Participatory modelling for sustainable river catchment management

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Contents

- Project background
- Aims
- Methodology
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What is fluvial geomorphology?

Fluvial geomorphology
(Flow and sediment dynamics, channel form and habitats)

Engineering design
(Channel dimensions and hydraulics)

Riverine ecology
(In-channel and floodplain habitats)
Associated impacts

Flooding

Ecology
The WFD specifically refers to the importance of fluvial geomorphology in achieving a “good ecological status” under ‘hydromorphology’.

The WFD recognises the importance of engaging with stakeholders in the process of managing water resources.
“The paradigm lock occurs because scientists do not grasp what managers require, and managers and stakeholders do not appreciate the scientific alternatives available” (Gregory et al., 2008)
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<tr>
<td>GILBERT (Chase, 1992)</td>
<td>ARCU (Smithers and Caldecott, 1993)</td>
<td>GOLEM (Tucker and Slingerland, 1994)</td>
<td>DELIM (Howard, 1994)</td>
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<td>MIKE-SHE (Renard et al., 1997)</td>
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<td>ZSCAPE (Densmore et al. 1998)</td>
<td>CHILD (Tucker and Bras, 2000)</td>
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A selection of the developed models.
“Physical models can be very good at reproducing sediment behaviour though they suffer from a number of disadvantages, mostly relating to scaling, which normally restrict their application to relatively short reaches of river” (Coulthard et al. 2012)
Animation - flow

Example: CEASAR-Lisflood
How do you get stakeholders using these models?

SIBERIA (Willgoose et al. 1991)

GILBERT (Chase, 1992) DRAINAL (Beaumont et al. 1992) PERFECT (Littleboy et al., 1991)

GOLEM (Tucker and Slingerland, 1994) ARCU (Smithers and Caldecott, 1993)

HSPF (Bicknell et al. 1996) GUEST (Misra and Rose, 1996) DELIM (Howard, 1994)

CASCADE (Braun and Sambridge, 1997) RAT (Graf, 1996) MIKE-SHE (Renard et al., 1997)

CAESAR (Coulthard et al. 1997) CHILD (Tucker and Bras, 2000)

ZSCAPE (Densmore et al. 1998) EROS (Crave and Davy, 2001) LAPSUS (Schoorl et al. 2002)

APERO/CIDRE (Carretier and Lucazeau, 2005) REAS (Wallerstein et al. 2006)

SIAM (Gibson and Little, 2006) ST:REAM (Parker et al. 2009)

CAESAR-Lisflood (Coulthard et al. 2011) LAPSUS-D (Keesstra et al. 2013)
Participatory modelling describes a diverse range of modelling activities whose common element is that they involve stakeholders in one or more stages of the modelling process, from data collection through to model construction and use.” (Hare, 2011)
Hare’s participatory modelling framework

Defines seven criteria:

1. Participatory modelling purpose
2. Model type
3. Stakeholders involved
4. Timing of events
5. Participatory methods used
6. Participation mode
7. Skills needed to organize and implement the participatory modelling
| 1. | To develop and evaluate a catchment-scale cellular model of sediment dynamics that can be used by stakeholders to engage in decision-making processes of sustainable river catchment management |
| 2. | To establish, implement and critically analyse a participatory modelling approach in the process of developing a catchment-scale cellular model of sediment dynamics |
1. Participatory modelling purpose

- Quality
- Acceptance
- Integration
2. Model type

```python
# Initialise the incoming parameters for each cell in the catchment
def __init__(self, precipitation_d, slope_d, land_d, soil_d):
    self.precipitation_d = precipitation_d
    self.slope_d = slope_d
    self.land_d = land_d
    self.soil_d = soil_d

# Method to calculate SCS soil type from HOST data
def SCSsoil(self):
    # Lookup dictionarys for incoming landuse and soil type
    for soil, value in self.HOST_SCS_soil.items():
        if soil == self.soil_d:
            return value

# Method for calculating the CN number from LCM2007 data
def SCSCN(self, SCS_soil):
    # Iterate through the SCS table and match the land cover and soil type to the correct CN
```

Numerical simulation cellular model as the proposed fundamental modelling structure

The stakeholders decide upon the role of the model

2. Model type

# Mountain habitat
(13, "A"): 35, (13, "B"): 56, (13, "C"): 70, (13, "D"): 77) # Montane habitats used -
3. Stakeholders involved

* The organising team (me and supervisory team)
* Multiple case study approach
  * The stakeholders primarily consist of policy-makers and management groups involved at the catchment scale
<table>
<thead>
<tr>
<th>Stakeholder Type</th>
<th>Public bodies</th>
<th>Private Bodies</th>
<th>Conservation Organisations (Wildlife Trusts and Rivers Trusts)</th>
<th>Fisheries and Agriculture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spey</td>
<td>Scottish Environmental Protection Agency, National Park Authority, Scottish National Heritage</td>
<td>Spey Catchment Initiative</td>
<td></td>
<td>Fisheries board</td>
</tr>
<tr>
<td>Taw</td>
<td>Environment Agency</td>
<td></td>
<td>Devon Wildlife Trust, West Country Rivers Trust, Farming and Wildlife Advisory Group, Silvanus Trust, North Devon Biosphere</td>
<td>National Farmers Union</td>
</tr>
<tr>
<td>Camel</td>
<td>Environment Agency, Natural England</td>
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</table>
4. Timing of events and 5. Participatory methods
Sediment Dynamics Cellular Model

Stakeholder and Case Study Selection

Participatory Methods
- Requirements Analysis
- Co-designing
- Model Use
- Model Evaluation

Model Development
- Data Collection
- Conceptual Model
- Draft Model
- Finished Model

Project background | Aims | Methodology | Results
6. Participation mode and 7. Skills needed

