Understanding the policy implementation deficit of the Swedish Environmental Quality Objectives system

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Abstract
The Swedish Environmental Quality Objectives (EQO) are sixteen in total and describe the desired state of the environment within one generation in each of the areas the EQO addresses. In the brief history of the EQO, there has been need of understanding what and how to measure success towards fulfilling the EQO. There is a need to create a better transparency between the implementation of policy to carrying out measures to, observing changes in the status of the environment into the desired direction. In this regards, identifying and understanding feedback loops and key driving forces that render implementation of environmental measures non-successful. This study analyses in what way environmental policy implementation can be better connected to success indicators and observation of changes in environmental state over time. And gives a proposal for a new gap-analysis process that is coupled with simple system dynamic modelling. The result of the case study show that the implementation of environmental policy has to be put into the context of understanding different time delays of the different factors within the system, i.e. time until environmental state has reach its target value. The study is ongoing and shows how novel qualitative analysis can be used to compare different types of policy option that address different types of strategies within the EQO.

Keywords: System dynamics, qualitative analysis, Sweden environmental objectives, causal loop diagrams, policy analysis

1 Introduction and purpose

The purpose of this paper is to showcase the approach the SEPA is taking in analysing the Environmental Quality Objectives (EQO) and its policy option. The study will show how novel qualitative systemic analysis can be used to compare different types of policy option that address different types of strategies. This is an on-going work and part of the main analysis package of the SEPA work on “In-depth evaluation” and an overall assessment of the Swedish environmental long-term reporting.

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1.1 Introduction to the Swedish Environmental Quality Objectives (EQO)

In 1999, 15 environmental quality objectives (EQO) were adopted by the Riksdag (the Swedish Parliament). They are contained in the Government Bill 1997/98:145, Swedish Environmental Quality Goals - An Environmental Policy for a Sustainable Sweden. The basic idea behind the Sweden's environmental objectives was to address the environmental problems now, and not have the passed on to future generations. In 2005, a 16th objective (on biodiversity) were adopted. The overall direction of the environmental efforts is guided by a generational goal, which indicates the changes in society that need to occur in order to reach the EQO's within one generation.

The EQO's are followed up on a regular basis, with annual reports to the Swedish government and through an in-depth evaluation, every parliamentary term. The 3rd in-depth evaluation was handed over to the government in June 2012. The next in-depth evaluation will be delivered to the Swedish government in June 2015.

1.2 Issues with measuring success

One of the lessons learnt from the In-depth evaluation 2012 (Steg på vägen. Fördjupad utvärdering av miljömålen 2012, June 2012), was the need to properly define and understand how to measure success. The environmental problems are complex and the goals formulated around solving them require often a complex set of policy actions. A mixture of short and long recovery time and issues covering different geographical scale make it difficult to derive effective set of policy option that can both address specific issues and not hinder goal fulfilment on a broader level. This poses challenges to policymakers that want to develop policies for improving the state of the environment and for the agencies and stakeholders involved that subsequently have to implement them. This complexity also creates difficulties when anticipating how policies affect the public administration and the state of the environment that are to be monitored and evaluated.

Policymaking initiatives and policy instruments that are implemented, assume a central role in assessing progress towards the Swedish environmental objectives. Depending of the type of policy instrument, the link between the environmental state and the policy can be more or less transparent. Decisions taken at the political level have to be implemented by a number of different actors if the policy adopted is to have an effect. Administrative instruments of various kinds often linger longer through the public administration before a change in activities in the society and a change of the state of environment is observed {*SEPA 2012*}. One example of this is the supervision under the Environmental Code and regulation. In other cases instruments have a shorter implementation chain, like the nitrogen oxides charge, where a decision results in change of activity more directly.

To enhance the transparency of the implementation chain and make the link between policy instruments and the chains in the state of environment more visible, it is important to identify feedback loops and key driving forces that creates the conditions for the implementation deficit that is repeatedly shown in the yearly reviews and in the in-depth evaluations of the EQO's {*SEPA 2012*}. This would create a more solid base for policymakers to make informed decisions and for agencies and other stakeholders to make the right priorities in their efforts to achieve the Swedish environmental objectives.

2 Introduction to case

In order to understand and test the new analytical approach for the EQO. A showcase study was chosen, the EQO *Good-Quality Groundwater* was chosen (www.miljomal.se). The definition of the EQO is as follow {*SEPA 2012*}:

Groundwater must provide a safe and sustainable supply of drinking water and contribute to viable habitats for flora and fauna in lakes and watercourses.

"Groundwater is important as drinking water forhumans, and also affects the habitats of plants andanimals in surface waters. Emissions of environmental lyhazardous substances can contaminate this water resource – pesticides are one example, particularly in agricultural areas of southern Sweden. Sodium chloride (common salt) from roads salted inwinter has also found its way into groundwater. As well as affecting the quality of the water, this causescorrosion of water mains....Eskers and similar formations in the landscape are important sources of drinking water. These natural gravel deposits are also of significance for our energysupply, the natural and cultural landscape, and recreation. At the same time, there is pressure to extractgravel from them, for concrete and other uses. By creating more protection areas, the authorities can safeguard deposits of this kind against exploitation" {*SEPA 2012*}.

