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M7.2.1 Evaluation of

QR models for learning about sustainable development, focusing on basic ecological and socio-economic features for an integrative and sustainable development of the riverine landscape of the Kamp valley

Organisation name of lead contractor for this deliverable:

University of Applied Life Sciences, Vienna

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Dissemination Level		
PU	Public	
PP	Restricted to other programme participants (including the Commission Services)	**X**
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

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Abstract

This document presents the final evaluation of the qualitative simulation models related to the sustainable development of the Kamp valley to be used by stakeholders and students as learning material about sustainable development. The evaluation mainly is based on

(1) a general evaluation of Model A ("Sustainability Management") proving the **"acceptance of the chosen approach and model"**

(2) and expert evaluations of both models (Model A "Sustainability Management" and Model B "Water abstraction and Fish") for **"validation and verification".**

The document ends with a summary and a short discussion of the evaluation results.

Document history

Version	Status	Date	Author
1	Draft, initial version.	17.10.07	Andreas Zitek, Paulo Salles
2	Final version	31.10.07	Andreas Zitek, Paulo Salles

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Introduction

The qualitative simulation models related to the sustainable development of the Kamp valley are intended to be used by stakeholders and students as learning material (Zitek et al., 2006). The models mainly explore aspects related to two topics:

(1) development and implementation of sustainable actions in a river catchment (stakeholder integration, quality of sustainability plans, development of ecological integrity and human well being, probability of catastrophic events) and

(2) hydropower production (water storage and release, water abstraction) and its effect on fish.

The evaluation of models is an important step in the model building process. Generally a model evaluation basically covers **"validation and verification"** of the model as well as the **"acceptance of the chosen approach and model"** by the addressed stakeholder groups. Validation proves if the scientific and conceptual contents of the model are acceptable for its intended use, verification proves that the model is correctly implemented by a demonstration of its use. Proving the acceptance of stakeholders mainly evaluates the potential of the model and the modelling approach for broader use.

More or less our evaluation approach is based on the model evaluation process described by Rykiel (1996):

(1) conceptual validation
does de model provide a scientifically acceptable explanation for the cause-effect relationships encoded in the model?

(2) operational validation (= verification)
does the model outputs meet the performance standards required for the model purpose?

(3) data validation
are the data (or information) used to build, calibrate and test the model of good quality? (sometimes applicable to QR models)?

Methods

To evaluate both models developed by the BOKU (Model A: "Sustainability Management" and Model B: "Water abstraction and Fish") a two phase approach was chosen. A general evaluation of Model A mainly focusing on the "acceptance of the chosen approach and model" by students and scientists of different domains and an expert evaluation of both models focusing on "validation and verification" of the models were conducted separately. Model A was evaluated by **Ao. Univ. Prof. Dipl.-Ing. Dr.nat.techn. Susanne Muhar** an expert in integrated management of riverine landscapes and the development and definition of integrated restoration activities related to the requirements of the EU-WFD, Model B was evaluated by **Ao.Univ.Prof. Dipl.-Ing. Dr.nat.techn. Stefan Schmutz,** an expert in the assessing the ecological status of running waters related to the effects of human pressures on aquatic ecosystems also dealing with the development and definition of restoration measures related to the requirements of the EU-WFD (both working at the Institute of Hydrobiology and Aquatic Ecosystem Management, Department Water-Atmosphere-Environment, BOKU Vienna). Both evaluations took place at the Institute of Hydrobiology and Aquatic Ecosystem Management at the University of Natural resources and Applied Life Sciences, BOKU, Max-Emanuelstrasse 17, 1180 Vienna.

The general evaluation, based on a power point presentation and a collective exploration of parts of the model using GARP3 on personal Lap tops was done at the 17.10.07 from 16:15 to 18:15. Eleven persons, divided into students and experts of different aquatic resource domains, participated the event.
The expert evaluations of Model A and B took place at the 30.10.07 between 8:30 and 12:30 each lasting about 2 hours and were run as face to face discussions based on the printed causal maps and a conjoint exploration of important model fragments and simulations using GARP3 on one Lap top.
After the presentation and collective and interactive inspection of important scenarios and model fragments the participants were asked to fill in pr-prepared questionnaires with GARP3 software. The following questions were used for the general evaluation of Model A ("Sustainability Management) on 17.10.07, dealing mainly with a general evaluation of the model represented in QR language, proving the acceptance of the modelling approach and the model and its potential for broader use.
At the beginning of the evaluation process, the attendees were asked, whether they are an expert in a specific scientific field or a student.

- o Expert
  Please add, which kind of experience you have (teaching, water resources management, research…)
- o Student
  Please add the type of study, you are conducting!

Then they were asked to answer the following questions carefully:

1) **QR models** present **complex knowledge** in an **understandable manner**.

○	○	○	○	○
1	2	3	4	5
I fully disagree	I largely disagree	I somewhat disagree/agree	I largely agree	I fully agree

Why not?

2) **The QR approach** allows for a **clear representation** of real world phenomena like **a sustainable development of the riverine landscape "Kamp".**

○	○	○	○	○
1	2	3	4	5
I fully disagree	I largely disagree	I somewhat disagree/agree	I largely agree	I fully agree

Why not?

3) **QR and GARP3** can be seen as a **valuable learning tool** for **real world causal relationships** related to **a sustainable development of riverine landscapes.**

○	○	○	○	○
1	2	3	4	5
I fully disagree	I largely disagree	I somewhat disagree/agree	I largely agree	I fully agree

Why not?

4) **The presented QR model** might significantly **contribute to the understanding of students and stakeholders which entities and processes drive a sustainable** development of a riverine landscape and therefore **enhances their capability of making decisions**.

○	○	○	○	○
1	2	3	4	5
I fully disagree	I largely disagree	I somewhat disagree/agree	I largely agree	I fully agree

Why not?

5) The **causal map** of the model reflects **important information** related to **a sustainable development of the Kamp valley.**.

○	○	○	○	○
1	2	3	4	5
I fully disagree	I largely disagree	I somewhat disagree/agree	I largely agree	I fully agree

What is missing?

