



# Decision-making Support System for climate change adaptation

a system-dynamics-based platform - GENIES

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**IGCI**

# Content

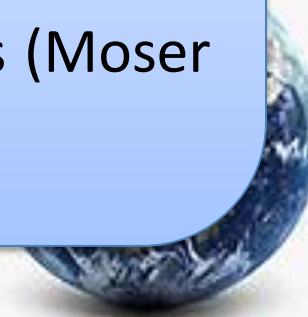
- Background
  - DSS for climate change adaptation
  - Systems thinking and system dynamics
- GENIES



# Climate change adaptation

Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2007).

Adaptation involves changes in social-ecological systems in response to actual and expected impacts of climate change in the context of interacting *non-climatic* changes. Adaptation strategies and actions can range from short-term coping to longer-term, deeper transformations, aim to meet more than climate change goals alone, and may or may not succeed in moderating harm or exploiting beneficial opportunities (Moser and Ekstrom, 2010).



# Decision-making for climate change adaptation

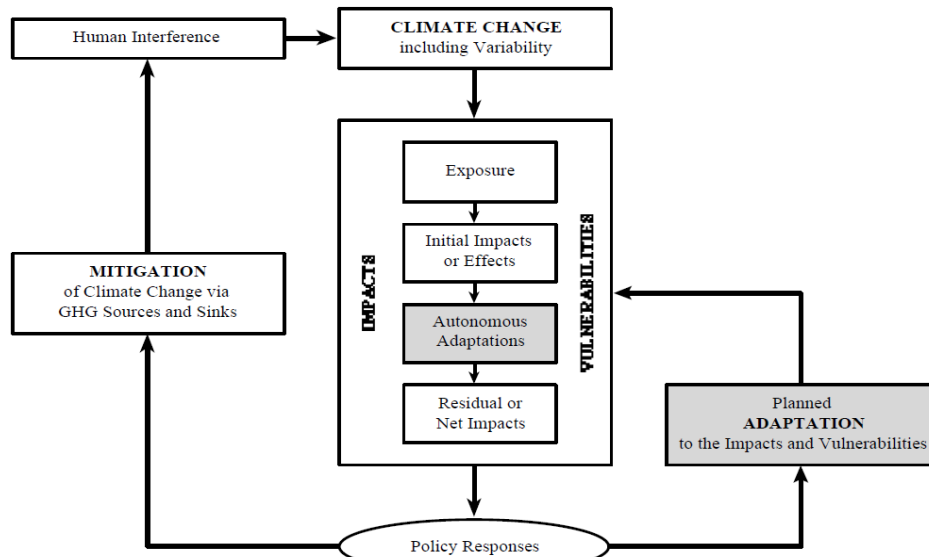
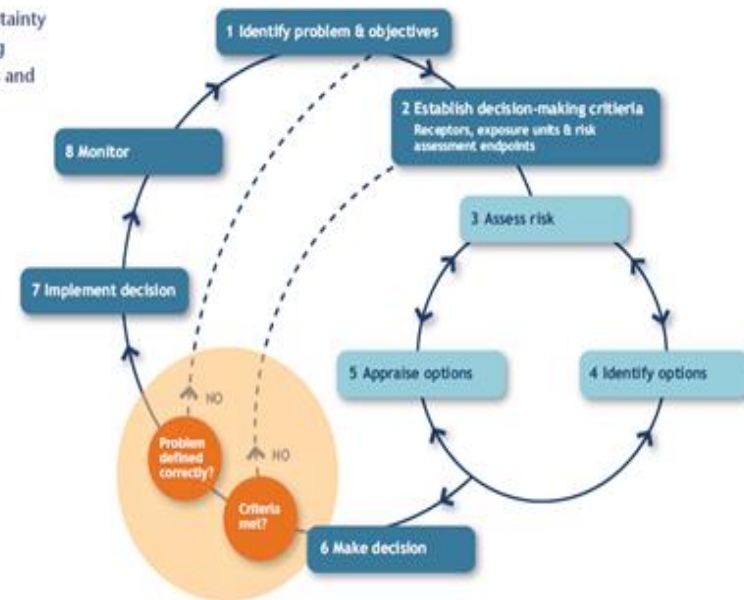


Figure 18-1: Places of adaptation in the climate change issue (Smit *et al.*, 1999).

Decision making is often perceived and practiced as a linear activity following simple steps of

- problem
- research
- Information
- decision
- implementation.

Figure 1: Risk, uncertainty and decision-making framework (Willows and Connell, 2003).



# (Spatial) Decision Support Systems in Reality

Despite the large amounts of time, effort and money invested into developing (S)DSSs, many of them have not been utilised in practice (Wenkel et al., 2013).

*The possible causes are:*

- Inadequately ***tailored*** to users' needs
- Insufficiently related to the ***specific problem*** at hand
- Too ***complicated*** and rarely interactive, and lack of transparency
- Lack of suitable data impedes the use and transfer of existing decision support tools.



# Complex (Wicked) Problems

Climate change adaptation falls squarely in the category of wicked problems.

