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A BAYESIAN NETWORK MODEL FOR INTERSECTORIAL POLICY ANALYSIS IN THE TONLE SAP AREA, CAMBODIA

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ABSTRACT

Tonle Sap Lake in Cambodia is the largest freshwater lake in Southeast Asia. Driven by enormous monsoon floods of the Mekong River, it grows fourfold during the wet season, with water level rising 8-10 meters. Tonle Sap is one of the most productive freshwater ecosystems of the world, and the livelihoods in its vicinity are strongly based on rice farming and fishery. We analyzed the impacts of Cambodian sector policies to the society, environment, natural resources and economics in the Tonle Sap Area with a Bayesian network model. The model was constructed for the Mekong River Commission with the input of an expert panel representing a range of stakeholders and expertise. Win-win sector policies were sought between economic growth, environmental sustainability and social equity. Each of these goals is very challenging on its own in Cambodian conditions, not to talk about the difficulties in meeting all these goals simultaneously.

1 INTRODUCTION

Environmental and socio-economic impacts of water resources management are tightly interwoven. This is particularly true in conditions such as the Tonle Sap Area, Cambodia, where the livelihood is mainly based on subsistence fisheries and agriculture, and poverty is widespread. The average annual income in that area is US$ 150, mere 41% of the international poverty line of US$ 1 a day.

Therefore environmental and socio-economic impact analyses must meet in a fairly basic level. It is not always unambiguously clear whether environmental degradation is a root cause for the deterioration of the living conditions of the rural communities that live in poverty, or vice versa. In most cases, these issues constitute a vicious circle, which needs to be analyzed in a multidisciplinary and holistic way.

Equally complicated is the policy framework what comes to regional development and its connections to water resources. Typically, water is included in the mandate of several ministries. In Cambodia, at least eight ministries are dealing with water in a way or another. The sector policies of these ministries require careful coordination and analysis.

This study is a part of a broadly-scoped project "Lower Mekong Modelling Project" (WUP-FIN), which is done as a consultation to the Mekong River Commission (MRC). This project includes hydrodynamic and water quality modeling of various parts of the Mekong Basin, a GIS-database system, field surveys and data collection, various capacity building and education activities, and socio-economic analysis and policy modeling component (Koponen et al. 2003; Keskinen et al. 2005). The WUP-FIN project is linked to the MRC's long-term planning process called Basin Development Plan (BDP) and done within the context of the Water Utilization Programme (WUP) of the Commission.

The policy modeling and analysis part of WUP-FIN is documented here, with the focus on the WUP-FIN Policy Model developed for this case. The Bayesian Network approach used allows the systematic analysis of causal interconnections in a complex environmental-socioeconomic systems. The risks to various components of the system can be assessed, as consequences of different policy strategies under evaluation. The social system components consist typically of stakeholders, i.e. different communities and groupings of people influenced by the implementation of policies in the studied geographical area. Frequently their aspirations and interests conflict. The environmental components are issues such as eutrophication, vegetation changes, and land degradation. These issues are modeled within a risk analysis framework, and a multidisciplinary analysis is performed, revealing the major risks, uncertainties, mismatches of information, and opportunities to find win-win solutions among the various stakeholders and the environment.

2 TONLE SAP LAKE AND THE MEKONG RIVER

With its 500 km^3 of water that it carries each year, the Mekong is the world's 8^{th} largest river (MRC 1997). It is one of the world's most pristine large rivers with approximately 70 million people living in the basin. The GNP per capita of the riparian countries ranges between Cambodia's US$260 to Thailand's US$2,010. In Vietnam, Lao PDR and Cambodia, around 40% of population live below the poverty line. Over 50% of the GNP originates from fishing and agriculture being totally dependent on water resources.

Cambodia's Great Lake, the Tonle Sap, is a unique lacustrine-wetland ecosystem. It is Mekong's major natural reservoir with annual water level fluctuations of 8 to 10 meters. The area exceeds 12,000 km^2 during the monsoon floods, and shrinks to 2,000 km^2 in the dry season. Being one of the world's most productive large wetland ecosystems, its biodiversity is extreme. Fish and rice are the backbones of the traditional livelihood.