6) **Which part of the model** was **most interesting** for you?

Please write down in short words.

7) **Which part of the model** most should be **enhanced**?

Please write down in short words.

8) The **model** can be used **for the targeted purpose of teaching students and other interested stakeholders** on **sustainability issues on a catchment level**.

○	○	○	○	○
1	2	3	4	5
I fully disagree	I largely disagree	I somewhat disagree/agree	I largely agree	I fully agree

If necessary, specify your answer.

9) For **which purpose** do you think the presented **QR approach is most suited?**

a. Stakeholder integration

○	○	○	○	○
1	2	3	4	5
I fully disagree	I largely disagree	I somewhat disagree/agree	I largely agree	I fully agree

b. University lectures

○	○	○	○	○
1	2	3	4	5
I fully disagree	I largely disagree	I somewhat disagree/agree	I largely agree	I fully agree

c. Decision making

○	○	○	○	○
1	2	3	4	5
I fully disagree	I largely disagree	I somewhat disagree/agree	I largely agree	I fully agree

d. **Others** (**to be added** e.g. technical staff from the government, researchers, secondary school students)…

Please add:…

○	○	○	○	○
1	2	3	4	5
I fully disagree	I largely disagree	I somewhat disagree/agree	I largely agree	I fully agree

10) Additional comments:

For the expert evaluation of Model A the following questions were added:

11) The **entities and configurations** are **relevant and sufficient** to support a representation of the system structure.

○	○	○	○	○
1	2	3	4	5
I fully disagree	I largely disagree	I somewhat disagree/agree	I largely agree	I fully agree

If necessary, specify your answer

12) The **quantities used** capture the **most interesting properties** of the entities.

○	○	○	○	○
1	2	3	4	5
I fully disagree	I largely disagree	I somewhat disagree/agree	I largely agree	I fully agree

If necessary, specify your answer

13) The **quantity spaces** and **values** capture the **most interesting qualitative states of the entities**.

○	○	○	○	○
1	2	3	4	5
I fully disagree	I largely disagree	I somewhat disagree/agree	I largely agree	I fully agree

If necessary, specify your answer

14) The (important) **model fragments** are conceptually correct and clear.

○	○	○	○	○
1	2	3	4	5
I fully disagree	I largely disagree	I somewhat disagree/agree	I largely agree	I fully agree

If necessary, specify your answer

15) The **presented scenarios** describe a **real situation** that it is good enough to trigger an **interesting/good simulation**.

○	○	○	○	○
1	2	3	4	5
I fully disagree	I largely disagree	I somewhat disagree/agree	I largely agree	I fully agree

What is missing?

16) The general behaviour (how it develops trough the simulation) of the **presented model** is **in accordance to what is already known** (or accepted).

○	○	○	○	○
1	2	3	4	5
I fully disagree	I largely disagree	I somewhat disagree/agree	I largely agree	I fully agree

If necessary, specify your answer

The same questions were used re-verbalized for the expert evaluation of the water abstraction model (Model B) run at the 30.10.07.

Results

General evaluation of Model A "Sustainability Management"

In this section, the most important results of the general evaluation of Model A "Sustainability Management" are highlighted. For the summarized results see Tab. 1. In total the **dominating answer** was **"I largely agree" (n=43 times)** followed by **"I fully agree" (n= 34 times)** and **"I somewhat agree/disagree" (n=18 times)**. 6 times the statements were commented with "I largely disagree" and 2 times with "I fully disagree" (see Fig. 1). For students the dominating statement was "I fully agree", whereas experts answered most of the questions with "I largely agree". As one student "largely disagreed" or "fully disagreed" with all of the statements, it could be, that he probably understood the evaluation scheme in the wrong way.

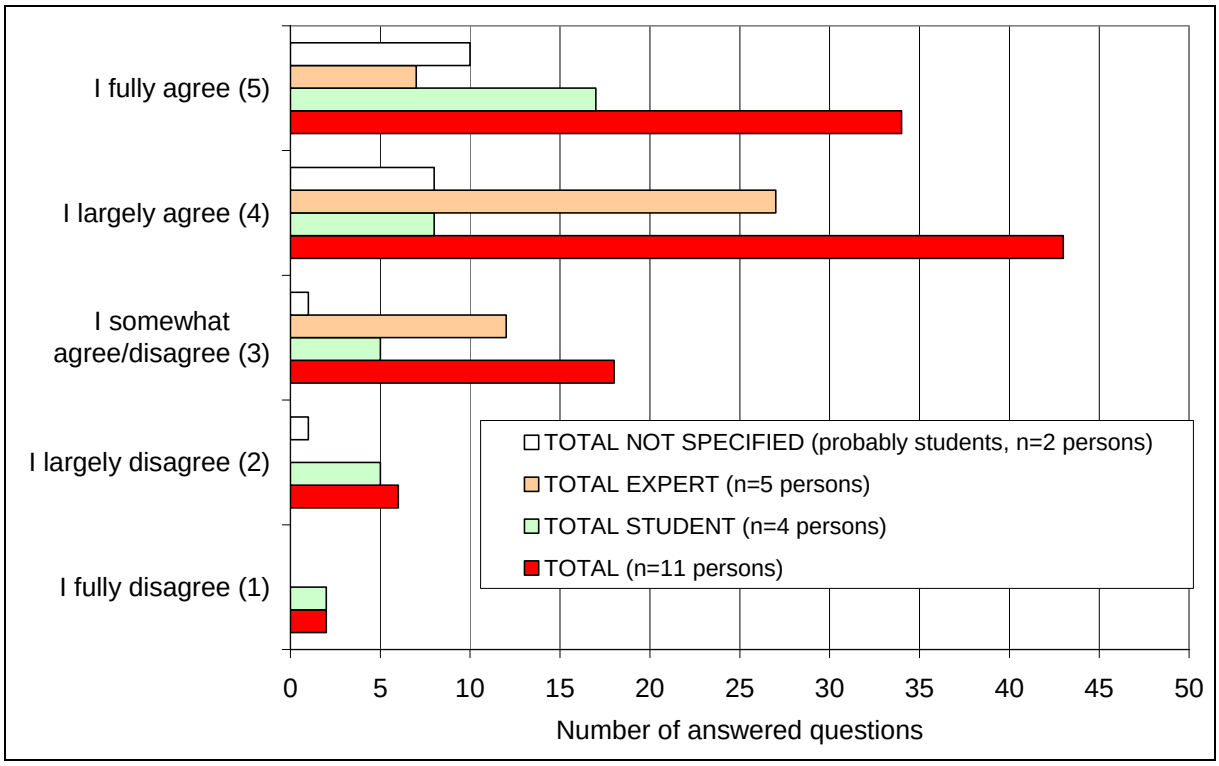

Figure 1: Summarized answers of the different groups of persons that attended the general evaluation of Model A „Sustainability Management".