The notion of 'wicked' problem

*“A class of social problems which are ill-formulated, where the information is confusing, where there are many clients and decision makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing”.*



# Challenges for climate change adaptation

- **Tightly Coupled**

*“Everything influences everything else”*

*“You can’t just do one thing”*

- **Dynamic**

*Change occurs at many spatial and time scales*

- **Policy Resistant**

*Many obvious solutions to problems fail or actually worsen the situation.*

- **Counterintuitive**

*Cause and effect are distant in time and space*

- **Exhibit Tradeoffs**

*Long term behavior is often different from short term behavior*



# New challenge and new solution

Decision making for climate change adaptation is a ***complex*** and ***dynamic*** process.

From both scientific and social view points, these challenges require ***collective learning*** and new modes of decision making and collaboration.

Perhaps, systems thinking/system dynamics is a potential solution.





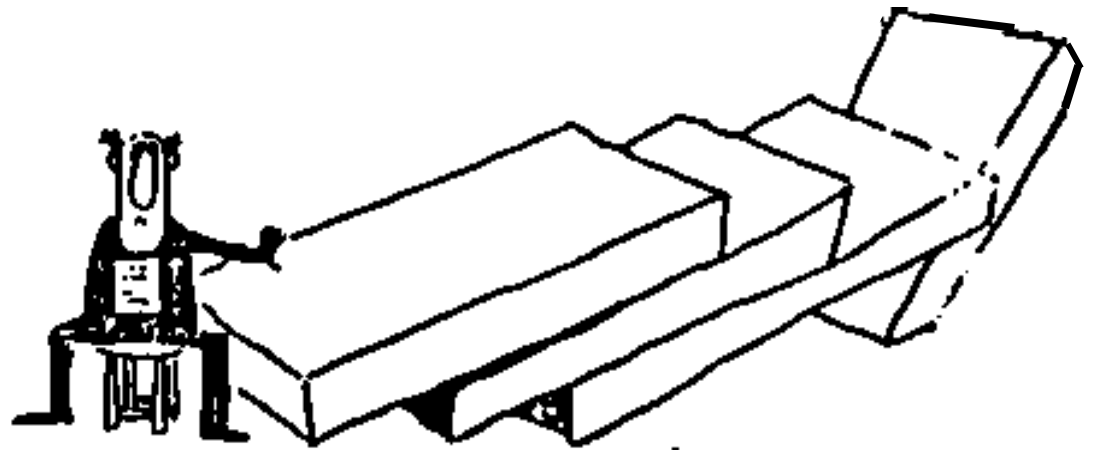
# Systems Thinking & System Dynamics

**Systems Thinking (ST)** is a scientific tool and language for understanding complexity and creating consensus within multi-actor decision environments. Systems thinking can help integrate social, economic and environmental factors which can help decision makers to understand all implications of their decisions and make trade-offs.

**System dynamics (SD)** is a perspective and set of conceptual tools that enable us to understand the structure and dynamics of complex systems. System dynamics is also a rigorous modelling method that enables us to build formal computer simulations of complex systems and use them to design more effective policies and organizations.