For this analysis, the lake was divided into five geographic zones (Figure 1; Keskinen 2005). Four of the zones were defined by the topography: Zone 1 ranges from 0 to 6 m above mean sea level, Zone 2 from 6 to 8 m, Zone 3 between 8 and 10 m, Zone 4 between 10 m and National Roads 5 and 6. Zone 5 includes the urban areas.

The Mekong Basin has witnessed a period of wars and disquiets in the past 60 years. The countries are now in the process of recovery on many fronts and rapid growth of economic prosperity. Infrastructure needs urgent development and is undergoing a speedy progress, and so are educational and health care systems. Government institutions, above all ministries, are still weak and corrupted but maybe on the way to the better.

Economic growth and globalization have changed the traditional rural-urban balance and thus the urbanization levels are soaring. Currently 23% of Cambodians are urban and the urban population is growing with 4% per year.

Economy of a big part of the Mekong Basin relies on very basic subsistence farming and fishery. Poverty is widespread. Illegal activities, largely based on destructive exploitation of natural resources, mushroom. Nature is heavily pressed by the present informal economy and poverty-driven destructive practices.

There are major ambitions to develop the basin in various ways; by dam construction in China and Laos, agricultural development and exploitation of forests throughout the catchment, road and settlement construction and other activities, which modify the mass flows and hydrology in a considerable way.

3 THE RESEARCH QUESTION

The Mekong River Commission and its predecessors have been the strongest international organizations in the region over several decades. Among the riparian countries Cambodia, Vietnam, Lao PDR and Thailand are its members, but China and Myanmar are not.

The contemporary MRC was set up 1995 to fulfill the following vision (MRC 2000, 2001): *"An economically prosperous, socially just and environmentally sound Mekong River Basin"*. Accordingly, it was mandated to work towards *"…a balance between the economic, social, and environmental decisions and development. With the majority of the basin's inhabitants being rural-based and poor, socio-economic considerations inevitably assume vital importance in development planning and implementation."*

These both are in accord with the sustainable development concept, as articulated in the Johannesburg Summit in 2002. Consistent to this philosophy, the Summit pro-

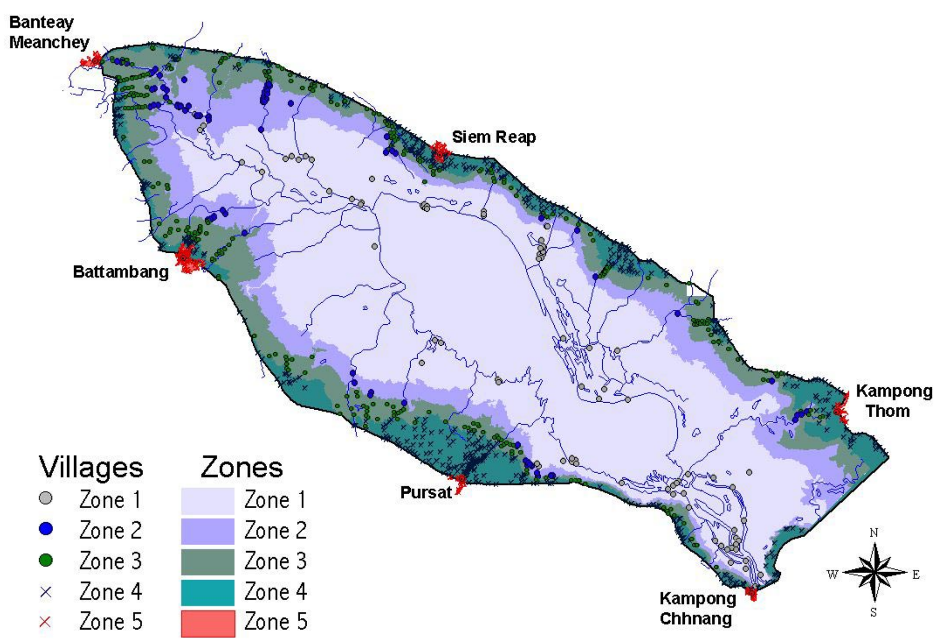

Figure 1. The map of the Tonle Sap Area with five zones and all villages in the Area.

moted powerfully the concept of Integrated Water Resources Management (IWRM), which can be condensed in the following way: waters should be used to provide economic well-being to the people, without compromising social equity and environmental sustainability. This should happen in a basinwide context, with stakeholder participation and under good governance. Thereby, the IWRM aims at developing democratic governance and promotes balanced development in poverty reduction, social equity, economic growth and environmental sustainability.

