Documentation for the SPACES Ecosystem benefit and wellbeing model.

Tim Daw, Leopard Beach Hotel, Diani, Kenya. 26th April 2015

This document summarises the NetLogo model that was created by Caroline Wanjiru, Maxwell Azali Mohammed Ahmed and Tim Daw during the SPACES toy modelling meeting.

# Developing the model – next steps (keep this part updated)

1. Write up documentation – done
2. Write up diary of progress so far
   1. Problems
   2. Next steps
      1. Objectives for model behaviour
      2. Plan of how model will do it
      3. Coding
3. Tim to get feedback from SRC colleagues
4. Meeting at 15.00 Kenya time on Monday 4th May
5. Set up Git Hub – Maxwell to investigate and show Caroline and Mohammed how to use
6. Mohammed to take lead on progressing the model with coding help from maxwell and input form Tim and Caroline.

# Model documentation

## Context

This model id designed to be used with stakeholders to think about system dynamics in the context of Coastal social-ecological systems in Kenya and Northern Mozambique. It is designed to be used in a stakeholder workshop including representatives from government, NGOs, tourism, developers, conservationists with a range of educational levels.

## Problem

The model is designed to provide insights into the problem that interventions in coastal communities to support poverty alleviation and sustainable resource use often don’t achieve expected outcomes. This approach assumes that these unexpected outcomes result from aspects of social-ecological complexity that are not fully understood or considered when the interventions are designed.

## Model question

This model aims to explore how interactions (between stakeholders, the resource, rules and outside agencies) result in complex emergent outcomes.

## Model domain

Although designed for stakeholder engagement in coastal E. Africa, the model describes a theoretical natural resource system. It is not calibrated with real data.

## Model outputs

* Wellbeing of each stakeholder
* Ecosystem condition
* [Benefits flow to each person, indicator for degree of conflict]

## Design and formulation

See detailed ODD-D table below.

Figure 1. Original sketched out model plan



# Other ideas and future development

* Jealousy function – cooperation (not destructively harvesting) is based on a perception of fairness
* Social pressure, mediated by power –people can use some resources to sanction others who are less powerful (lower material wellbeing) than themselves
* Interactions with an agency/manager
* Differential access for different types of agents (e.g. men/women)
* Access determined by assets, which can be built up by material WB.

### Brainstorm on Dynamics that the toy model could demonstrate

* Tragedy of the commons
* Effects of community organisation/empowerment, cooperation within communities and cooperation or antagonism with government/managers
* Different groups have different access and dependence which affects how ES constributes to WB
  + Multidimensional WB i.e. multiple basic needs supported by different ES
* Trade-offs – different benefits and costs for different people.
* Unequal shares of benefits to different people (e.g. benefits from tourism, from closed areas)
* Time delay for benefits to emerge vs discount rate of agents
* Interventions have surprising outcomes, a straigtforward solution based on partial view and linear thinking can have surprising effects
* Yeild per individual versus total (i.e. in fisheries, heavy exploitation leads to high total yeild but low yeild and profitability for individuals).

**Table A.1.** Template for ODD+D including guiding questions, examples and empty column for own model description. [square brakets denote features which have not been implemented yet.]

