# IIER

# The Ecological Sequestration Trust Modelling Suggestions

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## 1. Background

IIER is committed to supporting the efforts of the Sequestration Trust by providing input into the required models for economic systems which employ a "short carbon cycle". Ideally, this concept is represented by a city and its agricultural, forest and supply hinterland operating in a sustainable way by cycling all key inputs so the city plus surrounding area become stable in the long term.

In order to establish a realistic model for such an environment, a stable economy needs to emerge around this cyclical approach, keeping all inhabitants busy, nourished, healthy and satisfied with their duties and share in society. Equally, all trade with the outside world, bringing in needed supplements and accepting surpluses, needs to be sustainable and balanced.

Below, we introduce a number of concepts and modelling suggestions we consider relevant for accurately describing such an economy.

## 2. Scope

The scope of the model is a geographically well-defined area with all locally available "resources" (non-renewable, renewable, already built infrastructure, people).

Within these boundaries, the objective is to establish an inclusive model that contains all relevant parameters, entities and transfers which are required for a functioning of the societies within the above area, and for interactions required with the outside world.

To avoid creating a "nice but incomplete" world it seems important to not limit the modelling effort to the objectives of carbon sequestration, nutrient cycling and other aspects related to natural sources and sinks. Instead we should try to model the entire "economic system" with all relevant exchanges and processes to the finest degree possible. Given the limited geographical scope this seems feasible.

## 3. Basic assumptions

In order to correctly represent the long-term viability of cycled systems, 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 modelling components 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).

## 4. Long-term stability and balance

The objective is to establish an environment that is stable and resilient in the long run in many ways – not only from a perspective of resource availability, but equally in the sense that no agent or group of agents or location ends up accumulating resources in a way that is unsustainable for others. Wherever that is the case, mandated redistributions need to take effect to restore balance (taxation).

## 5. Equally, exchange with entities outside the boundaries needs to be balanced to avoid long-term instabilities in any one direction.Key model components

Below, we will introduce the key components of the model as we see them at this point. Please note that this is a first draft which needs further discussions and revisions.
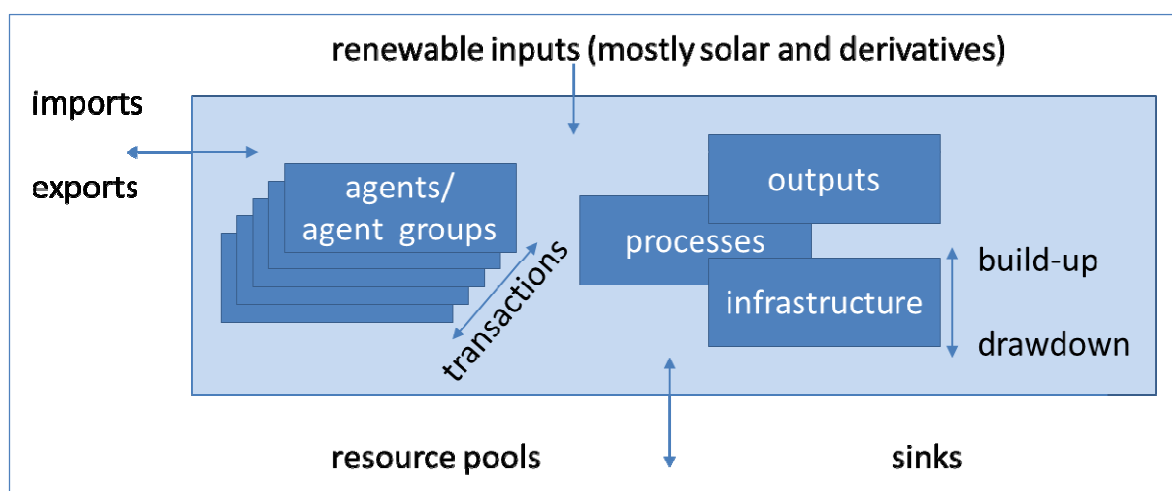
**Figure 1: broad overview of model components**

From our perspective, 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.