The policies and plans prepared by an institution such as the MRC are implemented chiefly by national governments. Typically, in a national level, water related policies are included in the mandates of several ministries. In Cambodia, such ministries count to eight. Besides, also several other ministries deal with water in a way or another.

The objective of this study is to answer to the following challenging question: How the vision for the Mekong Basin can be realized for the Tonle Sap Area in Cambodia?

The three goals included in MRC's vision are all very important, but in conflict in many ways. It would be very tempting to take only environmental protection, solely social questions, or barely economic growth under policy targets, but to include them all is a massive challenge.

Besides, reaching any of these goals seem today very distant. Economic growth is needed to reach economic prosperity. Massive poverty reduction is mandatory for feating social justness. Achieving environmental soundness likewise needs strong policies. Of particular interest in this analysis are 11 sector policies and how they can be used to develop the Tonle Sap Area into the desired direction. The time frame of the analysis is 10 years i.e. up to year 2013.

The policy analysis has also been used to support the Tonle Sap Sub-Area Analysis Process (TSSAP) that is carried out by the BDP and Cambodian National Mekong Committee. The TSSAP is a part of the BDP's task to "establish a planning process at national and regional levels that will enable the Lower Mekong countries to jointly plan the development of the river basin and to produce the first regionally-owned basin development plan" (MRC 2004). For more information on WUP-FIN Policy Model's use for the analysis of the strategies defined within the TSSAP, please refer to Keskinen and Varis (2004b).

4 ANALYTICAL APPROACH

The Bayesian Network methodology used (Varis 1998, Varis & Fraboulet-Jussila 2002, Varis & Lahtela 2002) is based on the systematic analysis of causal interconnections in complex environmental-social-economic systems. The objective is to assess risks to various components of the environmental and social system under concern, as consequences of different policy strategies under evaluation.

The social system components consist typically of stakeholders, i.e. different communities and groupings of people that are influenced by the implementation of policies in the studied geographical area. It is not rare that their aspirations and interests are in conflict with one another.

The information from various sources and of varying quality is condensed in a risk analysis framework, and a multidisciplinary analysis is performed. The analysis reveals the major risks, uncertainties, mismatches of information, and opportunities to find win-win solutions among the various stakeholders and the environment.

The model has a set of variables, which were specified by us and refined in an expert consultation process. The model structure is defined as a link matrix (see Varis 1998), in which each pair of variables can be linked with a link parameter which stands for the likelihood for a conditional probability between those variables. Many of the variables also are assigned an a priori tendency of evolution which is then updated with probabilistic information from the rest of the model, in a Bayesian sense.

A logical sequence in the socio-economic model study starts from a set of scenarios, which are followed by a selection of development priorities, which allow the society to react to these scenarios. Different policies have different impacts on the environment and the socio-economic system. Finally the local and national stakeholders feel these changes—either benefit or suffer from them (Figure 2).

The model allows trade-off analyses between different development objectives, and helps in finding policy combinations that create a maximum amount of win-win situations between the competing stakeholders.

4.1 Technical outline

The WUP-FIN Policy Model includes two primary interfaces that the model and its functioning are based on: the tendency sheet where the future tendencies of different environmental, economic and social variables are defined, and the link matrix where the linkages between these different variables are specified. The model is run from the scenario sheet where different kind of policy scenarios can be constructed and modified. Also the model results, i.e. the impact of different policy scenarios on development goals and other variables, can be analyzed in scenario sheet. Keskinen and Varis (2004a) present detailed pictures from the three interfaces.

The model interfaces have been programmed using the Microsoft Excel spreadsheet environment, and the computational routines have been realized as VisualBasic worksheet macro functions.

The definition of the variables' most probable future trends in tendency sheet lays the foundation for the model, whereas link matrix defines the model structure. While the tendency sheet is rather easily comprehensible and definable entity, it is the vast network of variables and their interconnections in the link matrix that produces the most unforeseeable—and therefore useful—impacts and information. The actual policy and sensitivity analysis is carried out by changing the relative importance of different sector policies in scenario sheet and analysing then the impact of these changes on the development goals.

