Thoughts on a Sustainable Human Ecosystem

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It is clear there are limits to the pollution a given ecosystem can absorb, the level of resources that can be depleted, and debt that can be incurred. Despite concerns of many about these limits we are far from tackling any of these problems on a meaningful scale. The question is why this is the case and if we (the Human Race) have the knowledge and capability to live within such limits on Planet Earth?

In this post, different modeling approaches to gain insights into sustainability will be discussed. We hope that readers will contribute their thinking of what a sustainable ecosystem would look like, and how to map the road towards it. One of the parts of this post is the initial outline of a project to model a human ecosystem from cradle to grave. This project will be carried out by the Institute for Integrated Economic Research (IIER), an institute in which Nate Hagens and myself are involved. Also IIER is looking for individuals to participate in this project, and encourages anyone with a passion for working on resources and energy consumption to take a look at our job advert and contact us via recruiting at iier dot ch.

Can a sustainable world be achieved?

The question of sustainability at a global scale can be difficult to fathom. In the case of ecosystems the size of damage done in past decades to centuries is immense, relative to the original state these ecosystems were in before the industrial revolution. For example, between 1950 to 2003, around 29% of fish species that are frequently caught today had collapsed, defined as their catch being 10% below the recorded maximum (Worm et al. 2006). The trend of this problem is many ways similar to non-renewable resources such as oil depletion, in that first the best available and cheapest resources are depleted. Historically, the big fish in the rivers on land were depleted first. In Europe this already occurred in the Middle Ages. Subsequently, the large fish near the shores, then further offshore, then the arctic, the shallow waters, and finally the deep sea. About twenty to thirty years ago we began to deep fish the ocean at depths of 1 km below the ocean surface in order to continue catching sufficient fish (Roberts 2007). This pattern does not imply that there are no longer fish in the rivers or offshore, but that the number of fish and their size is much smaller than before, and that a large portion of species have ceased to exist or are dying out. More importantly, at a global scale there are no new regions to explore in terms of fish catch today and the total number of fish caught began to plateau in the 1990s. It is likely that the total catch will decline in the not too distant future if the worlds fisheries continue to collapse at a rapid pace. The big question is if we are able to prevent this from happening, can we maintain the fish catch at today's level, or at least not let it decline too much, by better management of fish stocks globally. So far global agreements to regulate fishing and to protect stocks have failed to make a substantial impact, notwithstanding the success that has been made in some cases locally. The reason is fairly common for all the 200+ global agreements made today, when they come in effect the actions posited in them are often not implemented, at least not at a sufficient scale. This because sanctions are not a part of such agreements which makes non-compliance the norm. Many reasons can be found for this type of behaviour, one example being the tragedy of the commons as first described in detail by Garret Hardin.

The lack of proper management of the world's non-renewable and renewable stocks underlies what I think is part of general behaviour of the human species. We are not capable to deal with these problems by consuming less, or only with great difficulty. At an aggregate level because this would impact our path of economic expansion, at a disaggregate because it effects the wages and income of people (fishers in the example above). We as humans are best at solving a problem by developing new technologies and practices to fix one part of the problem. It is very unlikely that this will continue to work, as you cannot engineer your way out of depletion in the long run. For instance aquaculture as a technology in our fish example can help, but this is not a solution at the global scale of fishing today. For several fish species it is more profitable to catch them in the wild and deplete these stocks first before switching to aquaculture (Koldewey and Martin-Smith 2009), because of which the present lack of global regulation and sanctions imply a continuance of wild-fish depletion.

In light of the above, the solution to achieve a sustainable human ecosystem lies in developing solutions beyond more than technological change, but also into regulation of extraction to sustainable levels (which means consumption). The question is how to achieve such a sustainable human ecosystem, a system wherein all material and energy flows can endure, instead of being either exhausted or accumulated as waste. Can this be done at a global scale? Probably it cannot, at least not at the level of welfare that we enjoy today in OECD countries, but we can make meaningful attempts at a smaller scale of cities and regions to take important steps towards such a future. To do so we have to further develop the knowledge and capabilities to know which steps to take.