The following assessment of the prospects of achieving the objective (forecast for 2020) was made in 2012:

> *"Contaminated groundwater occurs throughout Sweden, but mainly in agricultural and densely populated areas. A quarter of private wells supply water unfit for human consumption. Use of natural gravel has been curbed by stricter legislation. Meeting this objective will require measures taken in the areas of environmental supervision and water management."* {*SEPA 2012*}

Each of the Swedish EQO's has a number of **specifications** which aims to clarify the state of the environment to be attained. The EQO Good-Quality Groundwater has a total of 6 specifications. They are (SEPA: www.miljmal.se):

- *the quality of groundwater is such that, with few exceptions, it does not limit the use of groundwater for public or private supply of drinking water,*
- *bodies of groundwater covered by the Water Quality Management Ordinance (2004:660) have good chemical status,*
- *discharging groundwater is of such quality that it contributes to good habitats for plants and animals in springs, lakes, wetlands, watercourses and seas,*
- *bodies of groundwater covered by the Water Quality Management Ordinance (2004:660) have good quantitative status,*
- *groundwater levels are such that there is no negative impact on water supply, ground stability or animal and plant life in nearby ecosystems, and*
- *natural gravel deposits that are of major importance to the supply of drinking water, energy storage and the natural and cultural heritage continue to be preserved.*

2.1 Defining system boundaries

The EQO Good-Quality Groundwater can be defined into two target areas; *water quality* and *water quantity*. In both target areas, a specific objective of the future environmental state is described. The current status on water quality and water quantity illustrates the "gap" between the desired state and the actual state. In order to define the key parameters for the EQO, the authors used five steps (fig. 1).

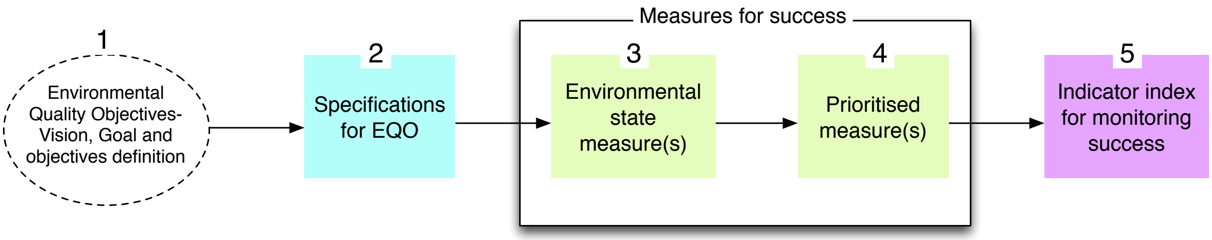

Fig 1: Defining key parameters through 5 steps.

The definition of key parameters is done through five steps; where the EQG goals and objective are defined (1) and a list of its Specific Objectives for the environmental state through space and time are detailed (2). The measures for success, i.e. what the desired environmental state is for each Specific Objective and its indicator target value (3) are defined. The prioritised measures (4) are the Specific Objectives that contribute most to the fulfilment of the EQG, e.g. out of 8 Specific Objectives of the EQG, four of them could contribute to 90% of fulfilling the EQG as a whole. Since the Specific goals have different definitions and different indicator units and values, it is necessary to define indicator index (5) that sums up the total impact of each prioritised measure in relation to the fulfilment of the EQG as a whole. In the case study, the basic parameters chosen for measuring success where; "Available drinking water- in ground" and "Pollution in groundwater". The parameters in the study are unit-less.

3 Methods

The purpose of using prioritised EQO measures to define both status and progress toward success is to enable scaling of what policy parameters are necessary to preserve and maintain the function of the water quality and water quantity. For this purpose a Causal Loop Diagram (CLD) method [2] was used {Richardsson 1981;Sterman 2000;Cavana 2004;Binder 2004;Haraldsson 2004; Haraldsson 2006} and a CLD was developed in order to define and confine system boundaries of the EQO and furthermore define the appropriate level of details for analysing the policy parameters. Previous work {Wolstenholme 1983; Wolstenholme 1999; Burns 2001; Luna-Reyes 2003;Binder 2004;Haraldsson 2005;Lorenz 2012; Lorenz 2014} has focused upon using the system dynamic qualitative approach to highlight simple structures as either CLDs or stock and flow diagrams (SFD), and often in relation to transferring a qualitative model to a quantitative one. This study utilises the CLD modelling approach and utilises the

[2] *Causal Loop Diagrams show cause-effect of variables that either change in the same direction (indicated with a "plus") or change in opposite direction (indicated with a "minus"). Processes that feedback in the same direction are called reinforced processes (indicated with R) since they amplify a condition and processes that feedback to give change in opposite direction (indicated with B) balance (dampen) out a condition.*

modelling tool Consideo[3] to construct the CLDs and perform the qualitative analysis of different policy options. The analysis utilises a relative scale 0-100 as provided by the software.

4 Results and discussions

The analysis of the EQO Good-quality groundwater shows that the two prioritised EQO Specifications, Quality and Quantity, is depended upon how accessible the water is and where the supply is. Although Sweden has high water supply per capita and it is available in high quantity, it is not located where it is needed. The urban areas in Sweden are more often depended upon local water supplies. Therefore the focus of the EQO Good-groundwater quality has been partially upon where water is available for urban use and its quality.

4.1 Results of the Causal Loop Diagramming

The EQG Good-quality groundwater CLD was mapped with focus upon water quantity and water quality. The main question posed and answered through the CLD was: "What are the main factors that maintain water quantity and quality, and contribute to the fulfilment of the EQO?".

The definition of the system boundaries and confinement of the is illustrated in fig 2-5. The key factors that the CLD addresses is the quantity status of the EQO through available drinking water (*Surface water and Groundwater) and qualitative status through Pollution in the drinking water (Surface water and groundwater)*.