The operation of the model is based on these three interfaces and their connections. Policy scenarios and tendency sheet have through link matrix an impact on the development goals and other variables.

The scenarios for different policy variables are technically identical to the tendencies of environmental, economical and social variables presented in the tendency sheet. The reason why these variables have been separated into different worksheets is their difference in how they can be managed and controlled: scenario sheet includes variables that can be controlled directly, while tendency sheet includes the variables that can be controlled only indirectly. The model-user can manage and control (i.e. redefine and modify) different policy variables as they are the variables that the decision-makers are able to control directly. In contrast, environmental, economic and social variables (such as biodiversity decline, cash crop farming and empowerment) can be managed and controlled only indirectly through different policies. Hence, the tendency sheet (i.e. the tendencies of environmental, economic and social variables) is intended not to be redefined, while the scenario sheet (i.e. policy variables) can be interactively elaborated as much as needed. The tendency sheet will be redefined only when important additional information is obtained: the aim is obviously to define the tendency sheet so well that there rarely emerges need for this. The same applies for link matrix.

Why then to define the tendencies if we cannot control them? The reason is that in the real world environmental, economic and social variables are rarely in a constant state but exhibit a certain tendency, i.e. are changing to certain direction with certain pace and probability. These tendencies, or trends, influence strongly on how effectively different management options (i.e. policies) are able to affect these variables and other variables linked to them. For example, if biodiversity decline has a strong tendency, extremely firm policies are needed to turn or even reduce this tendency. Thus, the tendencies are included in the model in order to get a realistic picture of the impact of different policy options on development goals and other variables.

4.2 Data acquisition: the expert consultation process

The first version of the model was constructed with the two authors of this article, with a frequent consultation with the MRC and several other relevant stakeholders and experts. This version was used to draw initial conclusions about the impact of different sector policies -and consequently of different management options- on the vulnerability of Tonle Sap Area as well as on 3 development goals (Varis 2003).

There was a clear need to integrate wider expert judgment on the model and to include the possible end-users firmer into the development of the model. Therefore, an expert consultation process –or stakeholder involvement process- was carried out. The emphasis of expert consultation was put on the three things: variables included in the model, the valuation of the structure of the model (link matrix) and input data (tendencies), and on the overall functionality of the model.

The process of expert consultation started with email contact to the experts that were seen as potential end-users of the model, and/or that could contribute with their expertise to the development of the model. The objective was to find as wide and diverse range of experts as possible. The experts contacted thus represented various different disciplines from various different organizations and institutions including government ministries, NGOs and the MRC. Approximately half of the experts were already familiar with the policy model. Due to limited time and resources for the actual expert consultation process, the amount of experts contacted was limited to ten persons. Due to two refusals, the expert panel finally consisted of 8 individuals.

The actual consultation process was carried out individually with each expert. For four experts, two separate meetings were held:

- *Introduction*. The model and software were introduced. The principle of the model was explained, and feedback was received, particularly from the functionality of the model and from the variables used in it.
- *Interaction*. The second meeting was held to evaluate the model structure and input data interactively. All experts also received CD-Rom containing the model software for further examination and analysis.

For the other ones, only one meeting took place due to time constraints, combining the above tasks. During the meetings it also became evident that the valuation of link matrix and tendencies is so time-consuming process that there was not enough time to go it thoroughly through with any of the experts. Instead, each of the experts concentrated to the variables and linkages s/he was most familiar with.

This also implied that the original idea of analyzing the differences between policy models defined by different experts was not possible. Nevertheless, the consultation process offered a great amount of information and feedback for the improvement and development of the model. For details, see Keskinen and Varis (2004a).

4.3 Model structure and variables

The model variables are grouped under 6 headings (Figure 2): sector policies, impacts on environment, on natural resources, on society,on economy, and goals.