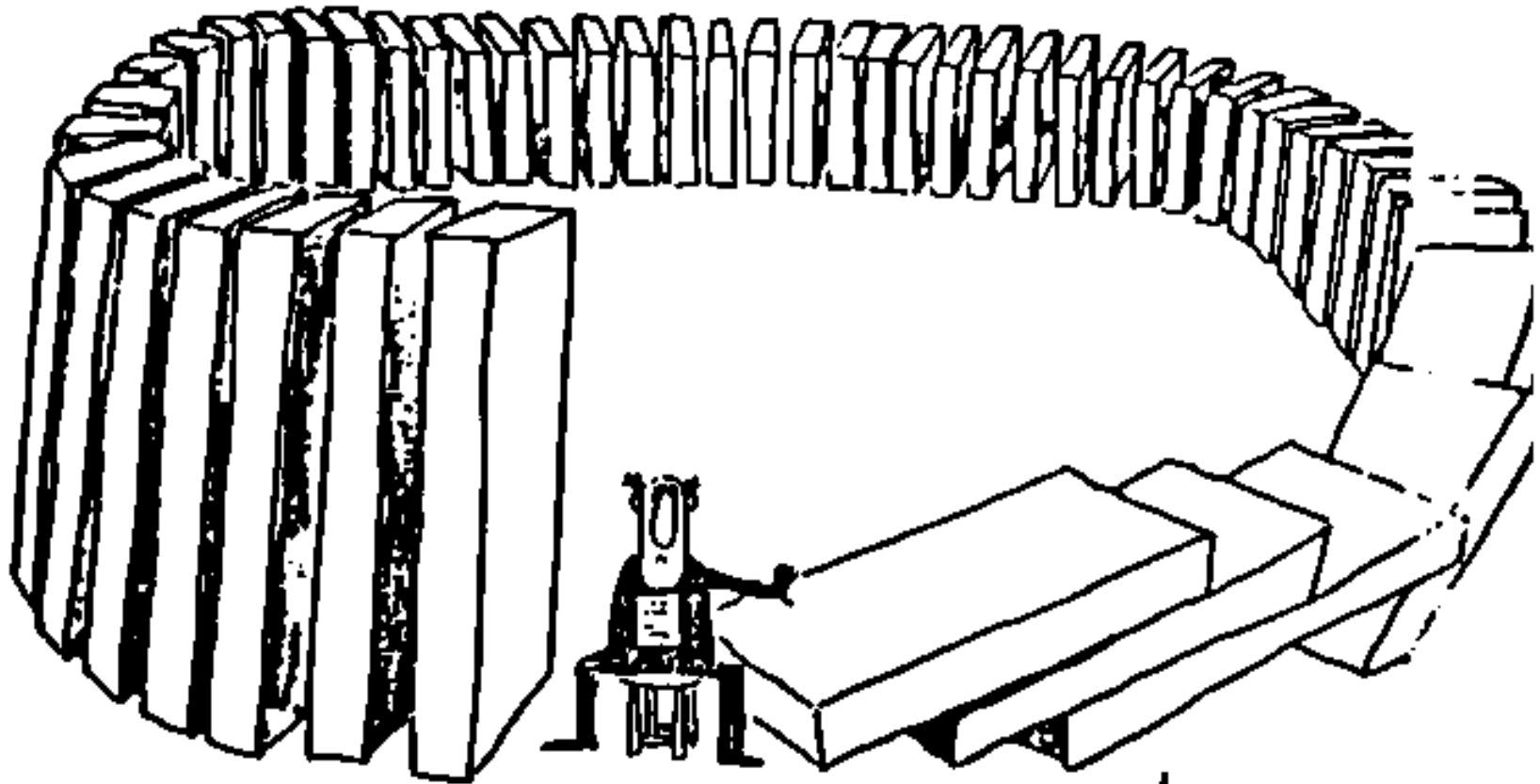
# Understanding Systems



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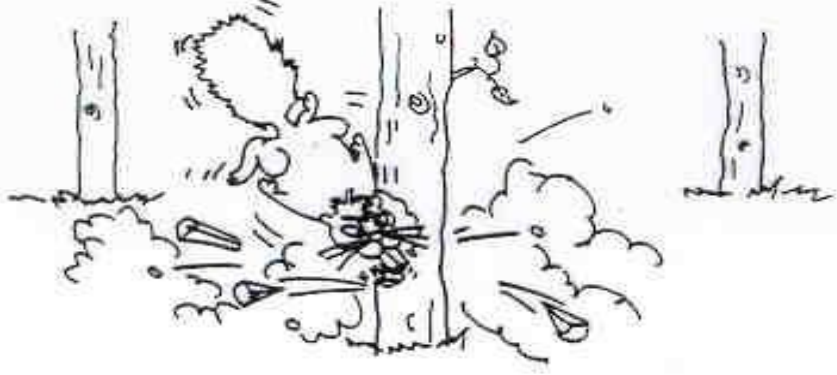
# Understanding Systems



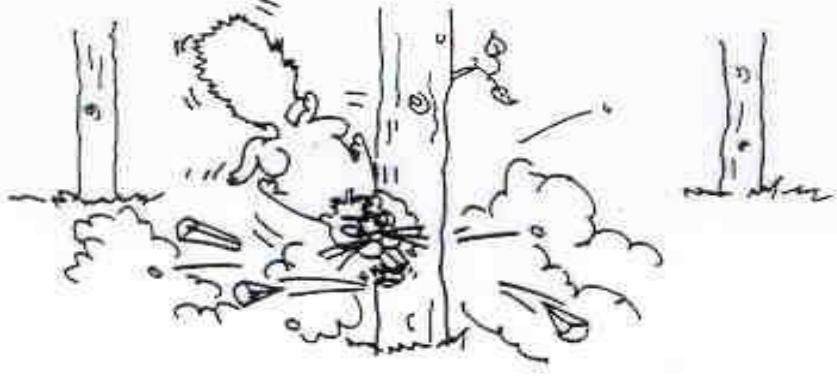
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Levin