Fig 2 illustrates the availability of drinking water as part of describing **water quantity status** of the EQO. The surface water and the groundwater provide available drinking water (B1). The Available surface and groundwater is depended upon how much is flowing with in the ground and on surface and how *pollution* is affecting the available surface and groundwater available for consumption. The expression of water flowing out of the system is expressed through loop B2. The available water in the system is described through stocks of gravel deposits that can hold certain amount of water quantity (see fig. 3).

[3] www.consideo.com

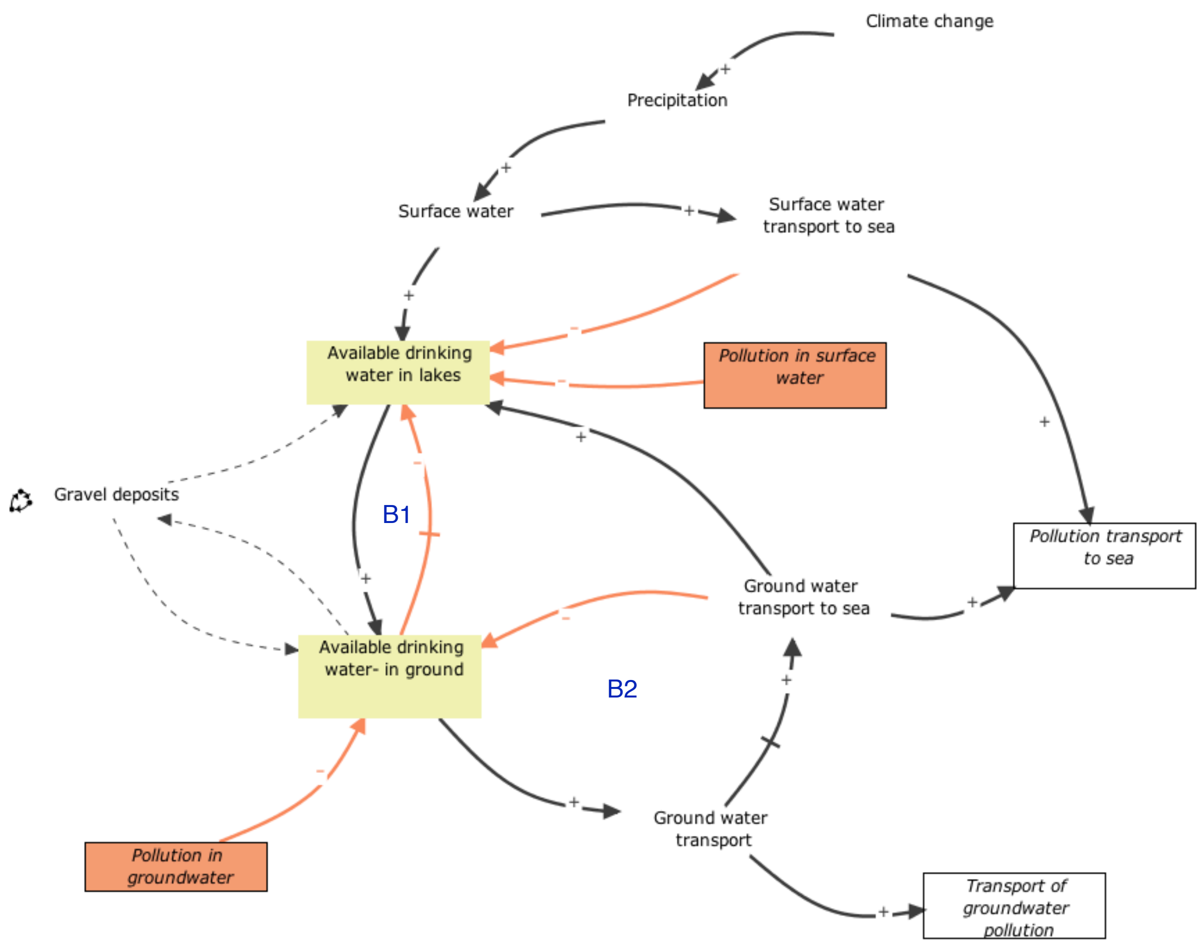

Fig. 2: Water quantity expressed as available surface and groundwater for consumption.

4.2 Gravel deposits as ecosystem functions

The gravel deposits can be considered as a form of ecosystem service (provisioning services) that provide both quantity and quality of water. This is described as, 1) how much water quantity can the gravel deposits hold that is available for consumption and, 2) how much does pollution affect the available water quantity for consumption. The quality aspect of the water is determined by how much of the water is affected by pollution and is in relation to maximum level of contaminants allowable for consumption. In figure 3 the natural gravel deposits are the main stocks that hold the available water for consumption. Using the natural gravel deposits for water infiltration is a form of land use based upon a non-renewable resource, i.e. the gravel deposits. And in order to maintain that land use form, it deprives the option of using the area for other activities that can jeopardise the fresh supply of water through pollution, or activities that physically remove the resource (*gravel use*). On the other hand, it is possible to shift the land use of the resource without jeopardise the ecosystem function through pollution or removal, e.g. *Natural gravel deposits area usable for energy storage (R1).* Land use through energy storage is relative small scale currently but shows the potential how land use activities can shift over time. One of the secondary effects of land use as groundwater infiltration is the possibility to combine it with cultural-landscape and ecosystem conservation, in which conservation is enhanced by the infiltration land use practice.