Approaches to understand what a sustainable world means

There is a common tendency in our industrial society to see solutions in terms of technological solutions. Many advocates of a sustainable world also adhere to this belief, one notable example being the plans outlined in Plan B (PDF). In this book Lester Brown, President of the Earth Policy Institute, outlines technological solutions and their cost to tackle a large number of problems such as deforestation, decreasing biodiversity, and lack of health care provision in developing countries. He ends the book by summing the cost of all individual solutions resulting in a figure of 187 billion US dollars needed to "restore the earth". The problem with this approach lies in the lack of integration of problems and their effects. Not only of the effects that these problem have on each other, but also the solutions which influences other problems than those they intend to tackle. For instance, consider the problem of exhaustion of the seas fish stocks. By consuming less fish to reach sustainable reproduction rates, demand will be shifted to other food segments, for instance meat or beans as an alternative protein supply, where other problems may emerge. For each alternative such trade-offs need to be considered. The solution to waste can be an increase in the rate of recycling, by separating materials and collecting them from households, but this will substantially increase transport movements as each waste stream needs its own transport chain. Similarly, the production of cadmium-telluride thin-film solar cells can reduce the amount of fossil based electricity, but will also produce a lot of toxic components that need to be dealt with (Fthenakis 2004), and so on.

To deal with these, increasing use is made of integrated models that look at different scales, including resources, energy, population, environment, and economy. These models are often not built to investigate what a sustainable system looks like, but assess how the present growth based system we have is affected by steps that are seen as part of a more sustainable system. For instance, the PRIMES energy model used by the European Union gives a full picture of energy consumption and production within the EU, and allows for application of different technologies as well as environmental regulation through taxes, permits, and subsidies. The way in which these models are used in policy are therefore to explore different options under the conditions of today's society, still assuming that the solution lies in obtaining technological solutions. There is little there in terms of halting certain activities, or choosing for radically different technology options which may be bad for short term economic growth, but beneficial for long term maintenance of welfare as their impact on the environment or resource exhaustion is low. Such roads plausibly have to be taken, as can be learnt from global models that map the problems at an aggregate level. The best known of such models is the Limits to Growth developed for the Club of Rome. Many others have been developed since. For example, the most advanced of such a model today in terms of ecosystems modeling is the GUMBO model developed by the University of Vermont, which maps changes at a global level in key indicators of ecosystem services, including soil formation, water availability, and climate regulation, and hooks these up with economic and energy activities.

To summarize, we have many models that only map partial aspects, some that map a more integrated world but still operate without sufficient reality checks, thereby losing the goal of a sustainable human ecosystem, and finally global level models which focus on aggregate development trends, but these generate little in terms of clear solution pathways. The challenge today is therefore to work on models that are able to provide clear answers to what needs to be done within the constraints of what is physically feasible, at local, national, and international scales. The question is how to go about to achieve this goal? In the remainder of this post we will look at one possible approach, informed by a project in its early stages of the Institute for Integrated Economic Research (IIER).

A framework to map a sustainable human ecosystem

The objective of a sustainable society is to establish an environment that is stable and resilient in the long run in several ways:

• From a perspective of resource availability, both renewable and non-renewable;
• In the sense that no agent or group of agents or location ends up accumulating resources in a way that is unsustainable for others;
• Equally, exchange with entities outside the boundaries needs to be balanced to avoid long-term instabilities in any one direction.

Under these conditions the key to understanding what a sustainable human ecosystem looks like comes down to mapping all resource flows through the economy and its connected ecosystems. The mapping of an entire "economic system" including all relevant exchanges and processes allows for looking at various complexities and interactions. Any intervention in the starting state of the system related to the required sustainable conditions can then be examined as to determine what both feasible and best solutions are. It may seem like a gigantic undertaking, but this is not the case when taking a limited geographical scope and through some simplifications. It should be feasible to limit the description to those processes and outputs in a society which produce approximately 90% of vital outputs, and assume others without detailed specification, as long as they do not form vital inputs that could stop other key delivery systems from functioning.

We strongly discourage modelling the "economy" of such a world based on money, but rather on physical interactions between participants and systems – which can later be complemented with a monetary component. That way, distortions from market imperfections – for example the insufficient assignment of a price for externalities – can be avoided. Thus, instead of using money as the baseline, we suggest modelling the entire "economy" on a non-monetary basis, but with the assumption of money being present as an enabler of simple and smooth exchange between agents.
The key components to achieve a view of the entire economy are inputs, outputs and transactions

which get shifted between physical entities (sub-locations) and agents in the model. Transactions can be processes, services or other exchanges (trade). The outputs and inputs can end up as infrastructure, in usable or non-usable resource stocks, or as pollution in connected ecosystems. The flow that these components create should be built in a way to allow for "imperfection", as humans make errors and natural events can result in resource losses. This both in the availability of inputs (for example sunlight, wind, water), but also in the process stages, where human error and excess waste are rather the norm than the exception.

More details on each of these components can be found in the 9-page overview project document.

