MOIRA: A Computerised Decision Support System for the Restoration of Radionuclide Contaminated Freshwater Ecosystems

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Objectives of MOIRA

- A user-friendly computerised tool to choose optimal intervention strategies for different kinds of aquatic ecosystems and contamination scenarios.
- Using validated models to assess the behaviour of ^{137}Cs and ^{90}Sr in the contaminated water bodies, the effect of countermeasures and the radiation dose caused.
- Based on Multi-Attribute Analysis technique (MAA) for testing the effectiveness of different countermeasure strategies:
  - Social, ecological and economic detriment costs and *environmental* and health improvements are taken into account.

Elements of MOIRA software system

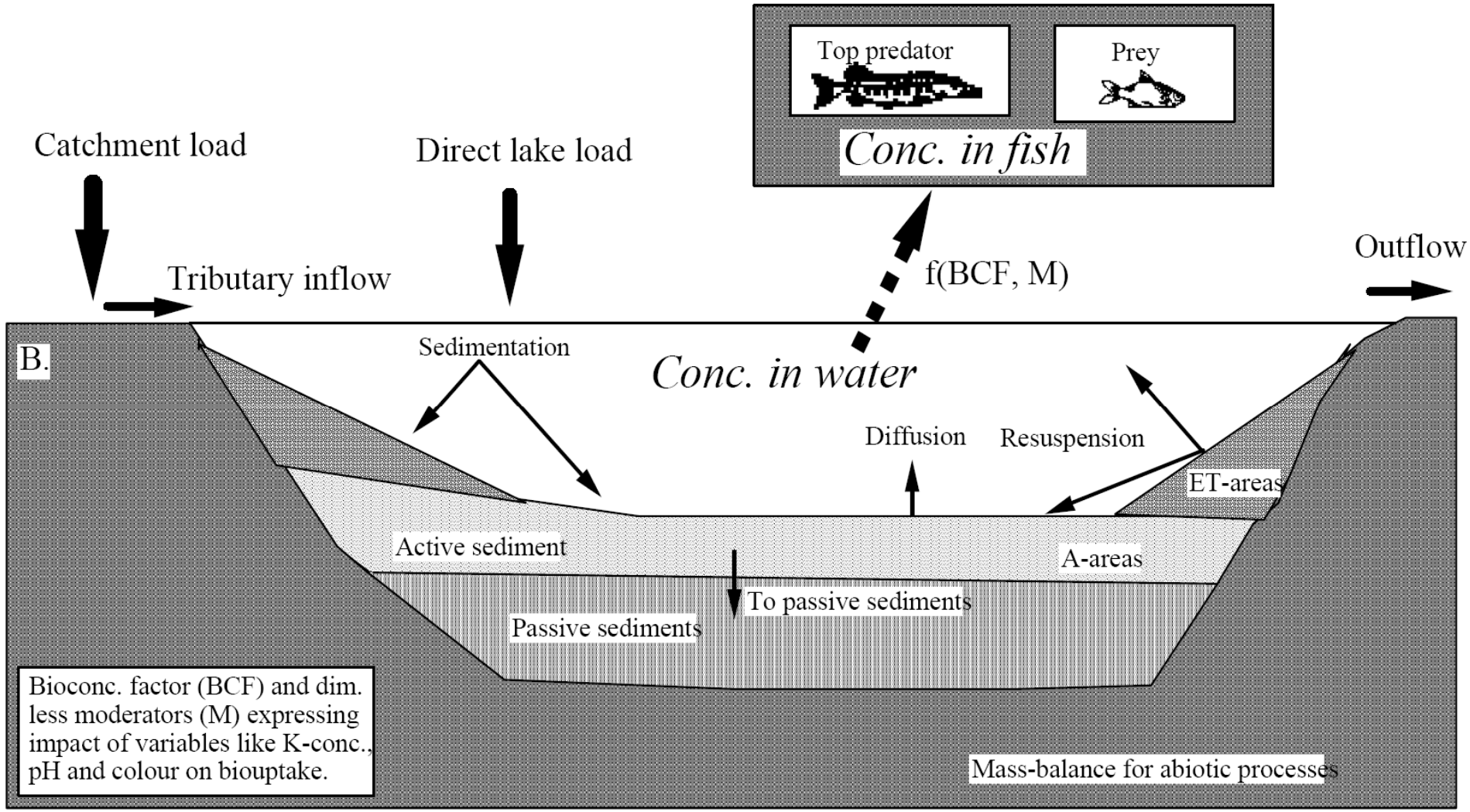
- **The MOIRA operating system**
- **Software realization of mathematical models**
- **Geographical information system (GIS)**
- **The MOIRA user interface**
- **Definition of intervention strategies**
- **Fast running** of the model-chain
- **The Multi-Attribute value Analysis module**
- **The MOIRA HTML report**