Unfortunately, there has been a tradition within the commercial building sector to use gravel deposits as foundation in construction of roads and buildings {*SEPA 2012*}. This activity removes the gravel deposit altogether and reduces the total infiltration capacity of the gravel deposit area and its function for providing clean available drinking water for consumption (fig 3).

4.3 Policy options to influence system parameters

A different set of policy option have been considered and partially implemented for maintaining the level of gravel deposits as well as reducing the level of water consumption and water pollution {*SEPA 2012*}. Figure 3,4 and 5 shows different policy options that focus on influencing specific activities through out the CLDs. The policy options are:

1) Taxation on gravel use from industry (in place)
2) Area protected and designated for infiltration (in place)
3) Allocating area for energy storage (not in place but planned)
4) Water saving strategies (partially in place)
5) Reducing rock salt use on roads (in place)
6) Reducing release of mercury from forestry (not in place)
7) Reducing point source pollution from industry (partially in place)

Policy options show what is being influenced but does not describe the administrative level of details how the influence impacts the target factor. For instance, the policy option 1- taxation on gravel use from industry is a generic tax that resulted in shift in consumption of gravel deposits to other type of products. The policy options show where there is a possibility to shifting or prevent activity to happen, that in turn influences the water quantity and water quality of the system.

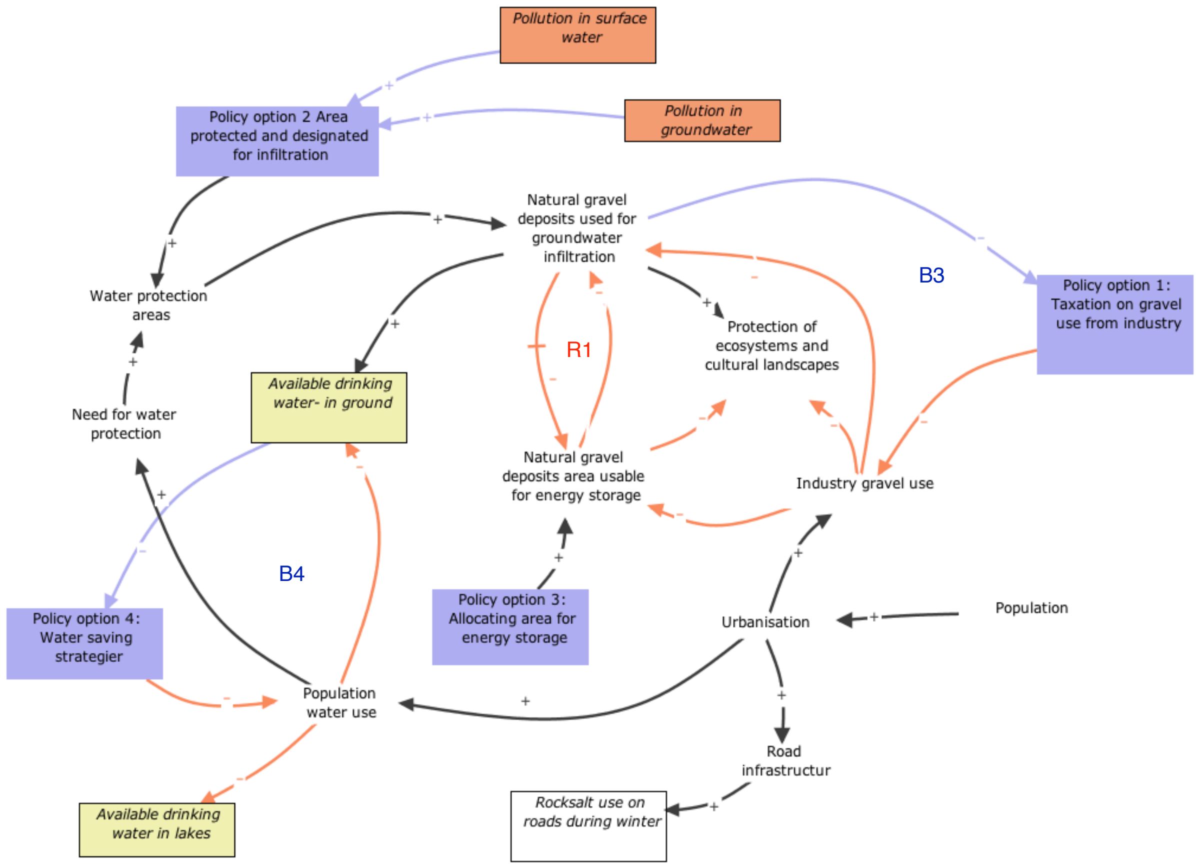

Fig. 3. Natural gravel deposits provide ecosystem services through provisioning of water quantity and purification of water through infiltration. A different set of policy options are being planned (and are partially implemented) to maintain natural gravel deposits. The initiative, in part, for the policy option being concern is described by the feedback loops B3 and B4.

Figure 4 and 5 describe the **water quality status** of the EQO. Mercury deposition is source of major concern and important pollution factor (fig4). Mercury source is from industries outside of Sweden and the deposition is directly into surface water and on soil. The mercury accumulates in the soil and is transported through the groundwater system to the surface and ultimately to the sea (see loops B5-B8). Although the biota is effective in storing the mercury in the soil, its level is affected by disturbance of the topsoil. The forest industry operations more often disturbs the topsoil and cause the release of mercury. The policy option 6 shows the impact of reduction mercury release due to changed forest practices, e.g. clear cutting happening during winter when soil is frozen etc. The release of mercury due to forestry practices triggers the reinforcing loops (R2) which is strengthened by the reinforcing loop (R3), causing increasing levels of mercury in groundwater and surface water as long as the undesired activity continues.