Due to the varying levels of knowledge available, the changes and tendencies in the variables, their uncertainties, as well as the model's outcomes, are semi-quantitative. Attributes such as small increase, large decrease etc., and

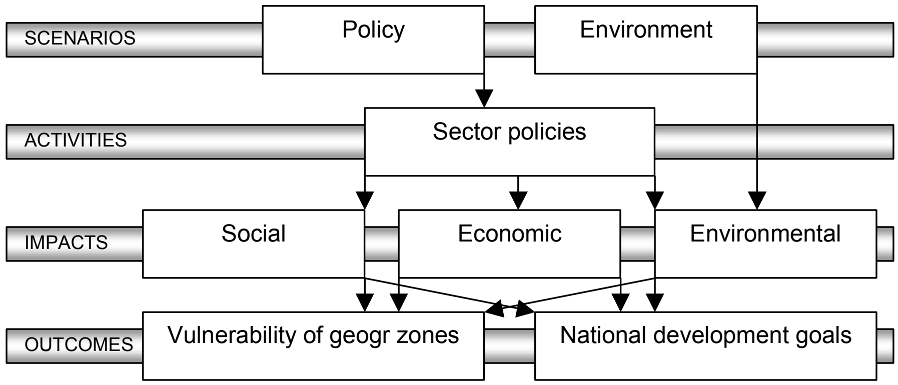

Figure 2. The logical chart of the analysis.

characterizations of the level and quality of knowledge these expected evolutions are used. Each variable can be linked to any other. In mathematical terms, this connection is a conditional probability distribution.

The model has 47 variables in total. They consist of 11 sector policies, 28 impact variables, and 8 development goals. Theoretically, the total number of links in this model is thus 47*(47-1) = 2162. Of these, 457 were used (for more details see Varis and Keskinen 2005).

The sector policies included in the Policy Model are:

- *Conservation*; The Tonle Sap is included in UNESCO's Biosphere Programme.
- *Small and medium-scale fisheries*; fish is the primary protein source for the region's people, and family fishing is of prime importance to the poor villages.
- *Large-scale fisheries*; the lake is used by commercial fisheries units that exploit the resource intensively, and often in disharmony with subsistence fisheries.
- *Agriculture, aquaculture, and irrigation development*; most of the villages cultivate rice and rice is the major staple food in the area. Rice farming has many forms depending on the location of the village in relation to the massive floods of the lake. Common to them is low productivity due to poor infrastructure and low level of resources to improve the yields.
- *Roads*; the road network is in a desperate state, but its massive reconstruction is under way. This will change rapidly the region's economy, and open the provincial towns to markets and trade.
- *Navigation*; harbors and other facilities are planned for improving the navigability of the lake. Tourism is one player behind these plans.
- *Water and sanitation services*; the water infrastructure is almost non-existing at the moment, and plenty of improvements are needed.
- *Rural development*; a variety of community and rural development activities are undergoing in villages, dominantly with foreign funding. Local authorities ally with NGOs, but the central government has little touch into this important activity.
- *Urban development*; the examples from economically blooming neighbors feed drams of developing Cambodia's towns and cities towards being attractive to foreign investments to industry and tourism. The famous Angkor temples could attract far more tourism than today.
- *Education*. Cambodia's schooling system has suffered vastly from the past conditions, keeping in mind the era of the Khmer Rouge that got brutally away of almost all educated people in the 1970s. Cambodian schooldays are among the shortest in the world. Much is needed to provide all Cambodian children an access to proper schools.
- *Formal institutions*; ministries in Phnom Penh live quite a different life from their local line agencies. This is only one example of the shortcomings of the Cambodian governance system.

Other variables are listed in Table 1. The model and its variables are described in more detail by Varis (2003) and Varis and Keskinen (2005).

5 SCENARIO ANALYSIS

5.1 Definition of policy scenarios

The policy scenarios are based on the different weightings of the three goals defined in the Mekong Agreement of 1995: environmental sustainability, economic growth and poverty reduction. Each of them is important to the development of the Tonle Sap Area. In many respects they conflict, but compromises are possible, and necessary, for balanced development of the area.

In the scenario analysis, one scenario that clearly prioritizes each of these goals is constructed. In addition, an integrated scenario is produced that makes a realistic compromise between these goals, in order to find win-win solutions between them. These scenarios are presented in Table 2, by using the notation defined in Table 3. The model allows interactive modification of the scenarios.

Table 1. Variables of the Policy Model. For policy variables, see text.