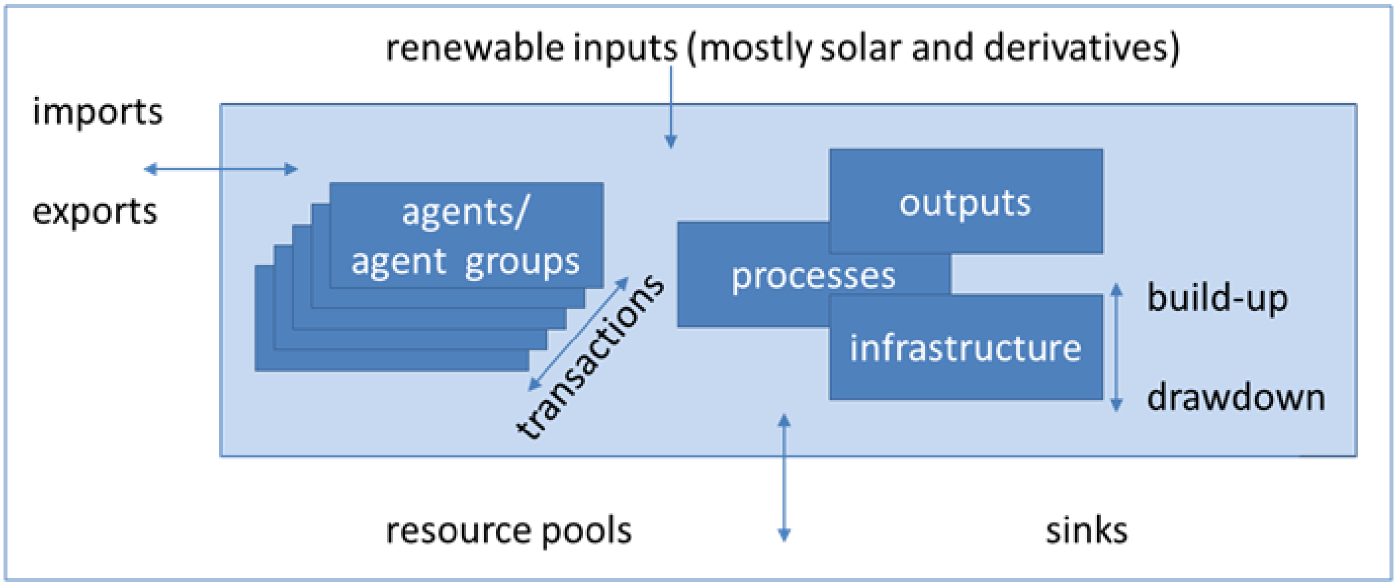

Figure 1 – broad overview of model components

The modelling of these components based on a given system such as a city, region, or country, allows for tracing all type of flows and stocks within the human ecosystem. We can then see what happens if one stock becomes depleted or when pollution accumulates.

To get a grasp for the level of wealth and required changes are to achieve a sustainable human ecosystem, we need to adapt the model to be able to work with different degrees of cycling as one key condition. In a 0% scenario, no cycling takes place and all waste and losses of the processes go into sinks. In a 100% cycling situation, the society is not allowed to lose more resources and energy than can be harnessed or cycled. This provides a tool to map the road towards a sustainable human ecosystem, which is more important than knowing what such a society plausibly looks like, as the goal is to derive insights in what steps need to be taken. In most cases, the final reality of such a newly created ecosystem is not one of full cycling. Some inputs – like fossil fuels – might still be present for extended periods and thus used, and in many cases full cycling cannot be reached because of thermodynamic limitations.

The challenges to modelling

The framework above should allow for understanding the present reality that underlies the chosen geographic "economic system", what a sustainable version of that system would like, and what a plausible road towards that sustainable system would be. The key challenge is to properly catch the boundary conditions of the model, and within these conditions understand what the essential variables and their interrelations are, as to resemble the real world as best as possible without introducing too much complexity. We think that with today's knowledge this can be done, but acknowledge that there are still many uncertainties that will remain despite best efforts. Therefore, our intent is to take an open source approach to the modelling, so that remaining uncertainties can be narrowed down over time through the contribution of many people.

We encourage readers to contribute their thoughts as to what they think about the framework above, and what their thoughts are on the main parts that need to be mapped to understand what a sustainable human ecosystem looks like, within the scales of resources, ecosystems, economy, and energy. We hope that by this modelling effort we can contribute to new insights on the road to a more sustainable human ecosystem, and for those interested in working on this project to take a look at our job advert and contact us via recruiting at iier dot ch

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