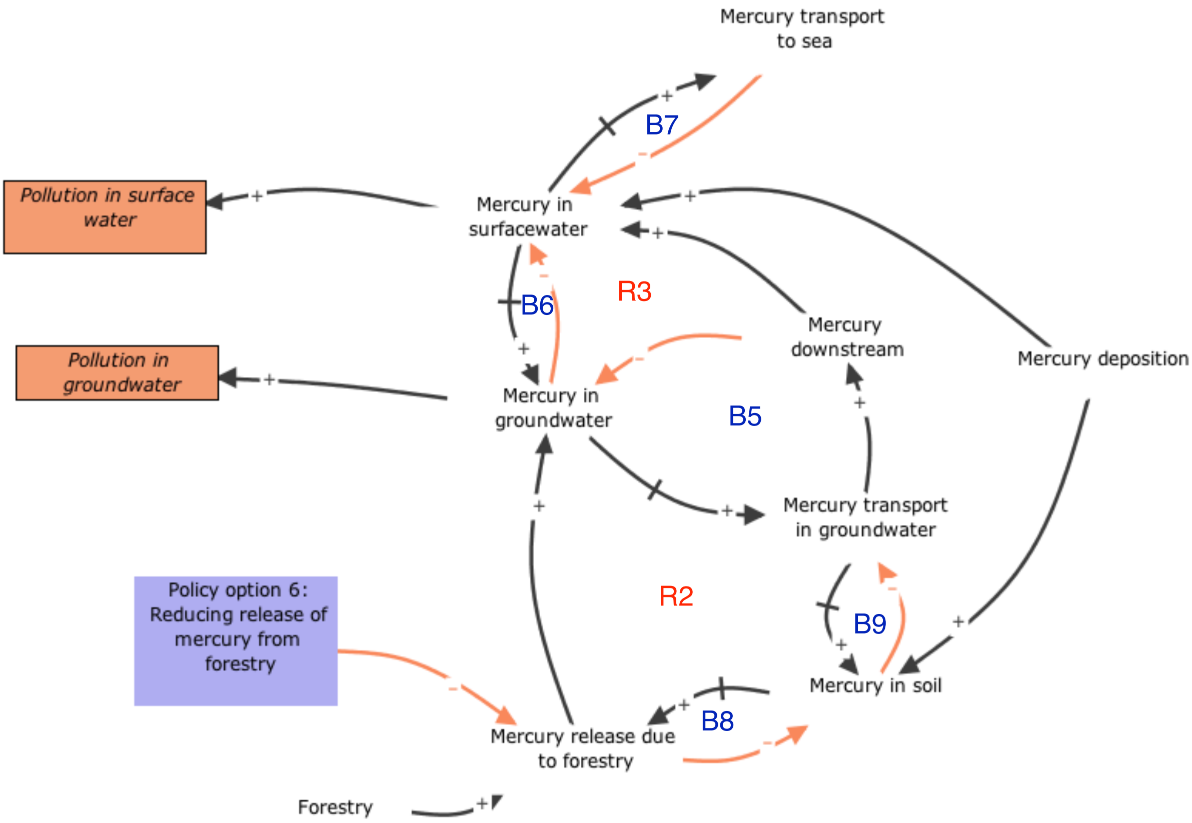

Fig. 4: Mercury deposition as a source of pollution in groundwater.

In figure 5, the pollution in the surface water and groundwater affects the available drinking water. Although point sources of pollution are concentrated to specific areas in Sweden, they reduce the total amount of water available for consumption. Similarly to mercury, some pollutants are stored in soil and transported through the surface or ground system (see loops B10-14). Others, such as chloride from rock salt are soluble and have impact as long as the source continues. Sources of pollution happen on different scales in time and space, as general deposition sources (nitrogen) and point sources (phosphorus). In figure 5, the policy options 5 and 7 aim at reducing point source releases. Policy option 5 is initiated through the loop B15.