1) **QR models** present **complex knowledge** in an **understandable manner**.

7 persons "agreed largely", 3 persons "agreed fully" and one person "largely disagreed". All experts "largely agreed" whereas 50% of the students fully agreed.

2) **The QR approach** allows for a **clear representation** of real world phenomena like **a sustainable development of the riverine landscape "Kamp".**

Most persons (n=6) "somewhat agreed/disagreed" with this statement, one person largely agreed, two persons fully agreed and one largely disagreed. One person did not answer this question.

3) **QR and GARP3 can be seen as a valuable learning tool for real world causal relationships** related to **a sustainable development of riverine landscapes.**

5 persons agreed fully with this statement, four agreed largely, one "somewhat agreed/disagreed" and one "largely disagreed". Most experts (n=3) "largely agreed"

and most students (n=3) “fully agreed” with this statement. One student added an additional statement: *“QR and GARP are well suited to visualize complex problems related to human affairs that are hard to capture with other approaches, but for a real clear & precise representation quantitative models will be needed”.*

4) **The presented QR model** might significantly **contribute to the understanding of students and stakeholders which entities and processes drive a sustainable** development of a riverine landscape and therefore **enhances their capability of making decisions**.

All experts (n=5) “largely agreed” and most students (n=3) “fully agreed“. One student added an additional statement: *“Adaptation of the model to the addressed stakeholder group (e.g. simplification) is probably necessary; people should understand the model (…related to the quantity “Ways to inform and integrate the public”).*

5) The **causal map** of the model reflects **important information** related to **a sustainable development of the Kamp valley.**

3 experts “largely agreed” and in total 3 persons “agreed fully” (1 expert, 1 student and one person not specified) and 3 persons (2 students and 1 expert) “somewhat agreed/disagreed” One student added an additional statement: *“More variables should be used to describe the situation more realistic”.*

6) **Which part of the model** was **most interesting** for you?

Students added the following statements: *“Most interesting to see was that private interests might negatively influence the sustainability process and that the combined influence of planners, science and local population (stakeholders) defines the quality of sustainability plans and the whole sustainability process”. “Most interesting was to see the interrelatedness of the involved entities of the Kamp management system. “It was interesting to see the possibility of different potential intervention options to reach the goal of a sustainable development. “It was interesting to see that ecological integrity AND human well being are represented in the sustainability model”.*

Experts added the following statements: *“Generating stock/flow elements in a qualitative way and relating quantities via P`s and I´s was very interesting”. One person not further specified added the following statement: “Specific scenarios were very interesting especially the catastrophic event as trigger for government action for sustainable development, the interrelatedness and influences of the different model components”.*

7) **Which part of the model** most should be **enhanced**?

Students added the following statement: *“Private interests should be better represented, as a basis to minimize them and achieve sustainable development”.*

Experts added the following: *“The full causal model looks a bit complex & heterogeneous (sorting?); pointing out better the most important variables for a sustainable development”.*

8) The **model** can be used **for the targeted purpose of teaching students and other interested stakeholders** on **sustainability issues on a catchment level**.

3 persons (2 students, 1 expert) fully agreed, 3 persons (1 expert, 1 student and 1 person not further specified) largely agreed and 3 persons (all experts) “somewhat agreed/disagreed”.

9) For **which purpose** do you think the presented **QR approach is most suited?**

   a. **Stakeholder integration**

      5 persons (3 experts, 1 student and 1 not further specified) largely agreed and 4 persons (2 students 1 expert and 1 not further specified) “fully agreed”

   b. **University lectures**

4 persons (3 experts, 1 student) largely agreed and 4 persons (2 students 1 expert and 1 not further specified) “fully agreed”

c. Decision making

6 persons (3 experts, 1 student and 2 not further specified) “largely agreed” and 3 persons (2 experts and 1 not further specified) “fully agreed”

d. **Others** (**to be added** eg. technical staff from the government, researchers, secondary school students).

The following statements were added: *“The model & the general approach could be also suited for NGO´s and other interest groups (stakeholders)”*, by a student. *“The model & the general approach are suited also for research”*, by an expert. “*The model & the general approach could be suited for general others and school teachers”*, added by 2 persons not further specified.

10) Additional comments:

The following statement were added by a student:

- *“Keeping the overview over the model and the P's and I`s is a bit complicated”, by a student.*

The following statement were added by a person not further specified:

- *“The modelling approach allows for a communication of new viewpoints of existing problems and facts; the application within different other fields & domains, mainly related to education, is thinkable; it is interesting to take different mental models (also culture-specific) as a starting point for developing models & discussions”, by 2 persons not further specified.*

Table 1: Summarized results of the general evaluation of Model A “Sustainability Management” conducted at the 17.10.07 with 11 participants; highest scores per question and in total are marked in red, additional comments to rating questions are given in text.