MOIRA models

- Migration of ^{137}Cs and ^{90}Sr in fresh water systems
- Dynamic dose assessment model
- Economic cost model:

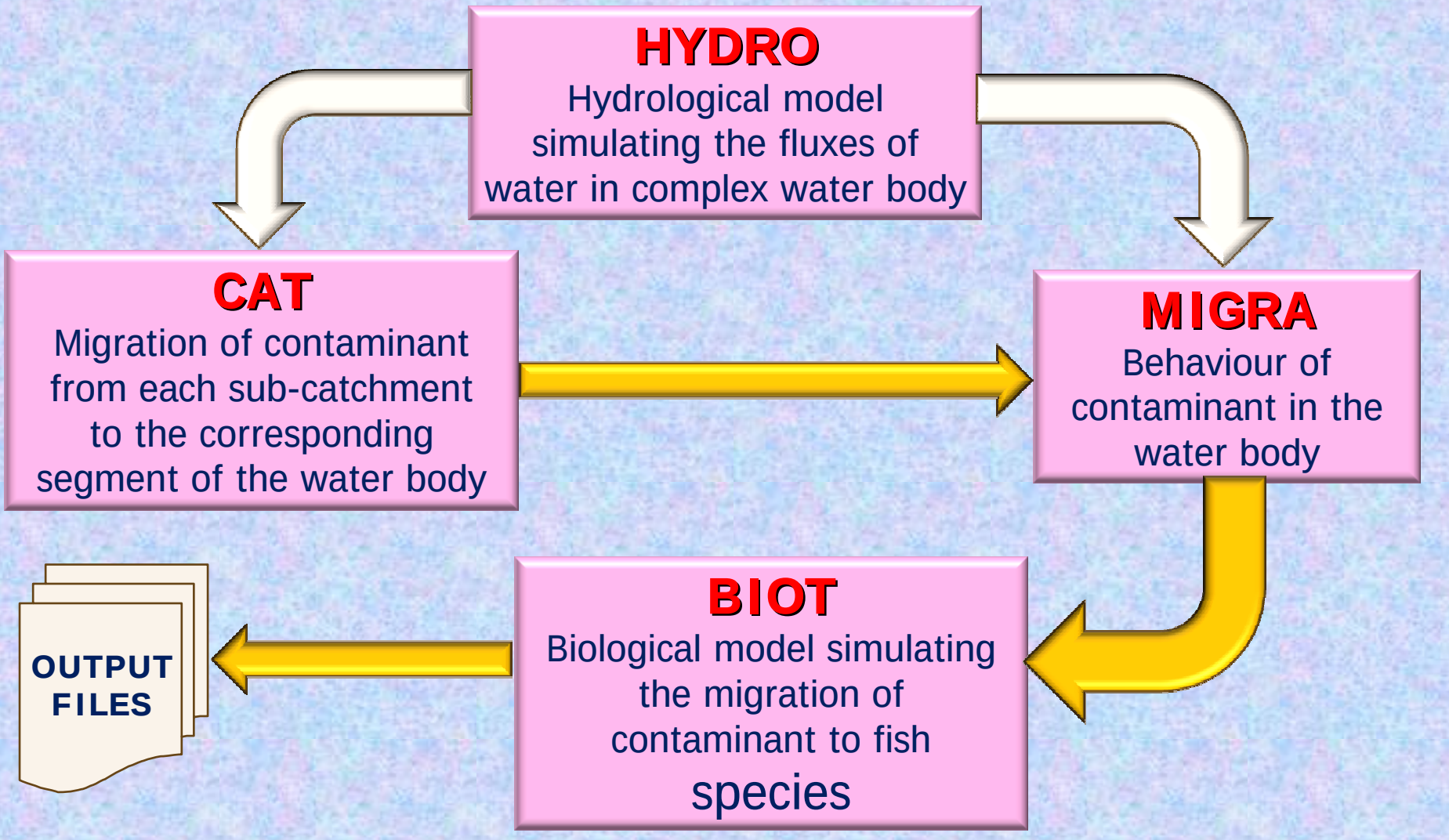
MOIRA Environmental models

- **Behaviour of ^{137}Cs and ^{90}Sr in lakes, rivers, complex catchments, and in biota living in the fresh water environment.**
- **Effects of a variety of countermeasures on the contamination levels.**
- **Built in** Powersim®