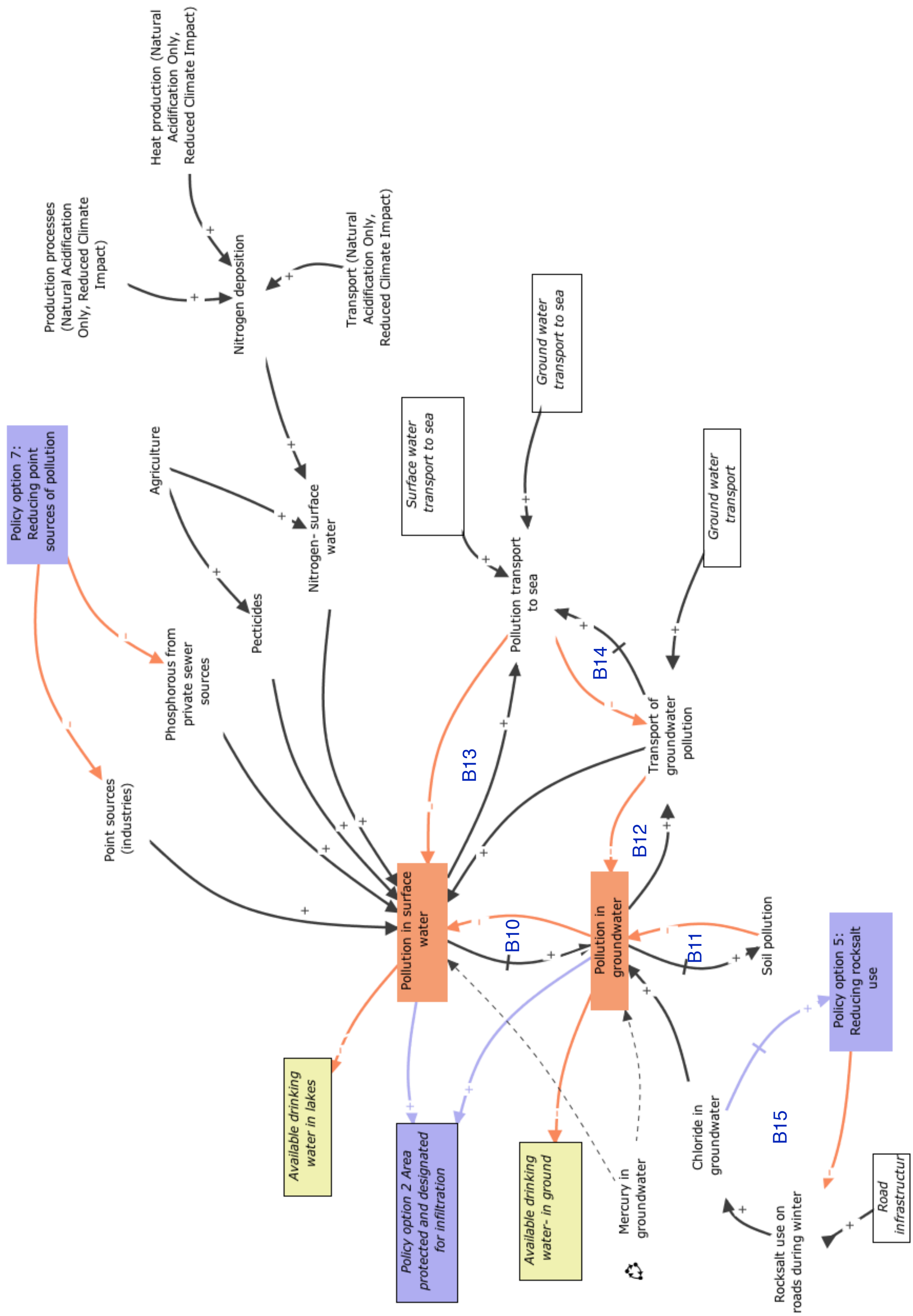

Fig. 5: Water quality is expressed as the impact on available surface and groundwater . If the water pollution is above acceptable levels, the quality for consumption is reduced and therefore the available drinking water reduced.

4.4 CLD Policy options analysis, results and discussions

The CLDs illustrate that the water quantity available for consumption is depended upon how much is physically being held in storage by gravel deposits (Available drinking water in ground) and how much is available of non-polluted water (indicated by Pollution in groundwater). Therefore the policy options must focus upon two strategies in order to maintain the water supply for consumption:

Strategy A: Increasing the amount of water supply in natural reservoirs.
Strategy B: Reducing the level of pollutants reaching the groundwater.

For simplification, the policy analysis will focus on groundwater supply and pollution (and exclude the surface water) since the storing capacity of water is mainly in gravel deposits. ***The results in fig 6-8 show relative impact of policies, scaled from 0-100.***

The results of policy option analysis show effectiveness of the different policy options. In figure 6 the policy option 4 has the largest impact upon increasing/maintaining the amount of groundwater available in the short and medium term. Whereas the policy option 2, is a stable measure over the short and long term perspective. Both these measures should be considered in combination. Policy option 3 is different since the focus of the measure is to increase energy production (as part of fulfilling other EQOs) but doing so will negate the possibility to use it for water consumption. Here the relative impact is rather high and shows that this policy option should be carefully weighted against other options.