Questions	I fully disagree (1)	I largely disagree (2)	I somewhat agree/disagree (3)	I largely agree (4)	I fully agree (5)
1) **QR models** present **complex knowledge** in an **understandable manner**.					
Student 1 , Student 2 (ecology/limnology), student 3 (landscape planning/social ecology), student 4 (Phd/aquatic ecosystem research)		1		1	2
Expert (water resources mangagement/n=1 , water resources research/n=2, hydraulic modeling & fish ecology/n=1, not specified/n=1)				5	
Not specified				1	1
TOTAL	**0**	**1**	**0**	**7**	**3**
2) **The QR approach** allows for a **clear representation** of real world phenomena like **a sustainable development of the riverine landscape “Kamp”.**					
Student 1 , Student 2 (ecology/limnology), student 3 (landscape planning/social ecology), student 4 (Phd/aquatic ecosystem research)		1	2		1
Expert (water resources mangagement/n=1 , water resources research,/n=2, hydraulic modeling & fish ecology/n=1, not specified/n=1)			3	1	
Not specified			1		1
TOTAL	**0**	**1**	**6**	**1**	**2**
3) **QR and GARP3** can be seen as a **valuable learning tool** for **real world causal relationships** related to **a sustainable development of riverine landscapes.**					
Student 1 , Student 2 (ecology/limnology), student 3 (landscape planning/social ecology), student 4 (Phd/aquatic ecosystem research)		1			3
Expert (water resources mangagement/n=1 , water resources research,/n=2, hydraulic modeling & fish ecology/n=1, not specified/n=1)			1	3	1
Not specified				1	1
TOTAL	**0**	**1**	**1**	**4**	**5**
4) **The presented QR model** might significantly **contribute to the understanding of students and stakeholders which entities and processes drive a sustainable** development of a riverine landscape and therefore **enhances their capability of making decisions**.					
Student 1 , Student 2 (ecology/limnology), student 3 (landscape planning/social ecology), student 4 (Phd/aquatic ecosystem research)			1		3
Expert (water resources mangagement/n=1 , water resources research,/n=2, hydraulic modeling & fish ecology/n=1, not specified/n=1)				5	
Not specified				1	1
TOTAL	**0**	**0**	**1**	**6**	**4**

Table 1 completed

5) The **causal map** of the model reflects **important information** related to **a sustainable development of the Kamp valley.**					
Student 1 , Student 2 (ecology/limnology), student 3 (landscape planning/social ecology), student 4 (Phd/aquatic ecosystem research)			2	1	1
Expert (water resources mangagement/n=1 , water resources research,/n=2, hydraulic modeling & fish ecology/n=1, not specified/n=1)			1	3	1
Not specified				1	1
TOTAL	**0**	**0**	**3**	**5**	**3**
6) **Which part of the model** was **most interesting** for you?					
Student 1 , Student 2 (ecology/limnology), student 3 (landscape planning/social ecology), student 4 (Phd/aquatic ecosystem research)	Most interesting was to see: that private interests trigger sustainability process, the combined influence of planners, science and local population (stakeholders) on the quality of sustainability plans and the whole sustainability processs; the interrelatedness of a system; the possibility for different potential intervention options; that ecological integrity AND human well being are represented in the sustainability model.				
Expert (water resources mangagement/n=1 , water resources research,/n=2, hydraulic modeling & fish ecology/n=1, not specified/n=1)	Generating stock/flow elements in a qualitative way and relating quantities via P`s and I´s was very interesting.				
Not specified	Specific scenarios, the catastrophic event as trigger for gv action for sd, the interrelatedness and influences of the different model components were most interesting.				
7) **Which part of the model** most should be **enhanced**?					
Student 1 , Student 2 (ecology/limnology), student 3 (landscape planning/social ecology), student 4 (Phd/aquatic ecosystem research)	Private interests should be better represented, as a basis to minimize them and achieve sustainable development				
Expert (water resources mangagement/n=1 , water resources research,/n=2, hydraulic modeling & fish ecology/n=1, not specified/n=1)	The full causal model looks a bit complex & heterogenous (sorting?); pointing out better the MOST important variables for a sustianable development would be good.				
Not specified					
8) The **model** can be used **for the targeted purpose of teaching students and other interested stakeholders** on **sustainability issues on a catchment level**.					
Student 1 , Student 2 (ecology/limnology), student 3 (landscape planning/social ecology), student 4 (Phd/aquatic ecosystem research)	1			1	2
Expert (water resources mangagement/n=1 , water resources research,/n=2, hydraulic modeling & fish ecology/n=1, not specified/n=1)			3	1	1
Not specified				1	
TOTAL	**1**	**0**	**3**	**3**	**3**
9) For **which purpose** do you think the presented **QR approach is most suited?**					
a. Stakeholder integration					
Student 1 , Student 2 (ecology/limnology), student 3 (landscape planning/social ecology), student 4 (Phd/aquatic ecosystem research)		1		1	2
Expert (water resources mangagement/n=1 , water resources research,/n=2, hydraulic modeling & fish ecology/n=1, not specified/n=1)			1	3	1
Not specified				1	1
TOTAL	**0**	**1**	**1**	**5**	**4**
b. University lectures					
Student 1 , Student 2 (ecology/limnology), student 3 (landscape planning/social ecology), student 4 (Phd/aquatic ecosystem research)	1			1	2
Expert (water resources mangagement/n=1 , water resources research,/n=2, hydraulic modeling & fish ecology/n=1, not specified/n=1)			1	3	1
Not specified		1			1
TOTAL	**1**	**1**	**1**	**4**	**4**
c. Decision making					
Student 1 , Student 2 (ecology/limnology), student 3 (landscape planning/social ecology), student 4 (Phd/aquatic ecosystem research)		1		3	
Expert (water resources mangagement/n=1 , water resources research,/n=2, hydraulic modeling & fish ecology/n=1, not specified/n=1)			2	1	2
Not specified				2	1
TOTAL	**0**	**1**	**2**	**6**	**3**
d. **Others (to be added** eg. technical staff from the goverment, researchers, secondary school students)…					
Student 1 , Student 2 (ecology/limnology), student 3 (landscape planning/social ecology), student 4 (Phd/aquatic ecosystem research)					1
Expert (water resources mangagement/n=1 , water resources research,/n=2, hydraulic modeling & fish ecology/n=1, not specified/n=1)				2	
Not specified					2
TOTAL	**0**	**0**	**0**	**2**	**3**
10) Additional comments:					
Student 1 , Student 2 (ecology/limnology), student 3 (landscape planning/social ecology), student 4 (Phd/aquatic ecosystem research)	Keeping the overview over the model and the P's and I`s is a bit complicated				
Expert (water resources mangagement/n=1 , water resources research,/n=2, hydraulic modeling & fish ecology/n=1, not specified/n=1)					
Not specified	The presented models allow for a communication of new viepoints of existing problems and facts; application within different other fields & domains, mainly related to education, is thinkable; interesting is to take different mental models (also culture-specific) as a starting point for models & discussion.				
TOTAL (n=11 persons)	**2**	**6**	**18**	**43**	**34**
TOTAL STUDENT (n=4 persons)	**2**	**5**	**5**	**8**	**17**
TOTAL EXPERT (n=5 persons)	**0**	**0**	**12**	**27**	**7**
TOTAL NOT SPECIFIED (probably students, n=2 persons)	**0**	**1**	**1**	**8**	**10**