## 5.1 Outputs

The key deliverable of the model society is a set of predefined outputs (which can vary in different scenarios and over time). These outputs range from services to goods of final consumption to inputs into processes, to recycling, and to contributions to the rebuilding of resource pools and damaged ecological systems.

All outputs have in common that they require a number of contributions:

- Processes, including process energy and capabilities and/or available time of agents (individuals/groups), who in turn require other outputs to lead their lives
- Other outputs that get introduced into the process (i.e. outputs at an earlier stage)
- Infrastructure (i.e. an aggregation of previous inputs) required for processing

Equally, the process and after-use related "waste" needs to be measured and fed into other processes that capture those wastes and bring them back into the system, or losses into the environment need to be accepted and quantified.

## 5.2 Renewable Inputs

Renewable inputs include all inputs into the "economy" that are provided repeatedly on an on-going basis and where their use does not negatively affect the source or only in such a minimal way that it can be neglected.

The key renewable inputs into each ecosystem are of solar origin, including sun, wind, water cycles and biological cycles that are not controlled by humans.

Examples for other renewable sources might be geothermal energy and some fast-regenerating mineral deposits.

## 5.3 (Non-renewable) resource pools and final sinks

All resource pools that are finite or finite in a meaningfully available quality fall into the non-renewable category – like fossil energy deposits, mineral ores, topsoil on actively farmed land, fossil water reservoirs and biomass that is withdrawn for human use, which remove nutrients over time.

Sinks, irrespective of type, are final destinations of waste (materials, heat) where they become largely irretrievable for any human effort, or only at great expense.

It is important to accurately determine the initial status of damages to sinks which require fixing, for example excessive carbon dioxide concentrations or pollution of water bodies.

## 5.4 Processes

Processes are all human-controlled activities that convert resources and other pre-processed inputs into outputs, typically including energy conversions, the time use of certain agents and the application and drawdown of technology (infrastructure).

Each process that leads to an intermediate and/or final output needs to be defined, in certain cases even with multiple process pathways where they exist. Key properties of processes are:

- Inputs: renewable and non-renewable inputs, and outputs from previous steps
- Agent or agent group actions, where time and knowledge is applied to a process
- Use of infrastructure (which again is based on inputs)
- Outputs

- Waste (recyclable and non-recyclable ending up in sinks)
- Externalities beyond waste

Transportation services are part of processing, as are activities to ensure the stability of the ecosystem, including the rebuild of damaged environments.

## 5.5 Infrastructure

This describes all the "technology" required to produce an output (goods or services) and consists of the physical aspects of it, like machinery, buildings, roads, other infrastructure).

It should be possible to include soil on arable land as one type of "infrastructure" with properties requiring restoration after use (withdrawal from nutrients, runoff, etc.).

For each infrastructure element the following aspects should be determined:
- Required inputs into the creation of the infrastructure (from outputs and agent services)
- Inputs into the operation of the infrastructure
- Inputs into the renewal of the infrastructure (life expectancy, maintenance, repair)
- Inputs and outputs at the point of discontinuation of use (decommissioning)
- Waste and other externalities from the creation, operation and decommissioning of infrastructure

The model should be built in a way that interdependencies and relationships between processes become apparent (nested process chains). This further allows to model resiliency.

Infrastructure that is no longer used can be run in "drawdown" mode, or – where new technologies are introduced, a build-up is required. For infrastructure which is to be used indefinitely, drawdown on existing infrastructure should always be balanced with recreation. It is important to – for already existing environments – accurately determine the initial status of the infrastructure.

## 5.6 Agents/Agent Groups

Human inputs form the vital part into the entire economy, both from a knowledge and actual time (labour) perspective. It might be sufficient to introduce them as agent groups associated to processes (and output consumption), The key parameters are:

• Capabilities and needs, health status and perceived happiness

• Association with processes as producers (operators of processes) or consumers (e.g. education)

• Participation rate (i.e. number of humans being only consumers)

• Birth/death/migration model (to achieve a balanced economy)

• Input required to educate and train for various capabilities

• Initial status and vectors required to achieve a balance

## 5.7 External Exchange

Imports fill the gaps in output delivery which is not covered by local inputs or agent action. It may include resource inputs, but equally technology that is delivered, and may well extend into human services through external knowledge or migration.