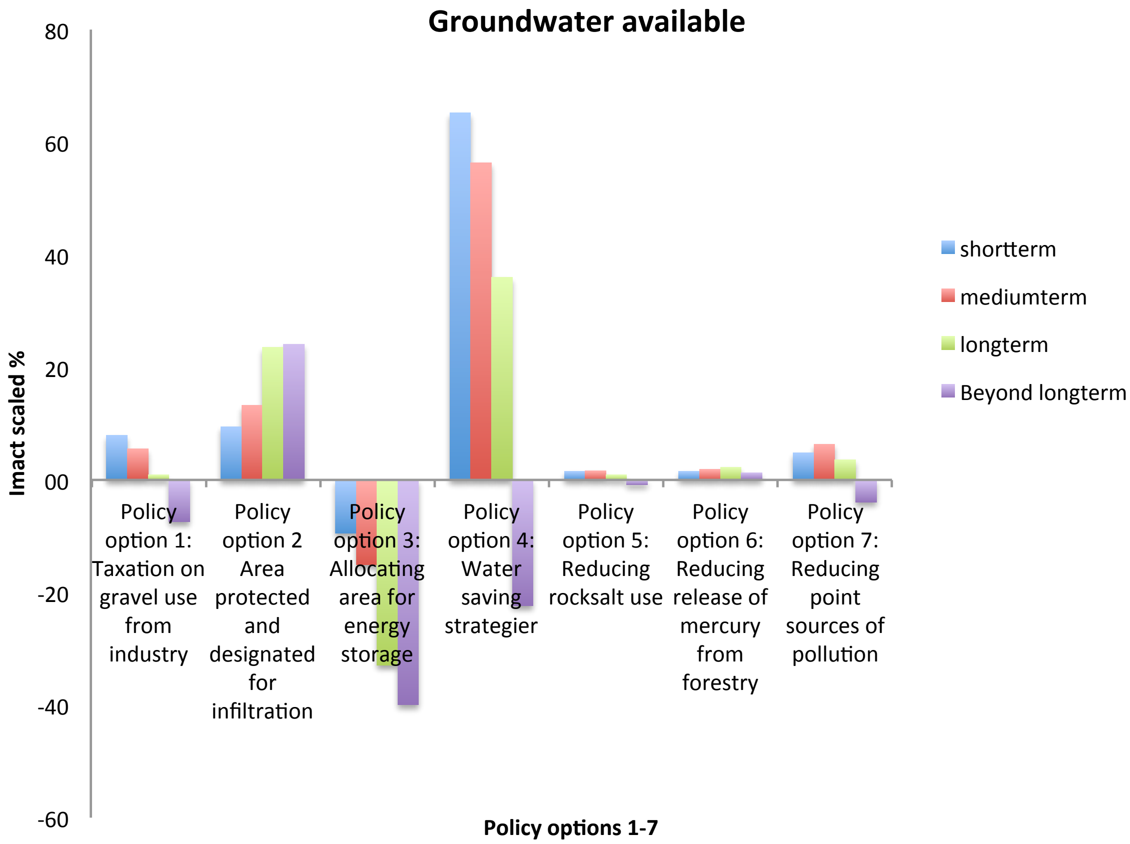

Fig. 6: The impact of policy options upon groundwater available for consumption. Policy option 2 and 4 have a large impact upon maintaining available groundwater although the effect of the policy option 4 will reduce over time. Policy option 2 is stable option over time.

Figure 7 shows the impact of policy options upon reducing groundwater pollution. Policy options 5,6 and 7 have strong impact upon reducing/preventing groundwater pollution, which is expected. But policy options 1-5 show virtually impact upon water quality measures.

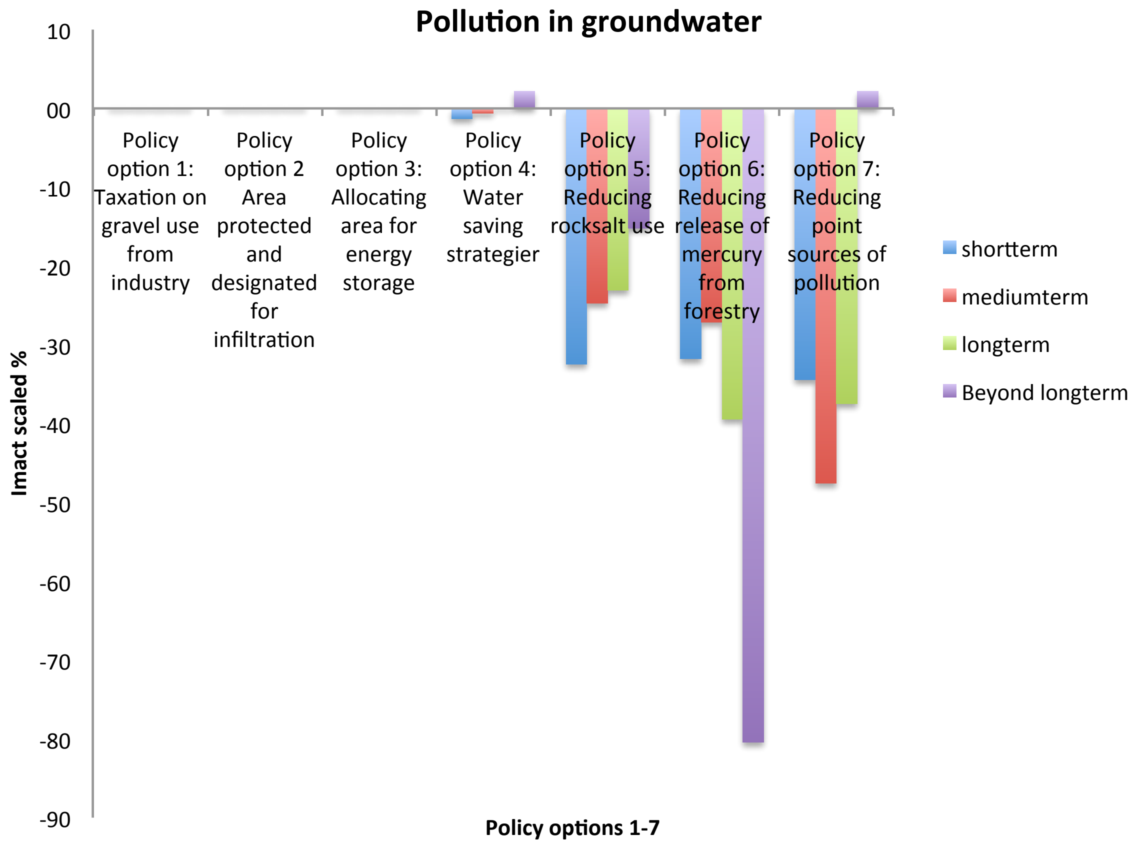

Fig. 7: The impact of policy options upon reducing groundwater pollution. Policy option 5,6 and 7 have strong impact upon reducing/preventing groundwater pollution.