Expert evaluation of Model A „Sustainability Management“

Out of 16 possible answers, 14 were answered with "I largely agree" during the expert evaluation of Model A "Sustainability Management" at the 30.10.07 (Tab. 2). Many additional statements were given.

1) **QR models** present **complex knowledge** in an **understandable manner**.

"I largely agree". Additional statement: *"If you are not part of the modelling process, it is not so easy to understand all definitions of the terms used within the model".*

2) **The QR approach** allows for a **clear representation** of real world phenomena like **a sustainable development of the riverine landscape "Kamp".**

"I largely agree". Additional statement: *"The model shows interdepencies and causal relationships very transparent; but if all of the model assumptions are really true, further real world assessments and studies have to be done (more case studies)".*

3) **QR and GARP3** can be seen as a **valuable learning tool** for **real world causal relationships** related to **a sustainable development of riverine landscapes.**

"I largely agree". Additional statement: *"It is important to address the needs of the specific stakeholder group; sometimes these models might be too complicated (people need to have some education e.g. to deal with complexity and causal relationships – to understand I`s and P`s for example, in a modelling approach like this)".*

4) **The presented QR model** might significantly **contribute to the understanding of students and stakeholders which entities and processes drive a sustainable** development of a riverine landscape and therefore **enhances their capability of making decisions**.

"I largely agree".

5) The **causal map** of the model reflects **important information** related to **a sustainable development of the Kamp valley.**

"I largely agree".

6) The **entities and configurations** are **relevant and sufficient** to support a representation of the system structure.

"I largely agree".

7) The **quantities used** capture the **most interesting properties** of the entities.

"I largely agree".

8) The **quantity spaces** and **values** capture the **most interesting qualitative states of the entities**.

"I largely agree".

9) The (important) **model fragments** are conceptually correct and clear.

"I largely agree".

10) The **presented scenarios** describe a **real situation** that it is good enough to trigger an **interesting/good simulation**.

"I largely agree".

11) The general behaviour (how it develops trough the simulation) of the **presented model** is **in accordance to what is already known** (or accepted).

"I somewhat agree/disagree". Additional statement: "Other scientific fields (sociology, political science…) should be integrated and/or asked to deal with these questions properly".

12) **Which part of the model** was **most interesting** for you?

Additional statement: *"Causal relationships in general". "To model the money for community driven development as an own quantity; the idea, that money spent for measures can only be treated as money spent for a community driven development, if the community is involved in the process of developing and implementing measures (stakeholder participation); otherwise the money spent is not a community driven investment!"*

13) **Which part of the model** most should be **enhanced**?

Additional statement: *"The government action for sustainable development should be better described, as in reality this is of high complexity, being also driven by the general political structure, difficulties between different organization units with regard to their competences (personal behaviour!) and differences in financial resources; additionally very often policies with complementary aims are existing, as policies often lack behind the social development. That means, a more detailed study and representation of the internal political structures determining the implementation process is needed".*

14) The **model** can be used **for the targeted purpose of teaching students and other interested stakeholders** on **sustainability issues on a catchment level**.

"I fully agree".

15) For **which purpose** do you think the presented **QR approach is most suited?**

a. **Stakeholder integration**

"I somewhat agree/disagree".

b. **University lectures**

"I largely agree".

c. **Decision making**

"I largely disagree".

d. **Others** (**to be added** e.g. technical staff from the government, researchers, secondary school students).

Planners, for their understanding of their social role (e.g. as shown in Model A) ("I largely agree").

16) **Additional comments**

- *"A good approach for social learning and conflict management (mediation), when applied together with students or stakeholders in a mediated or group modelling process".*
- *"Identifying dependencies and causal relationships is of high interest and importance for understanding a system".*
- *"It could also be of relevance, to think about which degree of fulfilment the three pillars should have (the weighting of the individual factors) to really reach a sustainable development; who defines the relationships between the pillars? Often the focus is more on the ecological side, sometimes more on the economic side that is currently closely linked to human well being in industrial societies; human wishes or controlling paradigms of society are often not sustainable; probably the currently controlling paradigm of integrating all the needs and wishes of the human population does not always lead to a sustainable development from an ecological point of view".*
- *"It is important to very well define the terms and their use within the model"!*

Table 2: Summarized results of the expert evaluation of Model A "Sustainability Management" conducted at the 30.10.07; highest scores per question and in total are marked in red, additional comments to rating questions are given in text.