Theme	Group	Variable
Impacts: Environment	Water	Floods
		Droughts
		Suspended solids, sedimentation
		Toxics, oil spills
	Regional	Soil degradation
		Aquatic weeds, eutrophication, low oxygen
		Biodiversity decline
Impacts: Natural resources	Forests	Flood forests
		Other forests
	Agriculture	Floating rice
		Wet season rice
		Dry season rice
	Fish	Black fish
		White fish
		Small fish
Impacts: Economy	Subsistence	Fisheries
		Agriculture
	Market	Fishery (commercial)
		Cash crop farming
		Others (tourism, trade etc)
Impacts: Society	Poverty	Human development
		Food security
		Empowerment
		Social and gender equity
	Governance	Social cohesion
		Formal governance
	Migration	Rural push
		Urban pull
Goals	Vulnerability	Zone 1 to Zone 4
		Urban
	Sustainability	Economic growth
		Poverty reduction
		Environmental sustainability

When analyzing the vulnerability of the five geographical zones, the vulnerability can be reduced the more, the closer the zone is to the national roads. Yet, uncertainties involved are strikingly high. Other remarkable results are:

- *Environmental sustainability scenario*: vulnerability goes down only slightly. For Zone 1, there is not much change from the present level, in the others some improvement takes place.
- *Economic growth scenario*: higher uncertainties than in other scenarios.
- *Poverty reduction scenario*: best among the three basic scenarios in terms of reducing vulnerability, particularly in zones closer to the lake.
- *Integrated scenario*: Better than any of the three basic scenarios. More reduction of vulnerability and less uncertainties.

5.2 The three sustainability goals

With respect to the three sustainability goals, the policy scenarios give interesting outcomes. As can be expected, the economic growth scenario gives the best response in the economic growth goal. However, the difference is not too big to the poverty reduction scenario. In fact the latter contains much less uncertainties than the former, and is therefore better in a way. What comes to the other goals and scenarios, Figure 3 shows and Table 4 summarizes the results. The most important issues are:

- Economic growth scenario contains high uncertainties.
- Conservation scenario is not very favorable in achieving the goal Environmental sustainability, since it obviously ignores the villages and their development.
- Poverty reduction scenario gives fairly good results in all respects, but it can be clearly improved in the Integrated scenario by putting more attention to institutional development and some other issues that are obviously undervalued in the poverty reduction scenario.

Table 2. The four development scenarios investigated with the WUP-FIN Policy Model. For the notation, see Table 3.

	Conservation		**Economic growth**		**Poverty reduction**		**Integrated**	
	Mean	**Accuracy**	**Mean**	**Accuracy**	**Mean**	**Accuracy**	**Mean**	**Accuracy**
Society								
Formal institutions	>	**	>	***	>	**	>	***
Education, public health	>	**	>	**	>>	****	>	**
Urban development		***	>>>	****		*	>>>	****
Rural development (villages)		***		*	>>>	****		*
Water, infrastructure								
Water and sanitation services		**	>	*	>>>	****	>	*
Navigation		***	>>	****	>	*	>>	****
Roads	>	***	>>>	*****	>	**	>>>	*****
Agriculture, fisheries								
Agriculture, irrigation		***	>>	**	>	***	>>	**
Large-scale fisheries	<<	****	>>>	***	<	**	>>>	***
Small, medium scale fisheries		***	<	**	>>>	***	<	**
Environment								
Conservation	>>>	*****		***	>	**		***