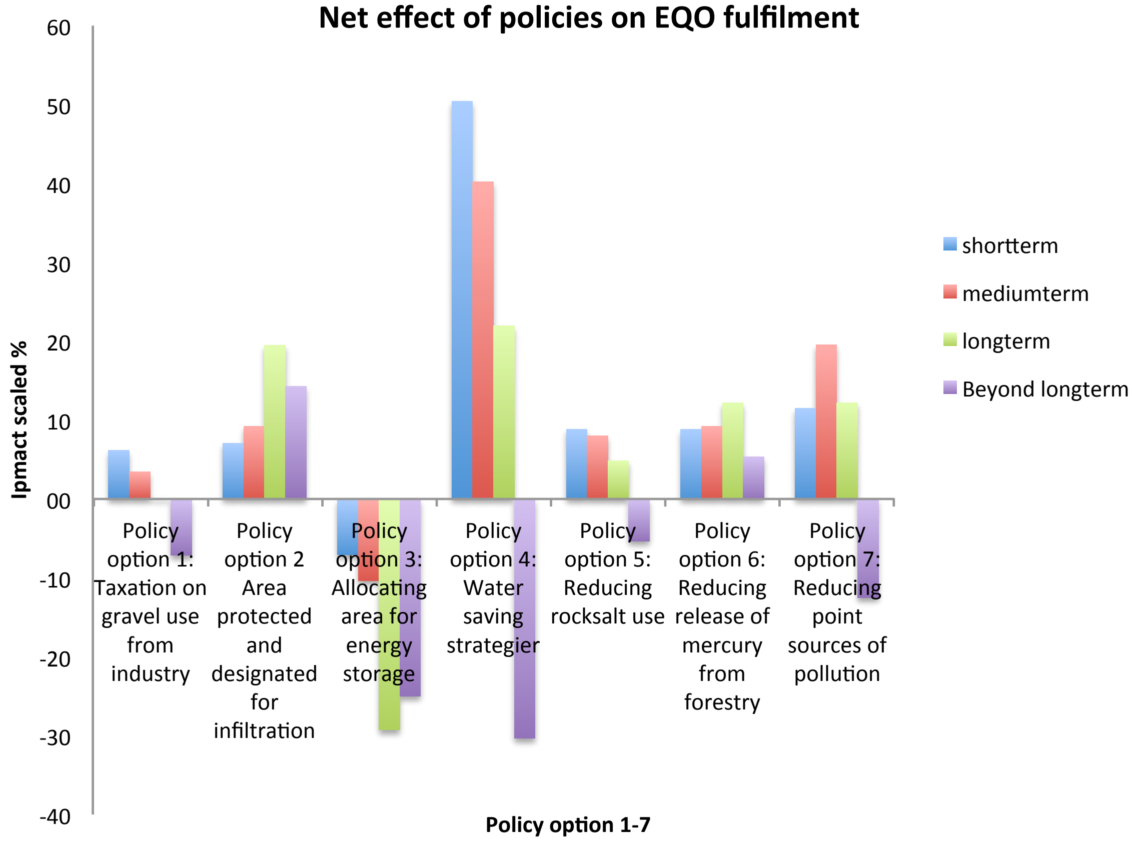

Fig. 8: The net intended effect of all the policy options (apart from policy option 2) on both reducing pollution in groundwater and maintain a good quantitative status shows a high initial effect but a reducing effect over time.

The Figure 8 shows the integrated effect of all the policy option upon fulfilling the status of available groundwater for human consumption and reducing/preventing pollution of groundwater as part of the EQO goal fulfilment. Although the two separate strategies, increasing the amount of drinking water (A) and reducing the level pollutant reaching the groundwater (B) have a win-win effect upon EQO goal fulfilment, the policy options impact differ between those two. The policy option 1-4 has impact upon strategy A whereas policy option 5-7 has primary impact upon strategy B. When the effect of strategy A and B are put together into context of EQO fulfilment as whole, the net effect (cocktail effect) of the policy options 1-7 slightly different than A and B separate. Fig. 8 shows that policy option 1, 4, 5, 6 and 7 are most effective in the short-term and medium-term, and show a sharp reduction in effect of the policy in the long-term, even negative. This indicates that these policy options should be designed through a short- to medium-term perspective, or with a shorter update cycle in mind. The policy options 2 and 3 are more effective in the long-term and indicate that a longer policy planning cycle should be considered.

The limitation of the analysis is that it only shows the relative impact of the policy options upon quantitative status (available groundwater) and qualitative status (pollution in groundwater). The results presented in figures 6-8 show a neutral weighing, i.e. connections between the factors have equal weighting in the model. This method gives a good idea of basic the morphology of impacts upon the strategies and how they are distributed in the model. A further step would be weighting the impact between the factors (arrows) based upon known facts or data. This would give a better idea of prioritisation of the model factors and their relative strength of impact upon the goal strategy.

This qualitative analysis is the basis for a system dynamic modelling analysis. Quantitative modelling work (in Stella) is underway and has already identified key variables needed to connect to relevant policy options. The aim is to create an integrated model that enables scenario analysis of key policy options that influence goal fulfilment of all the Swedish EQOs.

Further work

This work is an example how SEPA intents to model the Swedish EQO. The continuation of the work will see integrated analysis of different policy options that are cross-cutting between EQOs and their impact over all EQO fulfilment. All the EQOs will be modelled and results will be available in the autumn 2014. The work will furthermore identify where quantitative modelling can contribute through system dynamic modelling. Stella modelling effort is well underway and will eventually cover all the relevant EQOs. The main results will be produced in the main report “In depth Evaluation of the Swedish Environmental Quality Objectives 2015”.

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