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Outline (🡪 template) | | | Guiding questions | Own ODD+D Model description |
| **Overview** | | I.i Purpose | I.i.a What is the purpose of the study? | To explore how interactions between agents and an ecosystem, the benefits they get and impacts they receive from an ecosystem result in emergent patterns in wellbeing and ecosystem health. |
| **I.ii.b For whom is the model designed?** | representatives from government, NGOs, tourism, developers, conservationists with a range of educational levels |
| I.ii Entities, state variables, and scales | I.ii.a What kinds of entities are in the model? (Units of the environment, ecological or social, stocks or turtles) | A number of stakeholders modelled as agents.  One ecosystem stock modelled using system dynamics.  Benefits flow from the stock to agents and improve their wellbeing  Impacts on the stock result from agents harvesting benefits. |
| I.ii.b By what attributes (i.e. state variables and parameters) are these entities characterized? | Ecosystem: Recruitment rate, maximum stock  Agents: wellbeing, [access, multiple dimensions of wellbeing (one material and subjective)] |
| **I.ii.c What are the exogenous factors / drivers of the model?** | ‘Cost of living’ denoting how much benefit needed to maintain wellbeing. |
| **I.ii.d How is space included in the model?** | Not at all |
| I.ii.e What are the temporal and spatial resolutions and extents of the model? | The model is theoretical, One time step represents ~1 week.  There is no space in the model |
| I.iii Process overview and scheduling | I.iii.a What entity does what, and in what order? | 1. Stakeholders decide whether to harvest from the ecosystem in a ‘good’ or ‘bad’ way based on their current level of wellbeing. If below a threshold ‘desperation level’ they choose ‘bad’  2. Exploitation happens and improves wellbeing and sets the level of impact for this time step.  3. The ecosystem stock grows and is reduced by the impact  4. Agents’ wellbeing is decreased by a ‘cost of living’  5. Repeat from 1. |
| **Design Concepts** | | **II.i Theoretical and Empirical Background** | II.i.a Which general concepts, theories or hypotheses are underlying the model’s design at the system level or at the level(s) of the submodel**(s)** | Ecosystem growth is logistic, limited by a carrying capacity and recruitment;  Exploitation of the ecosystem which generates higher benefits also is less efficient, causing more ecosystem impact per unit of benefit obtained (e.g. clear cutting or explosive fishing)  Yields from exploitation are a constant proportion of the available stock (e.g. constant ‘catchability’ in fisheries models).  We assumed that there is only anthropogenic disturbance |
|  | |  | II.i.b. Assumptions on which agents’ decision models are based. | People are driven to destructive behaviors by poverty (Malthusian overfishing). People who are wealthier can afford to exploit in a sustainable way.  [People are less willing to sacrifice the gains from destructive harvest if they perceive that other people are gaining more benefits from the resource] |
|  | |  | II.ic. Why are certain decision models chosen | We wanted to have a feedback between benefits gained and the actions of the stakeholders which would then affect the resource.  One common discourse is that unsustainable exploitation is driven by poverty/desperation or lack of alternatives. This model explores the implications if that assumption is true.  [Evidence that dissatisfaction with e.g. marine parks derive from perceptions that others are reaping the benefit.] |
|  | | **II.ii Individual decision making** | There are more questions from the ODD framework to fill in here… |  |
|  | | **II.iii Learning** |  | No learning in this model |
|  | | **II.iv Individual sensing** |  | Agents only sense their own wellbeing  [agents sense the ratio of benefits to themselves and others] |
|  | | **II.v Individual prediction** |  | No prediction |
|  | | **II.vi Interaction** |  | No interactions  [ability of one agent to reduce the wellbeing of another] |
|  | | **II.vii Collectives** |  | No collectives |
|  | | **II.vii Heterogeneity** |  | Currently all agents are the same apart from their randomly assigned well-being  [agents have different characteristics leading to differential access and harvesting options] |
|  | | **II.ix Stochasticity** |  | Only the initial wellbeing values are randomly assigned |
|  | | **II.x Observation** | a. what data are collected for testing, understanding and analyzing it | A plot shows the development of the ecological stock over time.  [distribution of agents’ wellbeing, ratios of agents choosing different harvest strategies] |
|  | |  | b. What key results, outputs or characteristics of the model are emerging from the individuals (Emergence) | If the growth of the stock and efficiency of harvest is not enough to maintain the agents’ wellbeing, agents increasingly use ‘bad’ exploitation and the stock shows an accelerated decline.  The model shows a sensitivity to initial conditions, if most/all agents have a wellbeing above the desperation level at the start, the system can reach a stable, high stock-high wellbeing equilibrium. If too many agents start with wellbeing below desperation level, the increased drain on the ecosystem leads to reduced wellbeing and an equilibrium of 0 stock. |
| **Details** | | **III.i Implementation Details** | **III.i.a How has the model been implemented?** | In NetLogo |
| **III.i.b Is the model accessible and if so where?** | On SPACES Box in the folder: SPACES common team folders\Stakeholder workshops\Toy models\modelling training\ForParticipantsCourse\Resource use wellbeing model |
| III.ii Initialization | III.ii.a What is the initial state of the model world, i.e., at time t=0 of a simulation run? | Ecosystem stock = 100  Stakeholder wellbeing is randomly assigned a value from 0 to 10. |
| III.ii.b Is initialization always the same, or is it allowed to vary among simulations? | Random wellbeing.  A range of sliders allow different parameters to be manipulated. |
| III.ii.c Are the initial values chosen arbitrarily or based on data? | Arbitrary to balance one another and generate a system which does not immediately crash or spiral up into very high wellbeing. |
|  | III.iii Input Data | III.iii.a Does the model use input from external sources such as data files or other models to represent processes that change over time? | The stock model was taken from the Mangrove stand density model generated in the same workshop |
| III.iv Submodels | III.iv.a What, in detail, are the submodels that represent the processes listed in ‘Process overview and scheduling’? |  |
| III.iv.b What are the model parameters, their dimensions and reference values? | See table below |
| III.iv.c How were submodels designed or chosen, and how were they parameterized and then tested? |  |

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| Parameter | Range | Unit | Obs. |
| Rate of recruitment (r) | 0 – 0.5 | Ratio | Growth rate for logistic growth |
| k | 100 | Stems/ha | Carrying capacity of the forest |
| harvest-good | 0 – 0.20 (suggested 0.05) | Ratio | Benefits received from harvesting with a good harvest style, as a proportion of the current stock |
| Impact-ratio-good | 0 – 2.0 (suggested 1) | Ratio | How much impact is created for each unit of benefit gained when using good harvest style |
| harvest-bad | 0 – 2.0 (suggested 0.1) | Ratio | Benefits received from harvesting with a bad harvest style, as a proportion of the current stock |
| Impact-ratio-bad | 0 – 3.0 (suggested 2.0) | Ratio | How much impact is created for each unit of benefit gained when using good harvest style. I.e. how wasteful and destructive is this style |
| Benefit-ratio | 0.2 | Ratio | By how many points does wellbeing improve for each unit of benefit gained |
| Cost-of-living | 0-2 | Wellbeing points | How much does each agent’s wellbeing decrease by on each time step (and thus how much they have to harvest to not have their wellbeing reduce) |
| Desperation-level | 0-10 (suggest 3) | Wellbeing points | The level above which agents choose ‘good’ harvest level |
| Initial stock | 0-100 | - | Starting value for ecological stock |
| Num-people | 0-20 | Stakeholders | Number of agents created at the start of the simulation |
| Cos |  |  |  |