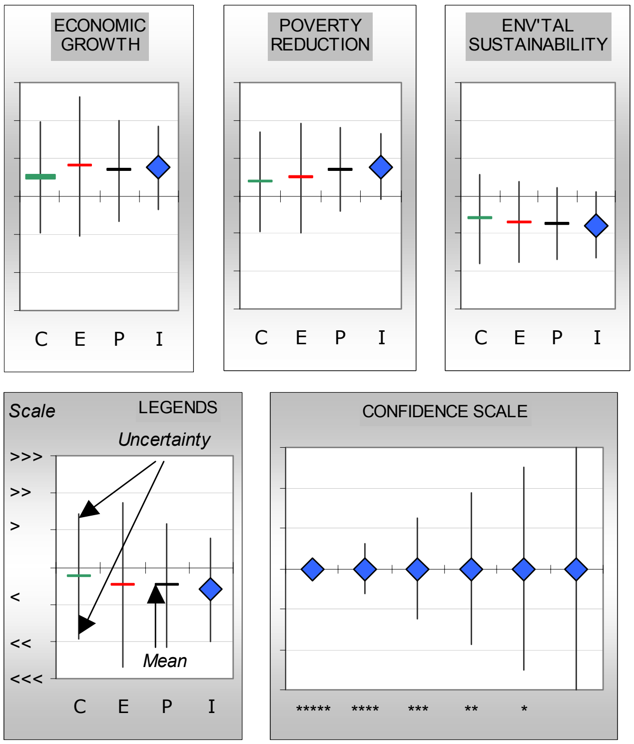

Figure 3. Results in the three development goals of the Tonle Sap Area with respect to the four development scenarios: C = Conservation, E = Economic growth, P = Poverty reduction, and I = Integrated. The legends are shown in the lower two diagrams.

A sensitivity analysis component was also made available to the model. A small perturbation is made to the prior probability distribution of each sector policy, and the response can be observed graphically, as in Figure 4. The plot shows the sensitivity of the goals to changes in sector policies. The further the line is away from the zero line (the circle denoted with 0.0%), the more impact the policy has on the respective development goal. The impact is negative if the line goes inside the circle, otherwise it is positive.

The sensitivity plot changes always when the scenario is modified, providing important information about how the scenario could be improved it with respect to each of the 3 development goals. In the Figure 4, investing in rural development, education and public health, and small and medium scale fisheries would yield best results in poverty reduction. Urban development and roads, in turn would benefit economic growth. Strengthening formal institutions would be beneficial to environmental sustainability.

It must be emphasized that the sensitivity results shown in Figure 4 are very much specific to the Economic growth scenario as defined in Table 4. Other scenarios produce different sensitivity results.

Table 3. The semi-quantitative scale used in the model.

Mark	All variables	Mark: knowledge level	Policy variables: credibility for a policy option	Others: knowledge level
	no change		Irrealistic	No
>	small increase	*	20% realistic	20%
>>	modest increase	**	40% realistic	40%
>>>	large increase	***	60% realistic	60%
<, <<, <<<	as above but decrease	****	80% realistic	80%
		*****	Will certainly come true	Fully known

6 CONCLUSIONS

The starting point of the policy analysis of the Tonle Sap Area was the Mekong Agreement of 1995, and particularly its Vision statement. It specifies three development goals for the basin: economic growth, poverty reduction and environmental sustainability.

The possibilities to find combinations of sector policies for achieving these, often conflicting goals were analysed systematically using a probabilistic, Bayesian network model. The model was specifically tailored for this purpose within the WUP-FIN Modelling Project. The Bayesian network approach turned out to be very useful in an analysis of this kind.

Table 4. Results of the four development scenarios with respect to the three development goals: economic growth, poverty reduction and environmental sustainability.

Goal \ Scenario	Economic growth scenario	Conservation scenario	Poverty reduction scenario	Integrated scenario
Economic growth	Slightly better average than in the two other basic scenarios. Very high uncertainty.	Lowest average and relatively high uncertainty.	Lowest uncertainty and not much lower average than in the Economic growth scenario.	Equal in average to the best of the basic scenarios (Economic growth) but much lower uncertainty.
Environmental sustainability	Sustainability goes down with all scenarios. Environmental sustainability scenario is slightly better in average but contains high uncertainties. Poverty reduction scenario and particularly integrated scenario contain less uncertainty and are therefore the best ones.			
Poverty reduction	Almost similar except economic growth scenario is more uncertain and slightly better in terms of average.		By far the best basic scenario.	Still better than the Poverty reduction scenario: less uncertain and better average.
Ranking	3	4	2	1