Exports, in turn, offer the ecosystem the ability to supply other ecosystems with outputs or services which are available beyond local need but are in greater demand elsewhere.

Overall, these exchanges need to be balance in two ways, first in that the assumed value (non-monetary) is equivalent in both directions and that no long-term trade deficit or surplus emerges. Equally, it must be ensured that no outputs requiring non-renewable inputs permanently leave the area in a model where 100% cycling is suggested.

## 6. Monetary system

As described, the entire ecosystem should be modelled under the assumption that money exists as a facilitator of transactions, but "prices" of exchanges should be formed according to underlying physical entities. This removes the risk for distortions from arbitrary value assignments and also removes the need for inflation management as part of the model.

However, monetary units should be established as an overlay on the entire system of transactions, allowing the introduction of monetary markers at any point in time. Equally, credit should be optionally possible in the system, shifting accumulated resources/inputs/process capabilities from participants who have accumulated beyond their needs to those who might benefit more.

## 7.   Modelling challenges – possible solutions

One key challenge to a modelling effort with such a broad scope is the lack of reliable and consistent data sources, particularly when it comes to process information for vital societal processes. Further problems exist when setting up local models is that granular data is unavailable for many aspects.

We suggest to apply a flexible model of input management that we have conceptually developed for a global resource flow model. It has a number of properties:

- Flexible interfaces to input sources (data warehousing approach), allowing to easily plug in all possible data sources with the ability to link, import and manually enter data depending on source with an integrated review protocol (sign-off)
- An data model which allows to keep inputs from various sources simultaneously and model multiple outcomes based on multiple sources
- A source qualification system which provides simple online review capabilities and the ranking and weighting of data sources
- The ability to fill data gaps with "closest approximation" from other data sources or locations until better data becomes available (for example – if a city doesn't have sufficient data on the energetic quality of their buildings, it is feasible to make a fairly reasonable assumption on the average standard based on weather data, sector energy consumption and local standards and expectations)

## 8.   Other parameters

In order to be realistic in the entire model, a number of key parameters have to be introduced which define the reality of the "economy" under analysis.

## 8.1 Level of cycling

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.

The model needs to be able to work with different degrees of cycling from 0-100% for the entire system or sub-systems as one key boundary. 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.

## 8.2 Realistic optimum/Resiliency

Models should be built in a way to allow for "imperfection", 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. This should be intro-duced in multiple ways

- Variations in inputs (predefined and stochastic variation)
- Realistic optimum for processes (related to human error, inadequate equipment, etc.)
- Disasters – rendering parts of process chains, agents and inputs unavailable for certain periods of time

One aspect of the model should be the ability to predict a society's resiliency based on these parameters and the method of nesting processes that deliver vital outputs. By running Monte Carlo simulations with "disturbances" in multiple subsystems it should become clear as to how tolerant the society reacts to those problems.

## 8.3 Tolerated inequality

Over time, it is likely that wealth and benefits will accumulate unsustainably in a model as they do in real societies. Each agent, however, needs to be able to attain an "acceptable" standard of living for him/herself and his/her dependents, which does not deviate from the average by a certain allowed deviation factor (i.e. income spread).

Thus it becomes relevant to define the ratio of tolerated equality in a number of ways:

- Minimum level of outputs available to agents at the "lowest rank", i.e. definition of the outputs (food, shelter, societal services, etc.) that form this minimum
- Maximum tolerated inequality between agents of the lowest and highest rank in a society over time (similar to GINI coefficient, but based on available outputs and not money)

The model needs to be able to evaluate all situations where such accumulations of wealth take place and compensate this with "taxation", i.e. a shift of resources according to a clearly defined and stable pattern or redistribution.