Scheme of the MOIRA lake model for ^{137}Cs and ^{90}Sr

River Model MARTE (Model for Assessing Radionuclide Transport and the Effects of countermeasures in complex catchments)



COUNTERMEASURES

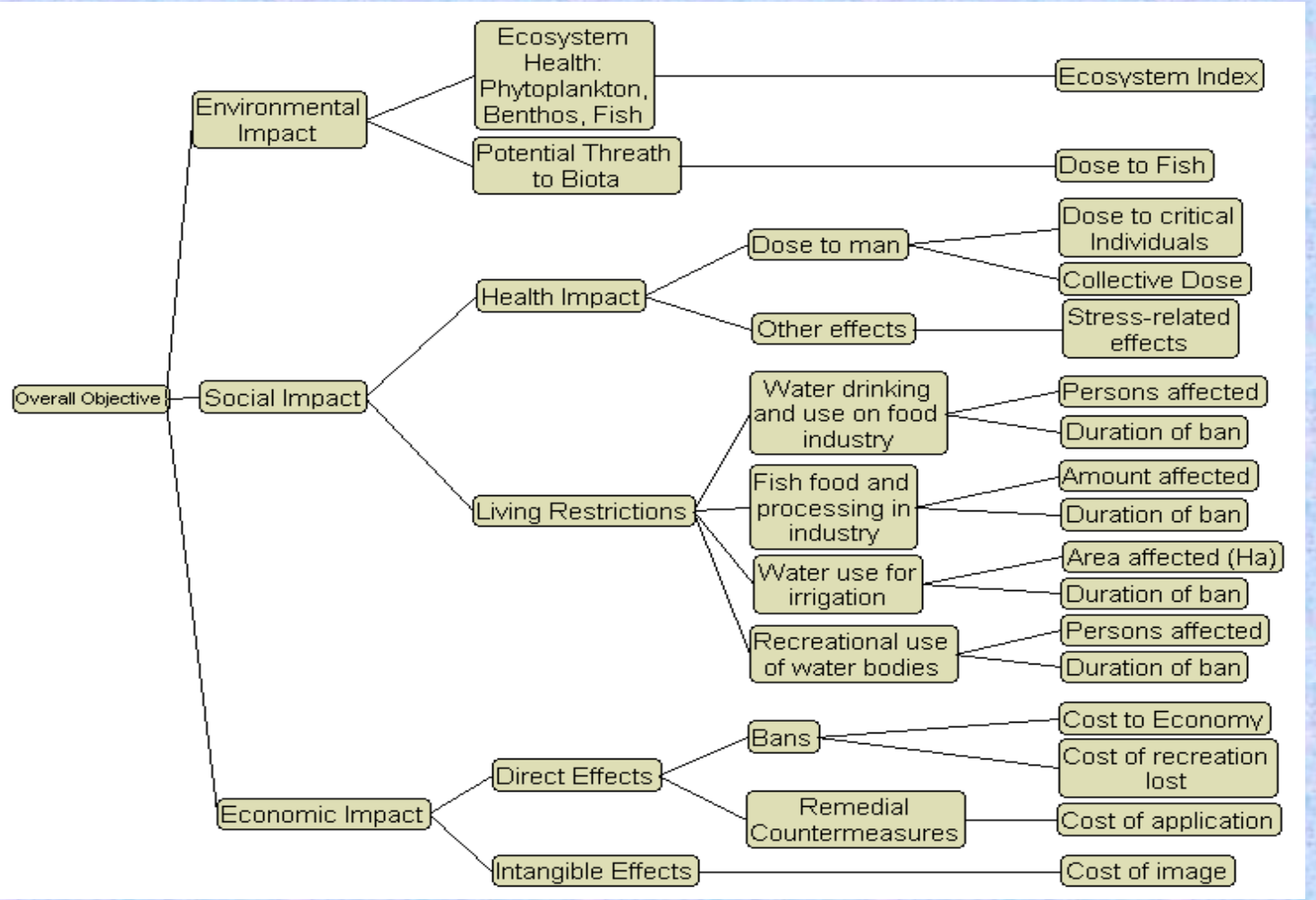
Chemical and Physical (active) Countermeasures

Social (restrictive) Countermeasures: Restrictions on people's normal living habits.

DECISION ANALYSIS

- A systematic procedure for rationally analysing complex decision problems
- Multi-Attribute Analysis a DA technique based on the assessment of “attributes” that measure the degree of achievement of certain objectives

Multi-Attribute Analysis



Tree of objectives considered in the MOIRA system: The overall objective is to minimise the ecological, social and economic impact; each of them is split into different sub-objectives. At the lowest level the objectives can be measured in terms of attributes that are quantified with the system models.

