) flows.

• Requirement 2: consequences of disasters of different origins should be predicted according to the power conservation law and the principle (criterion) of sustainable development, expressed in terms of measurable quantities.

This means that constant reduction in the growth of the disaster power is a necessary condition for sustainable development of socio-economic systems. Indeed, the growth of the disaster power reduces the growth of the useful power of socio-economic systems.

2. Theoretical Part

2.1. Energy Ecology Approach to Assessing Disasters of Different Origins

The purpose of the energy ecology approach to assessing disasters of different origins is to develop a set of methods that can be used to assess effects of disasters on the population, nature, economy, and ecology of a region, expressed in units of power (W). The assessment of energy ecology consequences of both natural and man-made disasters is aimed at studying the indicators that represent the sustainable development of the Nature—Society—Man system. In order to solve these problems, methods for studying the energy ecology consequences of emergencies are used in combination with methods of other sciences, such as physics, mathematics, ecology, etc.

The following objectives should be consistently addressed to achieve the formulated purpose:

The objectives of the energy ecology approach to assessing disasters of different origins:

1. To study consequences of disasters of different origins in terms of their influence on the Nature—Society—Man system, expressed in systems of sustainable development indicators.

2. To calculate and assess the basic indicators for energy assessment of effects of both natural and man-made disasters.

3. To calculate and assess additional indicators for energy assessment of effects of both natural and man-made disasters.

4. To assess and predict the energy ecology safety against disasters of different origins.

5. To develop insurance ratings of territories in terms of the energy ecology safety against disasters.

6. To develop criteria for creating safe living conditions that protect people against effects of disasters; to predict and mitigate consequences of disasters (compensation for damage on the basis of measurable quantities expressed in a single unit of measurement).

Subject of the energetic ecology approach: state, dynamics and prediction of changes in the Nature—Society—Man system under the influence of emergencies of different origins.

3. The basic terms and definitions of the energy ecology approach to assessing disasters of different origins:

Energy ecology safety from disasters is a state of the population, nature, economy, and ecology of a region at which the risk of the consequences of disasters does not exceed a certain acceptable level and supports sustainable development. The single criterion for the energy ecology safety against disasters is the integrity of natural, economic, and social conditions for living and working in the region. The acceptable level is understood as a value of human-induced load adjusted for the disaster density of not more than 70 kW per km².

Sustainable development indicators are indicators (derived from primary data that usually cannot be used to interpret changes) that provide insights into the state or change of an economic, social or ecological variable [6].

Sustainable development potential of a region is the combined ability of a region to ensure a cyclic and holistic process of maintaining non-decreasing growth rates of the useful power produced by the region, while not increasing growth rates of the power consumed by the region, but reducing
power losses due to breakthrough technologies and improving the quality of management at all levels of the region, industry, municipality, enterprise, and person.

**System of basic indicators for assessing energy ecology consequences of disasters of different origins** is a system of indicators that represent changes in values of the basic sustainable development indicators under the influence of emergencies of different origins.

**System of additional indicators for assessing energy ecology consequences of disasters of different origins** is a system of indicators that represent changes in values of the additional sustainable development indicators under the influence of disasters of different origins.

**Energy ecological balance of disasters of different origins** is a system of indicators that represent the balance in the Nature—Society—Man system under the influence of disasters of different origins.

**Disaster tolerance coefficient of a regional economy** represents the tolerance of a regional economy to effects of disasters. It is defined as a quotient of the total disaster power by the gross regional product (total power) of the region.

**Total disaster power** is the consequences of disasters of different origins, reduced to a single unit of measurement and expressed in units of power (W).

**Disaster power density (disaster power load factor)** is defined as the ratio of the total disaster power to the region’s area in km².

**Total power density (human-induced load power density)** is defined as the ratio of the annual total energy consumed to the country’s area, expressed in kilowatts per square kilometer.

**Biosphere unsustainability** is the ratio of the total power density (human-induced load power density) to the Fedotov constant (70 kW/km²).

**Biosphere unsustainability coefficient adjusted for the disaster density** is defined as the ratio of the sum of the density of the total power density (human-induced load power density) and the disaster density, to the Fedotov constant.

**Total power of the insurance market (insurance premiums)** is defined as the amount of insurance premiums paid by the policyholder to the insurer.

**Lost power of the insurance market (insurance payouts)** is the amount of payouts paid by the insurer to the policyholder in connection with the occurrence of an insured event.

**Useful power of the insurance market (profit)** is the difference between the total power of the regional insurance market and its lost power.

**Disaster insurance coverage ratio** is the indicator that represents the insurance coverage of the population of a particular territory against disasters of different origins. It is defined as a quotient of the full power of the insurance market by the disaster power. If the insurance coverage ratio is below 1, the disaster power exceeds the power of the regional insurance market. Therefore, the population is not provided with adequate insurance coverage against disasters. If the insurance coverage ratio is more than 1, the population is provided with adequate insurance coverage against disasters of different origins.

**Insurance ratings of territories in terms of energy ecology safety against disasters of different origins** are the ratings assigned to regions based on the analysis of energy ecology indicators of insurance markets in these territories.

4. Conclusion

1. The lack of a properly and formally described method for assessing consequences of disasters, which is consistent with the requirements and principles of sustainable development and can determine and measure the subject and scope of design, leads to wrong decisions and the accumulation of subjective information, makes it impossible to determine the contribution of disasters to the sustainable development of socio-economic systems.

2. Using the energy ecology approach to assessing disasters, we can determine the sustainability and sustainable development of socio-economic systems. The sustainability of socio-economic systems is determined by the scale and consequences of disasters, which lead to complete or partial
degradation of territories. The sustainable development of territories requires a continuous reduction of the disaster power at a non-decreasing rate.

5. References

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