Questions	I fully disagree (1)	I largely disagree (2)	I somewhat agree/disagree (3)	I largely agree (4)	I fully agree (5)
1) **QR models** present **complex knowledge** in an **understandable manner**.					
				1	
TOTAL	0	0		1	0
2) **The QR approach** allows for a **clear representation** of real world phenomena like **a sustainable development of the riverine landscape "Kamp".**					
				1	
TOTAL	0	0	0	1	0
3) **QR and GARP3** can be seen as a **valuable learning tool** for **real world causal relationships** related to **a sustainable development of riverine landscapes.**					
				1	
TOTAL	0	0	0	1	0
4) **The presented QR model** might significantly **contribute to the understanding of students and stakeholders which entities and processes drive a sustainable** development of a riverine landscape and therefore **enhances their capability of making decision**					
				1	
TOTAL	0	0	0	1	0
5) The **causal map** of the model reflects **important information** related to **a sustainable development of the Kamp valley**					
				1	
TOTAL	0	0	0	1	0
6) The **entities and configurations** are **relevant and sufficient** to support a representation of the system structure.					
				1	
TOTAL	0	0	0	1	0
7) The **quantities used** capture the **most interesting properties** of the entities.					
				1	
TOTAL	0	0	0	1	0
8) The **quantity spaces** and **values** capture the **most interesting qualitative states of the entities**.					
				1	
TOTAL	0	0	0	1	0
9) The (important) **model fragments** are conceptually correct and clear.					
				1	
TOTAL	0	0	0	1	0
10) The **presented scenarios** describe a **real situation** that it is good enough to trigger an **interesting**/**good simulation**.					
				1	
TOTAL	0	0	0	1	0
11) The general behaviour (how it develops trough the simulation) of the **presented model** is **in accordance to what is already known** (or accepted).					
			1		
TOTAL	0	0	1	0	0
12) **Which part of the model** was **most interesting** for you?					
	Causal relationships in general , to model the money for community driven devleopment as an own quantity - that can only be treated as "spent by the community", when the community nvolvement (stakeholder participation) is really implemented; otherwise it is not a community driven investment!				
13) **Which part of the model** most should be **enhanced**?					
	Government action, as this is in reality of high complexity, as it is also driven by the general political structures , difficulties between different organization units with regard to their competences (personal behaviour!) and financial resources, and policies with complementary aims as policies and their integration often lack behind the social development. That means a more detailed study of how internal political srucutures determine the implementation process is needed.				
14) The **model** can be used **for the targeted purpose of teaching students and other interested stakeholders** on **sustainability issues on a catchment level**.					
					1
TOTAL	0	0	0	0	1
15) For **which purpose** do you think the presented **QR approach is most suited?**					
a. Stakeholder integration					
			1		
TOTAL	0	0	1	0	0
b. University lectures					
				1	
TOTAL	0	0	0	1	0
c. Decision making					
		1			
TOTAL	0	1	0	0	0
d. **Others** (**to be added** eg. technical staff from the goverment, researchers, secondary school students)…					
				1	
TOTAL	0	0	0	1	0
16) Additional comments:	A good approach for social learning and conflict managment (mediation) when applied togehter with students or stakeholders in a mediated or group modeling process. Identifying dependencies and causal relationships is of high interest and importance for understaning a system. It could also be of relevance, to think about which degree of fulfillment of the three pillars (the weighting of the indicidual factors) of sd really is "sustainable" and who defines how the relationships between the pillars should look like (oftem the focus is more on the ecological side, sometimes more on the economic side often closely linked to human well being in industrial societies; human wishes or controlling paradigms often are not sustainable; probably the currently controlling paradimg of intgerating the needs and wishes of the human population is does not lead to a real sustainable devleopment form an ecolgical viewpoint). It is important to very well define the terms and their use within the model!				
TOTAL domain expert evaluation	0	1	2	12	1

Expert evaluation of Model B „Water abstraction and Fish“

Out of 16 possible answers, during the expert evaluation of Model B “Water abstraction and Fish”, **9 were answered with “I fully agree”,** 2 with “I largely agree”, 4 with “I somewhat agree/disagree” and 1 with “I largely disagree” (Tab. 3). Many additional statements were given.

1) QR models present **complex knowledge** in an **understandable manner**.

“I somewhat agree/disagree”. Additional statement: *“There are still OR domain specific ingredients, semantics and behaviours (e.g. the quantity spaces as points and intervals), that might conflict with the intuitive way of stakeholders to express things)”.*

2) The QR approach allows for a **clear representation** of real world phenomena like **water abstraction and its effects on fish.**

“I somewhat agree/disagree”.

3) QR and GARP3 can be seen as a **valuable learning tool** for **real world causal relationships** related to **water abstraction and its effects on fish .**

“I somewhat agree/disagree”. Additional statement: *“Sometimes the model does not reflect a "real" causal relationship; here it would be good to point out more specific the difference between real causal parameters and "surrogate" parameters ("latent" parameters, a definition used in structural equation modelling - SEM) that interact with variables in a "correlating" way”.*

4) The presented QR model might significantly **contribute to the understanding of students and stakeholders of how different modes of water abstraction might affect fish** and therefore **enhances their capability of making decisions**.

“I fully agree”.

5) The **causal map** of the model reflects **important information** related to **water abstraction and its effects on fish.**

“I fully agree”.

6) The **entities and configurations** are **relevant and sufficient** to support a representation of the system structure.

“I largely agree”.

7) The **quantities used** capture the **most interesting properties** of the entities.

“I fully agree”.

8) The **quantity spaces** and **values** capture the **most interesting qualitative states of the entities**.

“I fully agree”.

9) The (important) **model fragments** are conceptually correct and clear.

“I fully agree”.

10) The **presented scenarios** describe a **real situation** that it is good enough to trigger an **interesting**/**good simulation**.

“I largely agree”. Additional statement: *“Some behaviours related to intervals in quantity spaces might not be true in real world systems (e.g. that they stay within an interval for a certain time steps before they change). This should be avoided, when not explicitly defined as model target!”*

11) The general behaviour (how it develops trough the simulation) of the **presented model** is **in accordance to what is already known** (or accepted).

“I fully agree”.

12) Which part of the model was **most interesting** for you?

Additional statement: *“That it is easy to change the content of a scenario by using and exchanging different assumptions that simply allows to model the effects of the same human pressure on different guilds of fish (positive and negative effects of flow velocity and water temperature on different guilds).”*

13) Which part of the model most should be **enhanced**?