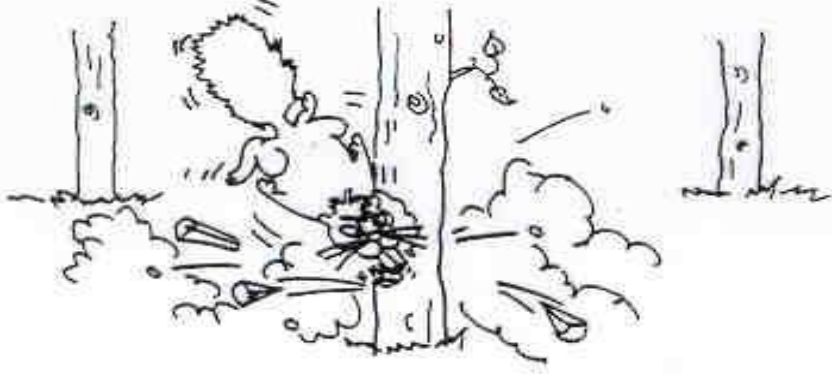
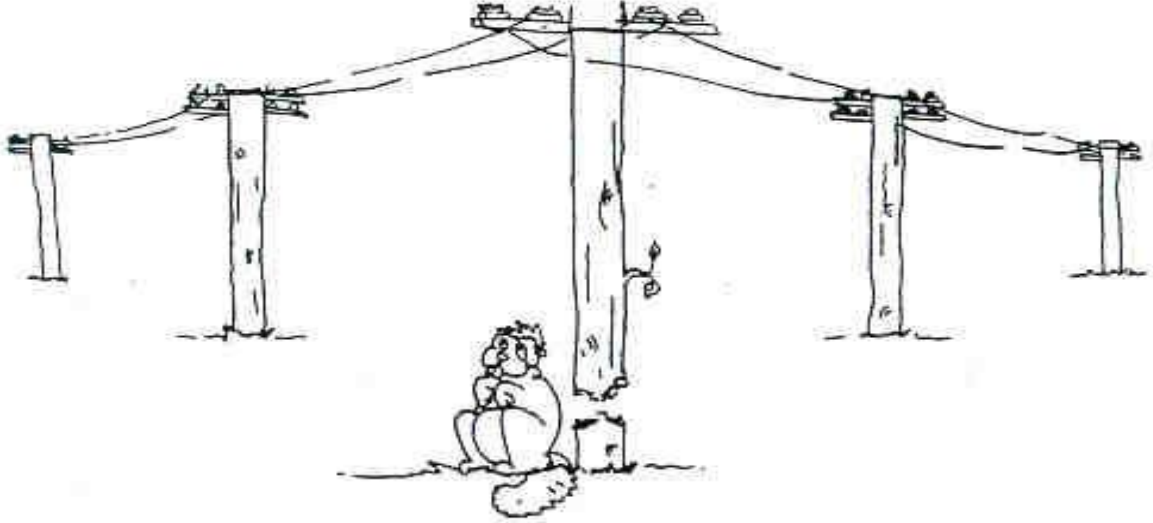
# Understanding Systems



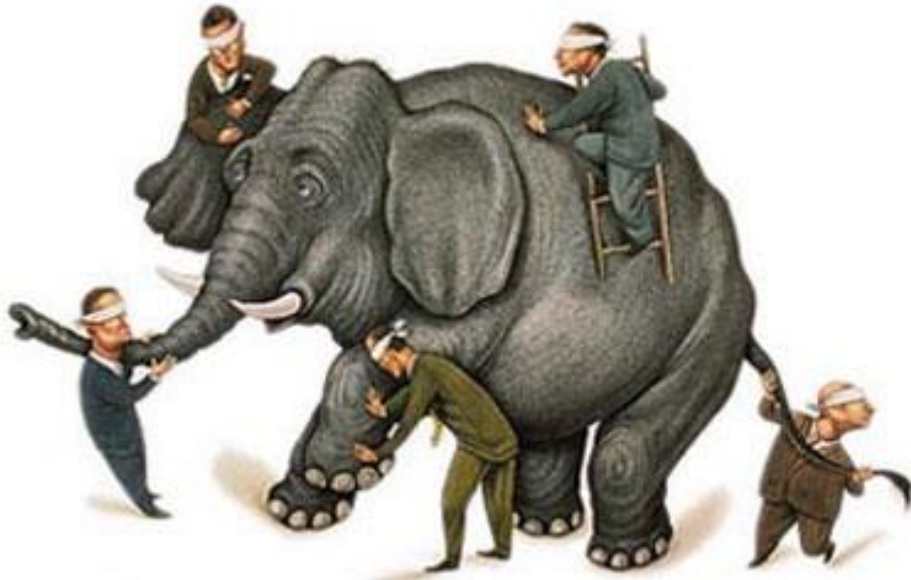
# Understanding Systems



# Understanding Systems



# The blind men & the elephant



## Moral of the Story

People tend to understand only a tiny portion of Reality and then extrapolate all manner of dogmas from that, each claiming only *his* one is the correct version

The behavior of a system cannot be known just by knowing the elements of which the system is made.



# Systems Thinking & System Dynamics

- see the world

***From:***

reductionist, narrow, short-run, static view

***To:***

a holistic, broad, long-term, dynamic view.