* Participation mode:
  * Stakeholders are involved as a group with homogeneous interests

* Skills needed:
  * Modelling skills
  * Facilitation skills
Results
Two activities:
- Introduction to cellular modelling
- Activity-oriented questions
- Thematic analysis using NVivo
- Cross-case analysis and triangulation of data sources was used to create thematic maps
<table>
<thead>
<tr>
<th>Questions</th>
<th>Bristol Avon</th>
<th>Camel</th>
<th>Taw</th>
<th>Spey</th>
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</thead>
</table>
| What are the current sediment issues effecting your river catchment? | - Sediment issues from upstream resulting in costly downstream dredging  
- Diffuse and point source sediment  
- Agricultural run off  
- Silting issues  
- Impacts on fisheries  
- Land cover change  
- Phosphate associated with the sediment  
- Impacts on river ecology  
- Impacts on flooding  
- Influence from urban (impoundments and flood defence schemes) | - In the amble tributary (Fish, diatoms, WFD targets):  
  - Land use (exposed ground)  
  - Bank poaching  
  - Tracks/roads/gates (routes for transport)  
  - Camel (SSSI / SAC targets):  
    - Maize  
    - Lanivet Stream  
    - Structures (role in sediment movement)  
  - NIRS – Soil / sediment reporting  
  - Exceedance of NE targets for suspended solids and deposited sediment impacts on in-stream  
  - Risky crops e.g. maize / potatoes  
  - Over-stocked out wintering  
  - Road sides due to narrow lanes and gateways at bottom of sloping fields | - Poorly managed forestry operations on steep ground  
- Slurry ‘Accidents’, leaks and spills  
- Maize growth / cropping  
- Land use (poor arable land management)  
- Compacted farmland  
- River bank erosion (livestock)  
- Invasive Species (Himalayan Balsam)  
- Road run-off and road verge erosion (hard surfaces)  
- Lack of vegetation in head waters  
- Upland overstocking  
- Lack of trees and buffer strips in high erosion riparian areas  
- Increased phosphate (associated with sediment)  
- Loss of salt marsh habitat through deposition  
- Deterioration of gravels and spawning habitat | - Abstraction of river flow in the upper catchment for hydro-power. It is estimated 25% of river flow is diverted to the River Tay. There are other sources of abstraction throughout the catchment such as the distillery.  
- Impact from river impoundments, series of dams (3/4) in the upper catchment.  
- Large river catchment, with high mountains (Cairngorms) and a wide flat valley floor. A typical Spey tributary would be steep firing lots of sediment down onto the floodplain where it deposits. The Feshie fan is an example of an enormous source of sediment to the Spey.  
- Sediment transport varies due to the geology and rainfall in the catchment. |
“I think that is one of the things if you want your model to have **credibility with stakeholders** is they will say it always **rains loads more here** and it is always **more intense here**, compared to down there, so I think there would need to be some recognition of that.” (Catchment Co-ordinator, Environment Agency, Camel)

“Also our rainfall, because you know we have **practically nothing for months**, but you ask us next month and it **probably won’t stop raining**, so it can be boom and bust.” (Project Officer, Spey Catchment Initiative, Spey)
Inputs

Land cover (LCM 2007)
Soil (HOST)
Rainfall (Daily)
Discharge Gauge
DTM (5-30m)

Stage 1

Overland flow
Infiltration and ground water

Stage 2

*Multiple flow routing

*Only recalculated if DTM changes

Hillslope soil erosion processes

Stage 3

Stage 4

Sediment transport

Recalculate DTM with sediment erosion/deposition

Precipitation falls down onto the catchment in daily ‘timesteps’
Welcome to the website for ENGAGE, my PhD research project which uses a participatory modelling methodology to develop a catchment-scale sediment dynamics model. If you want to find out more about participatory modelling and sediment dynamic models click here.

On this website you will find:

- The latest news
- Background information
- Sections on key concepts and terms
- Forms for model discussion
- Model and related document downloads

**LATEST NEWS**

06/06/2014 - ENGAGE model demonstration part 1
Model: Data processing demonstration
Co-designing workshop

Three activities:
* Conceptual model discussion
* Model influences prioritisation (Bulls-eye – using the pressures from the thematic map)
* Model application (Ranking exercise – using the model applications from the thematic map)
### Co-design results

<table>
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<th>Issue</th>
<th>Group</th>
<th>Supporting material</th>
<th>Suggested incorporation</th>
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<tbody>
<tr>
<td>Overstocking</td>
<td>Camel</td>
<td>CF</td>
<td>“If you think of a field over winter with 2 cattle compared to 30 cattle it is a completely different effect.”</td>
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<td></td>
<td></td>
<td>ST</td>
<td>“I think you might just have to run it under different scenarios e.g. good farmer scenario, bad farmer scenario.”</td>
</tr>
<tr>
<td>Crop Type</td>
<td>Camel</td>
<td>ST</td>
<td>“Are we going to sort of put in what farmers management impact is, so what their management impact is so their management decision is, so deciding to have a kale field alongside the camel in heavy soil is a bad decision so you can basically model bad farming, from the environment point of view and good farming.”</td>
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<td></td>
<td></td>
<td>ST</td>
<td>“DEFRA data basically on the single farm payment data. That does say permanent grassland, pasture land and what crop it is, so I think you can make use of that sort of data and fit it into your 10 metre squares”</td>
</tr>
</tbody>
</table>
Water quality in two Icelandic rivers: the influence of impoundment, agriculture, glaciation and permafrost
Nicholas Jones and Chris Parker In Press, Uncorrected Proof, Available online 20 May 2014. doi:10.2166/nh.2014.268

Thank you questions?

Twitter: @NickIceJones
Project website: www.engage-rivers.org.uk