Additional statement: *"A more realistic representation of the natural variability of the river discharge (probably by using the random function in the scenario editor) and the amount of abstracted water related to mean annual flow as this defines the frequency of water overflow events at weirs that are suspected to have a significant effect on fish. A more realistic representation of the influence of the length of the water abstraction stretch on the temperature development within the river (at the moment the river stretch is treated as a "container" with the same abiotic factors everywhere) and an integration of the effect of morphology on fish and on water temperature"!*

14) The **model** can be used **for the targeted purpose of teaching students and other interested stakeholders** on **the effects of different modes of water abstraction and its effects of fish**.

"I fully agree".

15) For **which purpose** do you think the presented **QR approach is most suited?**

a. Stakeholder integration

"I somewhat agree/disagree".

b. University lectures

"I fully agree". Additional statement: *"The approach is very well suited for interactive learning".*

c. Decision making

"I largely disagree".

d. **Others** (**to be added** e.g. technical staff from the government, researchers, secondary school students).

"Adult education and environmental education" ("I fully agree").

16) Additional comments

- *"The software now can be used very intuitively, which is a prerequisite for the target, to motivate stakeholders and students to put their conceptual knowledge in causal models"!*
- *"It takes time and engagement, to establish approaches like that in society and (university) education teaching such approaches are the basis for their broader use and application by the upcoming generation(s)".*
- *"To further enhance the modelling process itself it would be helpful to always see the consequences of my model definitions and implemented model fragments (configurations, proportionalities and influences) on the fly in an accompanying window of the software (for example as they can be explored by the "show entities & configurations" button, by the "show dependencies" button)".*
- *"It also could be helpful to have the full model shown in a screen like in the "show entities & configurations" window with the opportunity to select parts of the model to be run in a simulation (running only parts of the model by simply drawing a window over a certain part of the model)".*
- *"To link the outcomes of causal models to a GIS would open a new field of promising applications!"*

Table 3: Summarized results of the expert evaluation of Model B “Water abstraction and Fish” conducted at the 30.10.07; highest scores per question and in total are marked in red, additional comments to rating questions are given in text.

Questions	I fully disagree (1)	I largely disagree (2)	I somewhat agree/disagree (3)	I largely agree (4)	I fully agree (5)
1) **QR models** present **complex knowledge** in an **understandable manner**.					
			1		
TOTAL	0	0	1	0	0
2) **The QR approach** allows for a **clear representation** of real world phenomena like **water abstraction and ist effects on fish.**					
TOTAL	0	0	1	0	0
3) **QR and GARP3** can be seen as a **valuable learning tool** for **real world causal relationships** related to **water abstraction and its effects on fish.**					
			1		
TOTAL	0	0	1	0	0
4) **The presented QR model** might significantly **contribute to the understanding of students and stakeholders of how different modes of water abstraction might affect fish** and therefore **enhances their capability of making decision.**					
					1
TOTAL	0	0	0	0	1
5) The **causal map** of the model reflects **important information** related to **different modes of water abstraction and ist effects on fish.**					
					1
TOTAL	0	0	0	0	1
6) The **entities and configurations** are **relevant and sufficient** to support a representation of the system structure.					
				1	
TOTAL	0	0	0	1	0
7) The **quantities used** capture the **most interesting properties** of the entities.					
					1
TOTAL	0	0	0	0	1
8) The **quantity spaces** and **values** capture the **most interesting qualitative states of the entities**.					
					1
TOTAL	0	0	0	0	1
9) The (important) **model fragments** are conceptually correct and clear.					
					1
TOTAL	0	0	0	0	1
10) The **presented scenarios** describe a **real situation** that it is good enough to trigger an **interesting/good simulation**.					
				1	
TOTAL	0	0	0	1	0
11) The general behaviour (how it develops trough the simulation) of the **presented model** is **in accordance to what is already known** (or accepted).					
					1
TOTAL	0	0	0	0	1
12) **Which part of the model** was **most interesting** for you?					
	That it is easy to change the content of a scenario by using different assumptions to model the effects of the same human pressure on different guilds (positive and negative effetcs of flow velocity and water temperature on different guilds).				
13) **Which part of the model** most should be **enhanced**?					
	A more realistic representation of the natural variability of the river discharge (probably by using the random function in the scenario editor) and the amount of abstracted water related to mean annual flow as this defines the frequency of water overflow events at weirs that are suspected to have a significant effect on fish. A more realistic representation of the influence of the length of the water abstraction stretch on the temperature devleopment within the river (at the moment the river stretch is treated as a "container" with the same abiotic factors everywhere) and an integration of the effect of morphology on fish and on water temperature!				
14) The **model** can be used **for the targeted purpose of teaching students and other interested stakeholders** on **water abstraction and ist effects on fish**.					
					1
TOTAL	0	0	0	0	1

Table 3 completed

15) For **which purpose** do you think the presented **QR approach is most suited?**					
a. Stakeholder integration					
			1		
TOTAL	0	0	1	0	0
b. University lectures					
					1
TOTAL	0	0	0	0	1
c. Decision making					
		1			
TOTAL	0	1	0	0	0
d. **Others (to be added** eg. technical staff from the goverment, researchers, secondary school students)…					
					1
TOTAL	0	0	0	0	1
16) Additional comments:					
	"The software now can be used very intuitively, which is a prerequisite for the target, to motivate stakeholders and students to put their conceptual knowledge in causal models"! "It takes time and engagement, to establish approaches like that in society and (university) education teaching such approaches are the basis for their broader use and application by the upcoming generation(s)". "To further enhance the modelling process itself it would be helpful to always see the consequences of my model definitions and implemented model fragments (configurations, proportionalities and influences) on the fly in an accompanying window of the software (for example as they can be explored by the "show entities & configurations" button, by the "show dependencies" button)". "It also could be helpful to have the full model shown in a screen like in the "show entities & configurations" window with the opportunity to select parts of the model to be run in a simulation (running only parts of the model by simply drawing a window over a certain part of the model)". "To link the outcomes of causal models to a GIS would open a new field of app.".				
TOTAL domain expert evaluation	0	1	4	2	9

Concluding remarks

Both evaluations, the general evaluation of Model A "Sustainability Management" and the expert evaluations of Model A & B "Water abstraction and Fish" yielded a very positive feedback with regard to the QR approach, the GARP3 software used to build models and the models themselves representing important issues related to the sustainable development of the riverine landscape Kamp. For example most people "largely or fully agreed" that QR models represent complex knowledge in an understandable manner and that QR and GARP3 can be seen as a valuable learning tool for understanding real world causal relationships related to a sustainable development of riverine landscapes. Also most people "largely or fully agreed" that the presented QR models might significantly contribute to the understanding of students and stakeholders which entities and processes drive a sustainable development of a riverine landscape and therefore enhances their capability of making decisions. So the general aim, to produce software and models in QR language that allow people to interact with and learn about sustainable development clearly can be seen as fully achieved.