The tree of objectives can be interactively modified by the user

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Environmental Impact

Two attributes:

- radiation dose to biota (fish)
- Ecosystem Index (EI)

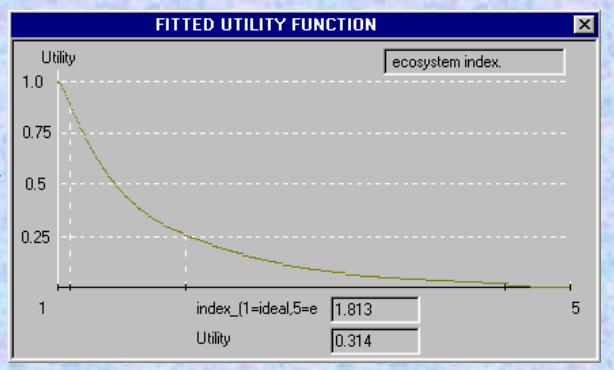
For lakes, LEI is based on the abundance of the critical functional groups of the ecosystem (periphyton, plankton, benthos, fish).

LEI is then related to the characteristics of the lake (for instance pH, K concentration, total-P).

Finally, changes of LEI in relation to its ideal value for the selected ecosystem are assessed from the time evolution of the above water characteristics following the countermeasure application.

LEI = 1, ideal

LEI = 5, irreversible ecosystem destruction



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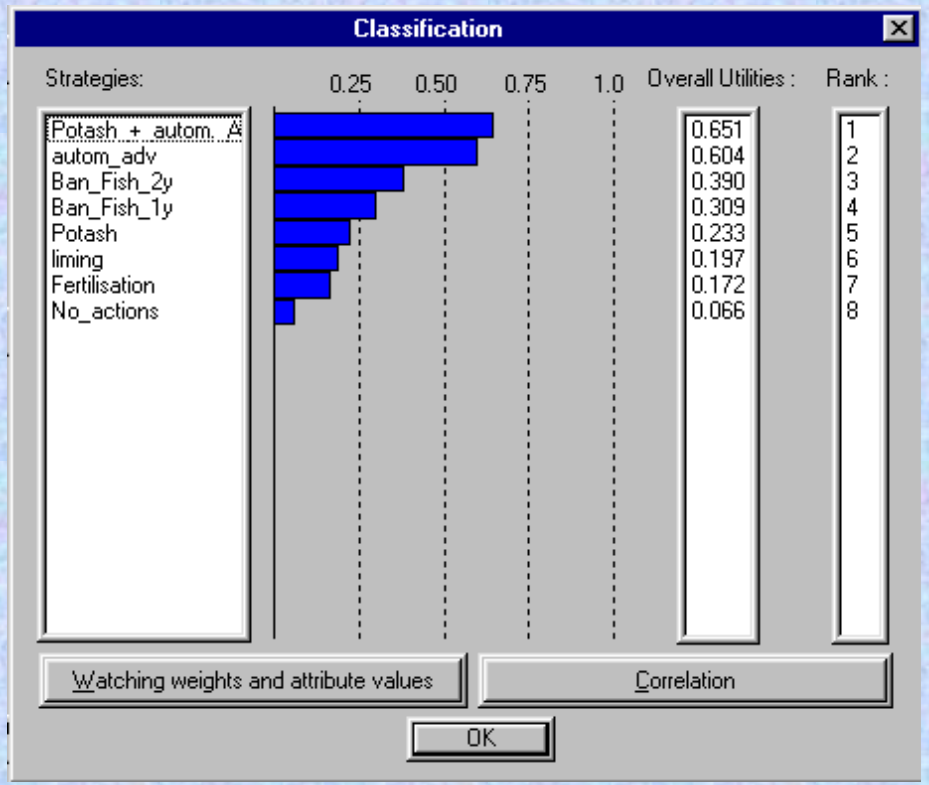
Ranking of Intervention Strategies

Display of final ranking of the analyzed strategies



System's full interactivity allows the user trying new alternative strategies, discarding the less scored

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Conclusions

- MOIRA is a friendly software system, based on scientific and theoretical foundations, for the management of intervention strategies to reduce the dose via aquatic pathways.
- MOIRA evaluates several types of countermeasures, and advises the user on the most effective method, taking into account **ecological, social and economic consequences**.
- MOIRA has produced scientific ideas: environmental indices (EI) for quantifying the impact of countermeasures on the aquatic ecosystems and new modelling methodologies for developing predictive models.