Ecosystem services aim to visualize assets and costs not traditionally covered by market valuations and thus giving ecosystems much lower value than their importance to economy. Emergy methodology, with its approach of donor values in contrast to receiver or market values, can increase our understanding of values of ecosystem services.

The Energy Hierarchy Principle

Emergy is a measure appearing when applying the energy hierarchy principle to natural (e.g. forests and lakes) or human (e.g. cities and countries) systems, postulating that energies in any system will self-organize in hierarchical patterns given time to do so (Odum 1994, 1996, 2007). Emergy is expressed in relation to one type of energy occurring in the hierarchy, most often solar energy Joules, seJ. In the context of economy, emergy values in seJ can be alternatively expressed in a proportional, currency related unit, for example Em€ or Em$. The significance is that Em€ or Em$ measures the contribution different items give to the whole system, rather than how individuals give market values for different items, a donor value approach rather than a receiver or market value approach.

Ecosystem Services and Emergy

There are two possible main paths in Emergy methodology when applied to ecosystem services. If the focus of an investigation is e.g. the ecosystem services of a forest, either the energy values of the natural driving forces (ES-DF) for the forest, as sun, rain and wind can be used or, alternatively, the emergy values delivered by the forest to the human society and economy can be used (ES-PS, environmental production systems).

Emergy flows of a region is ultimately expected to describe the same system as what in the terminology of the Millennium Ecosystem Assessment (MEA 2005) is described by supporting, providing, regulating and cultural ecosystem services. The MEA descriptions should relate to the flows ES-DF or ES-PS or both, where the values of ES-DF might depend on scale of region under study.

Discussion and Results

The Emergy ES-DF values has been calculated and compared for three different geographical scales: national level with Sweden as the example, regional level with the Swedish County of Jämtland as example, and local level with the small island of Norderön located within the County of Jämtland as example.

An important finding is that an aggregation of ecosystem producing units into two groups, “Anthropogenic ecosystems” and “Natural ecosystems” (see Figure 1), enhances the understanding of the system behaviour:

- In "Anthropogenic ecosystems" there is a significant direct feedback from the Economy. Part of this feedback has its origin in imported goods and services from other places. The emergy values delivered by the environmental production systems (ES-PS) from Anthropogenic ecosystems will therefore always be significantly higher than the emergy values of the natural driving forces (ES-DF) entering.

- In "Natural ecosystems" any feedback from the society that comes from imported goods and services is only indirect via a storage of “Abiotic factors” (e.g. as nutrients via liquid discharges from society and carbon dioxide via gaseous discharges). These feedback flows will in most cases contribute very little to the emergy values delivered by the environmental production systems (ES-PS) from "Natural ecosystems" to the Economy. When comparing the emergy values of the natural driving forces (ES-DF) entering "Natural ecosystems" from left, with the emergy values delivered by the environmental production systems (ES-DF), they will be.

Preliminary values of the external driving forces ES-DF for the year 2005 has been derived: For Norderön the ES-DF value was 2.3E+17 seJ/year, for the county of Jämtland 1.8 E+20 seJ/year, and for Sweden 4.3 E+22 seJ/year. In the process it has become obvious that some types of flows will have to be treated differently on different geographic scales. An example is differences regarding the treatment of wave energy, which for the island Norderön became an outside source, while it resides among local renewable sources for the national level of Sweden as for the county of Jämtland.

The MEA terminology of supporting, providing, regulating and cultural ecosystem services will relate to the emergy ES-PS flows. The total magnitude of ES-PS can for a given region be derived from the ES-DF and the imported goods and services flow.

Figure 1. Generic energy hierarchy diagram (from left to right). Emergy flows related to ecosystem driving forces (ES-DF) and production systems (ES-PS) are indicated. The dotted lines represent conventional monetary flows.

References