Generally experts were a bit more conservative in agreeing with the approach than students. That could be because A) that experts know better about problems of model building and therefore do not agree full with many things (they only agree "largely") or B) that students can be more influenced by the opinion of the presenter being on fire with QR modelling. On the other hand some students gave sometimes answers like "I fully disagree or largely disagree", which did not occur that often with the persons considering themselves as experts. That means in our opinion, that these students probably have not yet understood the potential of the approach or they simply made a mistake when answering the questions (they probably misinterpreted the rating scheme).

Important additional statements related to the QR approach, the software and the models were also collected. Most interesting for the attendees was to see the interrelatedness of the system presented and the use of qualitative "stock-flow" dynamics known from the System Dynamics approach. Only some added that they sometimes get a bit lost when confronted with the total view of the causal model describing a sustainable development of the Kamp valley. It was also stated that when showing these models to other user groups, their general ability to deal with complexity should be accounted for; meaning that for each user group the way of

presenting the model should be adopted. Probably sometimes these models might be too complicated for certain stakeholder groups (people need to have some education e.g. to deal with complexity and causal relationships – to understand I`s and P`s for example, in a modelling approach like this).
A high potential of an application of QR models in various fields, mainly in education but also in decision making and research was suggested by many participants. The potential of the GARP3 software and the QR approach to sustain collective, interactive social learning was clearly pointed out. Mainly the identification of dependencies and causal relationships can be seen as a prerequisite for understanding a system and therefore also for learning and decision making.
With regard to a broader use of QR models in society especially for decision making it was stated, that it might take some time and engagement to establish approaches like that in society. (University) education using and teaching such approaches can be seen as an important basis for a further application.

Parts of the Model A, that were most interesting for the evaluators were:

- to see the causal interrelatedness of the involved entities of the Kamp management system and especially that private interest might negatively influence the sustainability process and that the combined influence of planners, science and local population (stakeholders) defines the quality of sustainability plans and the whole sustainability process. This understanding opens up the possibility of different potential intervention options to reach the goal of a sustainable development.
- to see that ecological integrity AND human well being are represented in the sustainability model.
- specific scenarios showing the catastrophic event as trigger for government action for sustainable development.
- the idea that money spent for measures can only be treated as money spent for a community driven development, if the community is involved in the process of developing and implementing measures (otherwise the money spent is not a community driven investment!).

Parts of the Model A, that should be enhanced in the eyes of the evaluators were:

- Private interests should be better represented, as a basis to minimize them and achieve sustainable development
- The government action for sustainable development should be better described, as in reality this is of high complexity, being also driven by the general political structure, difficulties between different organization units with regard to their competences (personal behaviour!) and differences in financial resources; additionally very often policies with complementary aims are existing, as policies often lack behind the social development. That means, a more detailed study and representation of the internal political structures determining the implementation process is needed.

Parts of the Model B that were most interesting for the evaluators were:

- That it is easy to change the content of a scenario by using and exchanging different assumptions that simply allows modelling the effects of the same human pressure on different guilds of fish (positive and negative effects of flow velocity and water temperature on different guilds).

Parts of the Model B that should be enhanced in the eyes of the evaluators were:

- A more realistic representation of the natural variability of the river discharge (probably by using the random function in the scenario editor) and the amount

of abstracted water related to mean annual flow as this defines the frequency of water overflow events at weirs that are suspected to have a significant effect on fish.

- A more realistic representation of the influence of the length of the water abstraction stretch on the temperature development within the river (at the moment the river stretch is treated as a "container" with the same abiotic factors everywhere) and
- an integration of the effect of morphology on fish and on water temperature.

With regard to the presented models but also to the QR approach some further interesting statements were collected. For example it was stated, that some behaviours of simulations might not be true in real world systems (e.g. that they stay within an interval for a certain time steps before they change). This should be avoided, when not explicitly defined as model target! That means on the one hand that the simulation behaviours of final models to be presented should be restricted as much as needed to avoid outcomes that are not intended (although one also might also significantly learn from unwanted outcomes of a simulation) and on the other hand that there are still QR domain specific ingredients, semantics and behaviours (e.g. the quantity spaces as points and intervals), that might conflict with the intuitive way of stakeholders to express things. Therefore we suggest that the end user should A) only be confronted with simulations & scenarios that exactly show the intended behaviour and B) as less as possible confronted with QR domain specific features not to irritate an intuitive modelling building practice by domain specific restrictions.

There were also some suggestions specific to the GARP3 software produced within the project. With regard to the software packages available for building QR models prior to the project, GARP3 can now be used very intuitively to build QR models representing a prerequisite for the target, to motivate stakeholders and students to use the software and put their conceptual knowledge in causal models!

To further enhance the modelling process itself it could be helpful to always see the consequences of my model definitions and implemented model fragments (configurations, proportionalities and influences) on the fly in an accompanying window of the software (for example as they can be explored by the "show entities & configurations" button, by the "show dependencies" button). It also could be helpful to have the full model shown in a window like the "show entities & configurations" window with the opportunity to select parts of the model by hand to be run in a simulation (running only parts of the model by simply selecting parts of the model by drawing a window). To link the outcomes of causal models to a GIS would open a new field of promising applications!

Literature

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