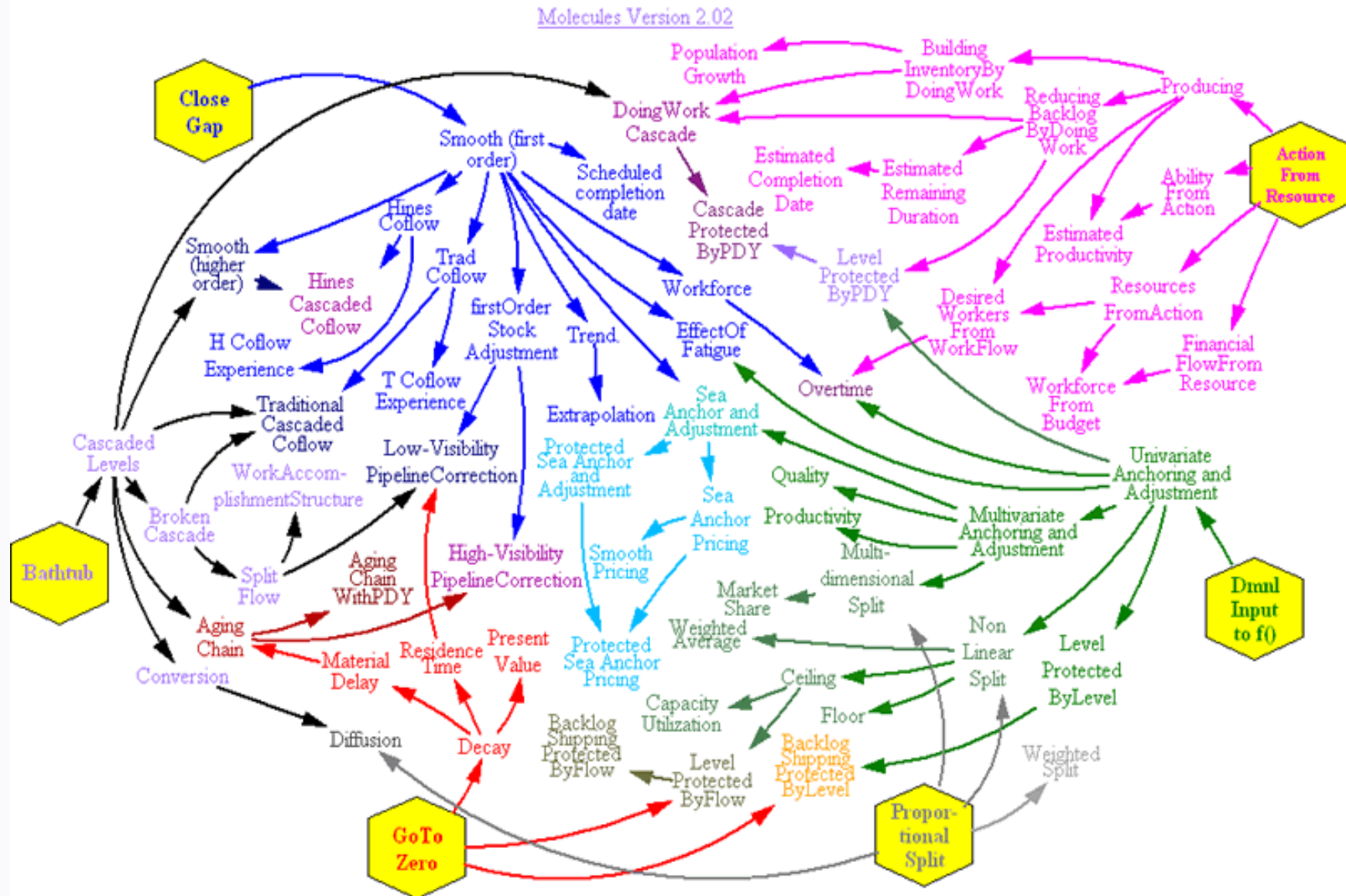
# Steps in the System Dynamics World

1. **Identify a problem,**
2. Develop a **dynamic hypothesis** explaining the cause of the problem,
3. Build a **computer simulation model** of the system at the root of the problem,
4. **Test the model** to be certain that it reproduces the behaviour seen in the real world,
5. Devise and test in the model **alternative policies** that alleviate the problem,
6. **Implement the solution.**