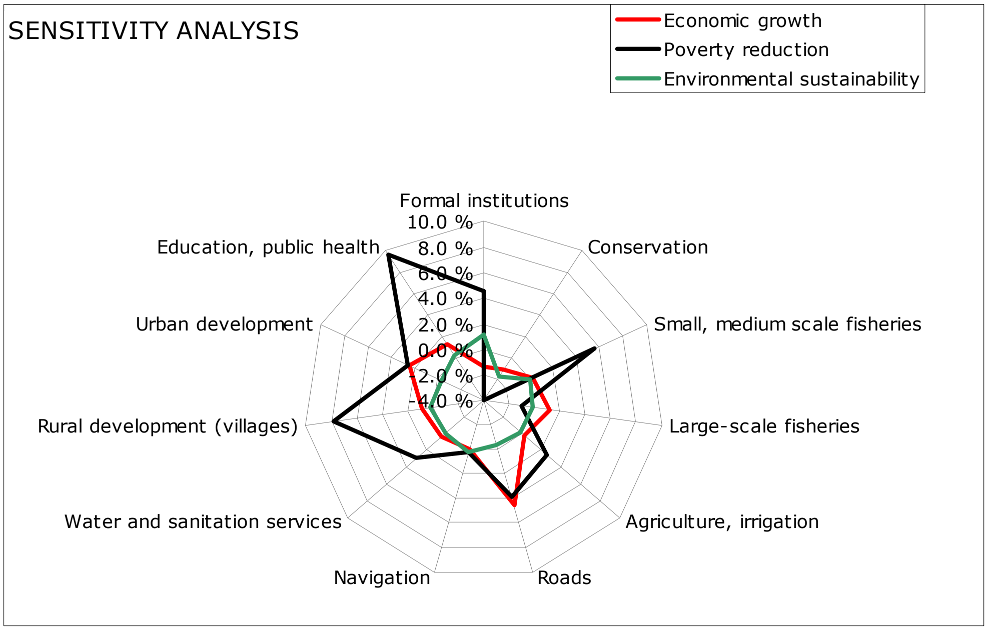

Figure 4. Results of the sensitivity analysis for the economic growth scenario.

Interestingly, some sector policies would be crucial for both the economy and poverty reduction, but not all. The huge shortcomings in education and institutions are obviously the ones that most strongly support these two goals. Rural development, in turn has a very important social function although it has not much immediate economical implication. Large-scale fisheries would be economically beneficial but counterproductive for poverty reduction. At the same time, with every scenario and sector policy, uncertainties related to their impacts remain very high and must therefore be appreciated. The reason for high uncertainties result partly from the lack of data, but even more importantly from highly complicated network of direct and indirect impacts that tend to be inconsistent in many cases, thus increasing uncertainty of possible impacts.

The biggest surprise was that the policies included in the model appear to be relatively toothless to environmental problems, particularly if defined as "environmental sustainability" as is done in the Mekong Agreement of 1995. This is obviously due to the following reasons:

- The concept of environmental sustainability is not easy to be conceptualized concretely enough so that it would be easy to treat analytically. In our model it is a combination of various issues and problems related to the environment and natural resources.
- As the majority of the population of the Tonle Sap area live in villages and make their living from the lake or the floodplain in a fairly direct way, the environmental issues are very closely bound to social issues. Social developments therefore are tightly bound to environmental impacts, and typically what happens in model simulations is that improvements in social conditions tend to introduce both positive and negative environmental impacts which cancel each other, seemingly to a great extent. The situation was different if the governance system was more efficient.

It must also be noted that the Tonle Sap system is governed by the mighty floods of the Mekong, which raise the water level up to 10 meters, and subsequently the surface area of the lake grows fourfold. The sediments and other mass flows are also dominated by these monsoon floods. There are no handles in the sector policies included in the model that would allow the control of these issues.

Besides the input to the WUP-FIN Policy Model itself, what are the lessons learnt from the expert consultation process? First of all, expert consultation proved to be a laborious task that demands lots of time and effort, and good human relations skills. These are particularly important when the methodology used is unfamiliar for a stakeholder and no immediate personal benefit from it is seen. In such situations the individual is –quite naturally- not too eager to participate in the model development and the concept and usefulness of the model has thus to be explained comprehensibly for him. Although it is important to involve the stakeholders into the model development from the very beginning, it seemed useful to have an initial model version ready when starting the expert consultation: in this way it is easier for stakeholder to understand the actual concept of the model, and consequently, to use, develop and give comments on it.

The WUP-FIN Policy Model proved to be a useful tool in analyzing impacts and uncertainties of different management options and finding compromise solutions between them. Thus, the policy model helps the decision making and possesses a great potential for further development and adaptation.

However, the model requires from its user certain allocation of time and effort before it can be utilised in full scale. User-friendly model-interface and a good training package help to get the stakeholders firmer involved in the use and development of the model, and they must therefore be an integral part of the model development. In addition, good human relation skills are vital condition for successful stakeholder involvement, and consequently, for full use of the model.

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