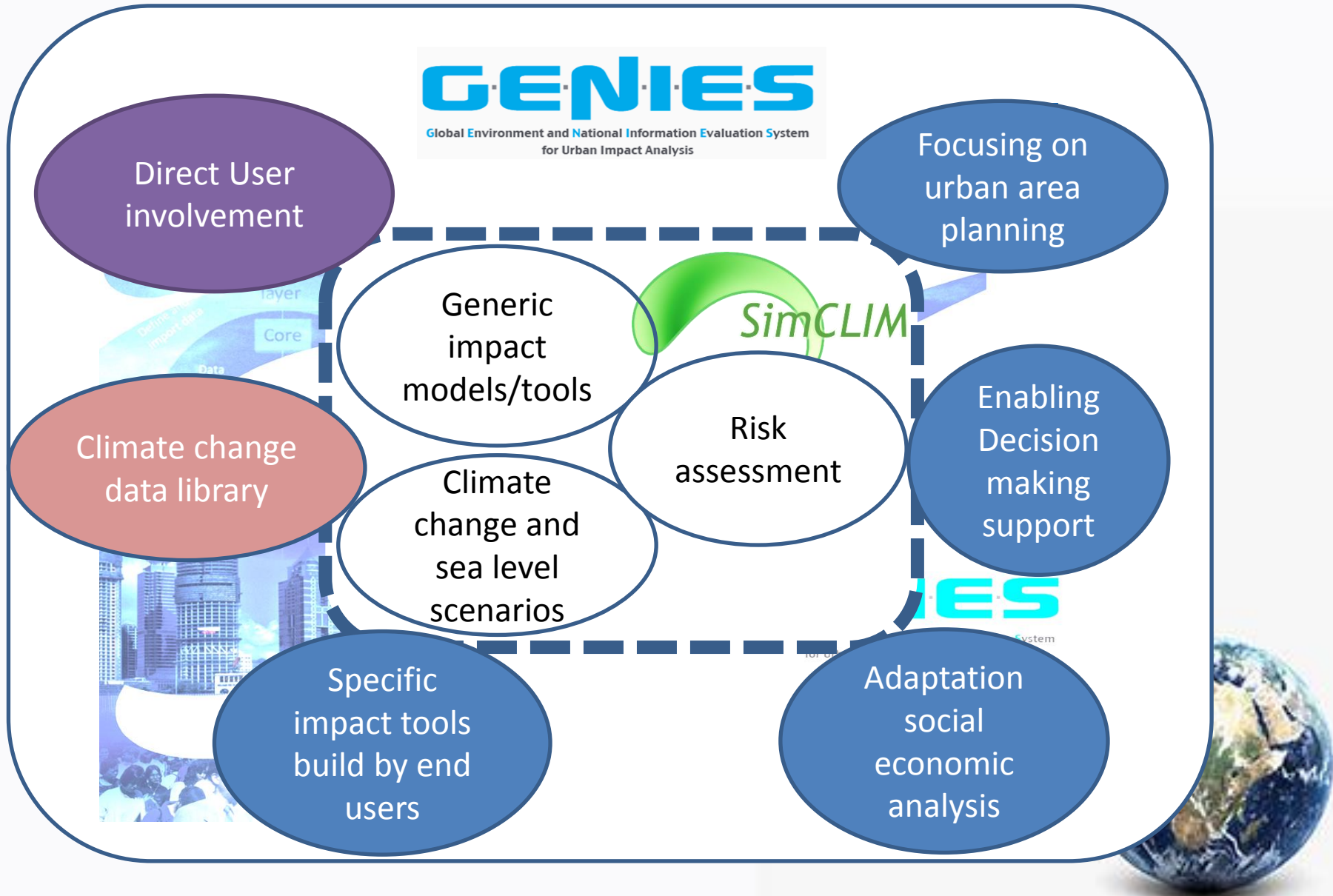
*Often these steps have to be reviewed and refined going back to an earlier step. For instance, the first problem identified may be only a symptom of a still greater problem.*



# Example – A SD Model



# SimCLIM(exists) and GENIES (evolving)



# Criteria

## for decision support systems in climate change science and adaptation

Development	Science	Application
<ul style="list-style-type: none"><li>• Related to specific problems to be solved</li><li>• Oriented to the demands of users/stakeholders</li><li>• Involvement of users from the very beginning</li><li>• Close cooperation between scientists, developers of climate projections, software developers and users</li></ul>	<ul style="list-style-type: none"><li>• Adapted model theory</li><li>• High quality of input data</li><li>• Coupled models from different backgrounds</li><li>• Reliability of model output</li><li>• Assessment of uncertainty</li><li>• Scenario building</li></ul>	<ul style="list-style-type: none"><li>• Flexibility</li><li>• Interactive use</li><li>• Communication of state-of-the-art knowledge</li><li>• Communication of the system's limitations and uncertainties</li><li>• User friendliness of the system</li><li>• Clear visualization of results</li><li>• Reliability and legal aspects</li></ul>



# GENIES - Software Demonstration

The screenshot displays the GENIES software interface. At the top, a menu bar includes 'File', 'Edit', 'View', and 'Tools'. Below it, a toolbar contains icons for file operations and a date range selector set to 'From: 1/01/2100' and 'To: 1/02/2100'. A 'Start to run the model' button is visible in the toolbar.

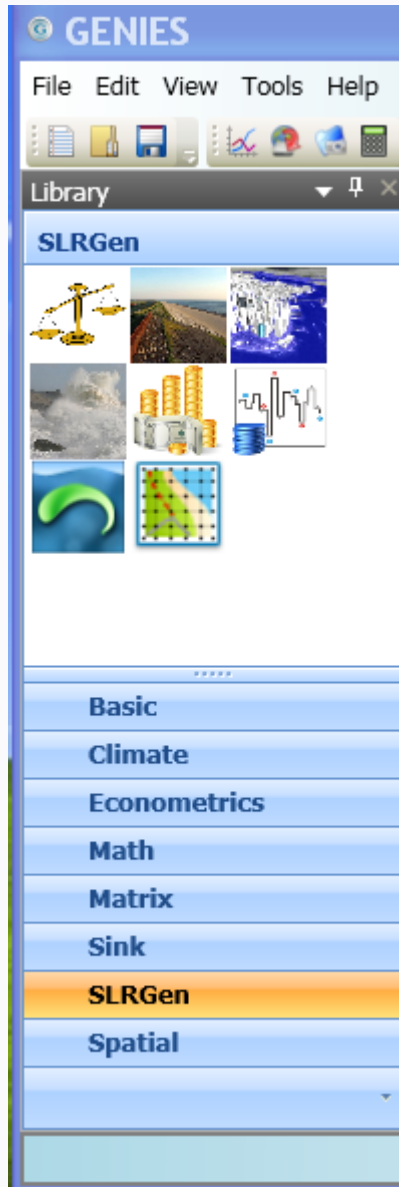
The main workspace is a 'Canvas' titled 'Sealevelriseimpact' with the instruction 'Drag model to here'. It contains a complex flowchart of interconnected model blocks: 'SealevelriseGenerator', 'ExtremeSeaLevel', 'AdaptSelevLevelRise', 'SimpleSplit', 'DEMSource', 'AreaLost', 'Investment Rate', 'Damage Rate', 'SLRInvestment', 'SLRCostBenefit', and 'SLRDam'. A 'CompanyLogo' for 'CLMSystems' is also present.

On the left, a 'Library' pane shows 'SLRGen' with various icons. Below it, a sidebar lists categories: 'Basic', 'Climate', 'Math', 'Matrix', 'Sink', 'SLRGen', and 'Spatial'. At the bottom, a 'Console' window shows the message 'Model Sealevelrise\_impact loaded.'.

Callouts identify key features: 'Block library' (left pane), 'Model time setting' (date range), 'Start to run the model' (toolbar button), 'Model status monitoring' (console), and 'Canvas' (main workspace). A callout also points to the overall model diagram, labeling it as a 'Coastal hazard/adaptation assessment model'.



# GENIES - Model/Block library



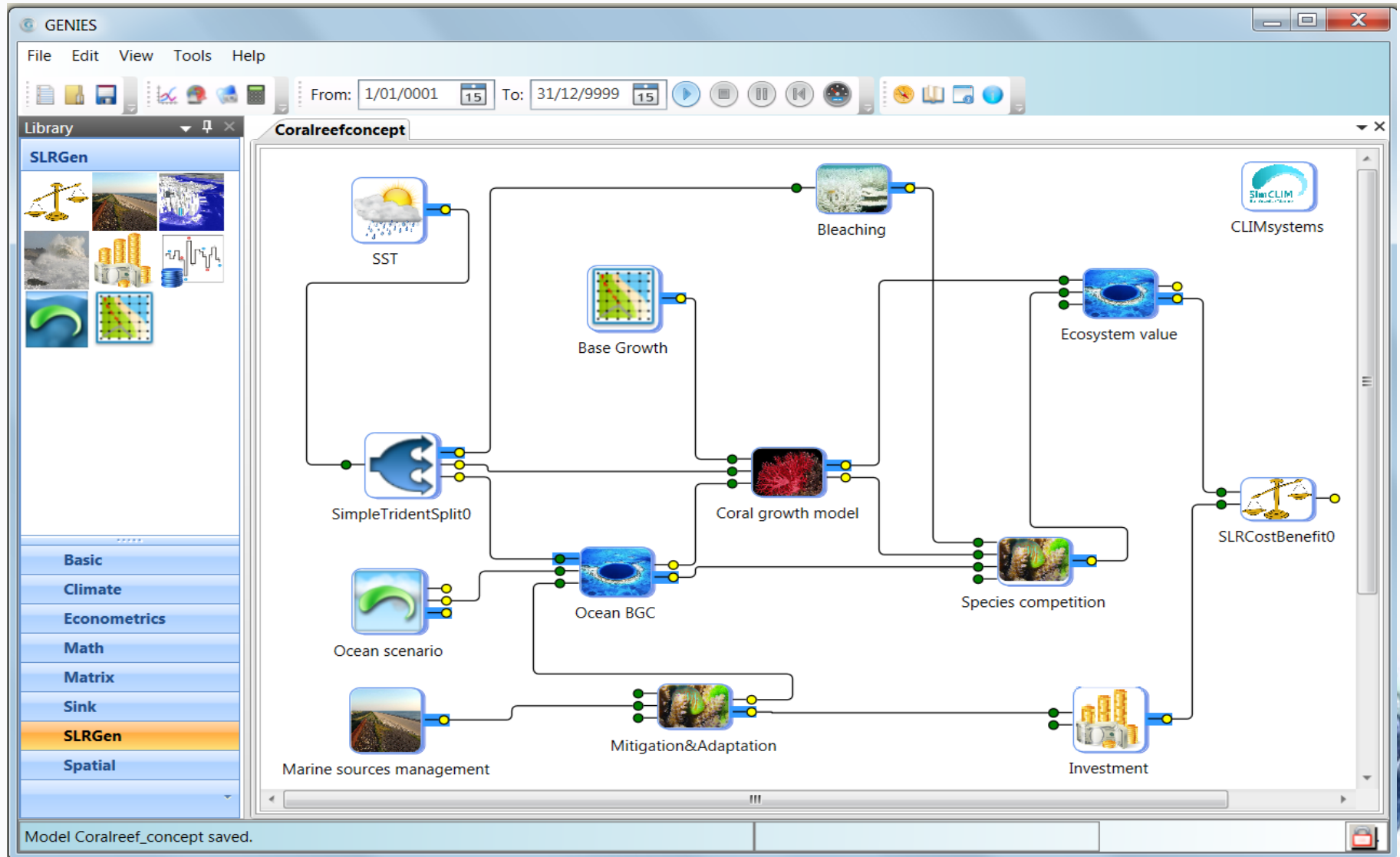
The blocks are classified according their functions. More blocks and categories will be added with the progress of GENIES.

Each block in the library can be dragged into the canvas to be configured and used as a component of a model. The blocks can be linked to each other according to their data and function nature.



# GENIES - Coral reef concept model

## - example for Systems Thinking



# GENIES Navigator

GENIES

File Edit View Tools Help

GENIES Navigator

Library

Basic

Climate

Econometrics

Math

Matrix

Sink

SLRGen

Spatial

Console

Console Trace

Navigator

Perform A Study

City Master Plan

Overall Plan

street map and satellite map. The building area was extracted using ENVI software feature, the building area was in GIS raster format, so the data can be applied for the inundation lost and adaptation option analysis.

Figure 1. The built up area data of Rach Gia extracted from Google maps, and the overlaying with the satellite images.

2. High resolution DEM, extraction

Show Navigator on Start



# Summary: GENIES Functions

*GENIES is an easy-to-use, yet extremely powerful, tool for simulating processes. It helps you understand complex systems and produce better results faster. With GENIES you can:*

- Predict the course and results of certain actions
- Gain insight and stimulate creative thinking
- Visualize your processes logically or in a virtual environment
- Identify problem areas before implementation
- Explore the potential effects of modifications
- Confirm that all variables are known
- Optimize your operations
- Evaluate ideas and identify inefficiencies
- Understand why observed events occur
- Communicate the integrity and feasibility of your plans



# Summary : GENIES Features

- **Modular design**

  - build on and link to existing models and related applications

- **Open framework**

  - allowing for multi-scale, multi-disciplinary impact assessment
  - easily can be customized case-by-case to suit each city

- **Climate change adaptation oriented**

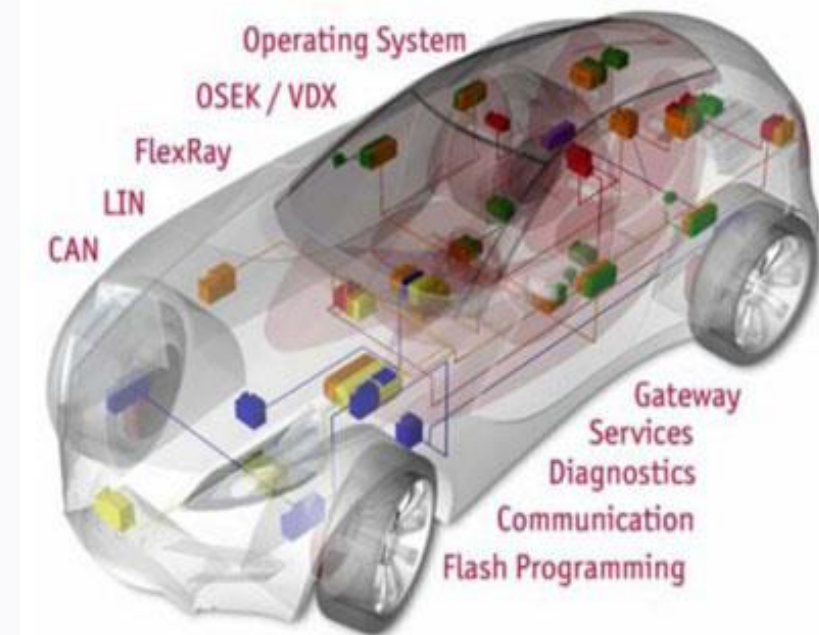
  - Integrated analysis of adaptation and mitigation options
  - Climate change uncertainty analysis

- **Multiple toolboxes**

  - risk and cost-benefit analysis tools
  - scripting
  - AHP and Decision tree

- **Visualization**

  - spatial
  - temporal
  - spatio-temporal



# GENIES Community of Practice



## Get together

Workshops  
visiting  
Remote  
communication



## Stay together

Presentations  
Discussion  
Common  
interests  
identification



## Work together

Work plan  
SCI. & Tech.  
collaboration

## Build up the community

Knowledge and  
tool sharing  
Contributions  
Synergy  
Initiatives  
Membership  
Climate change  
Good practice



# Progress on GENIES Community of Practice (existing members)

- **Research institutes and universities**
  - IAP, CAS, Yonsei, Ji'nan, Delhi, Nanjing, Waikato
- **International Climate Change Organizations**
  - MAIRS, CORDEX, CMIP, OCMIP, ALM
- **Planning institute**
  - Guangzhou, Beijing, New Zealand, Australia, Vietnam, Philippines
- **Practitioners**
  - AECOM, ARUP, CH2MHILL, ESRI ...
- **IFIs**
  - ADB, WB...





*Thank You!*

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