List of collated questions from QWMN CoP Multiple Plausible Futures Event

Participant Numbers attending: 84

Question for: Joseph
Question from: Jiadi Li (University of Utah)

just curious about how cost of performance can be measured?

Response from Joseph - Holger will show an example of this: looking at robustness of an optimal solution

Question for: Joseph
Question from: Brian McIntosh (IWC)

What are the key strategies that one might take to encourage the use of adaptive approaches?

Verbal Response from Joseph:
- Passive adaptive management is easy to get people to accept
- Active adaptive management is trickier to implement

Response from Holger:
As per the figure Joseph showed in his presentation, a few criteria should be considered to determine whether adaptive or robust solutions should be adopted. In cases where uncertainties over the planning horizon are very high, then the cost of gold-plated, robust solutions is very high, making a compelling case for adaptive solutions.
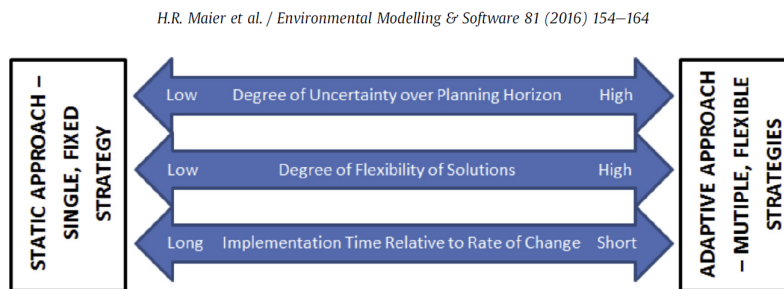
H.R. Maier et al. / Environmental Modelling & Software 81 (2016) 154–164

Fig. 4. Conceptual representation of conditions favouring the two main approaches to developing solutions when faced with multiple plausible futures.

Question for: Joseph
Question from: Jim Fear (SEQ Water)

What if decision making vs probability decision making. Eg low probability so no need to plan vs if it does happen we have a plan.

Response from Joseph - absolutely, if we think a scenario is unlikely then we probably don't need to be robust to it, but do need to have some kind of contingency plan - at the very least having governance arrangements that have a clear assignment of responsibilities in the case of a crisis

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Question for:
Question from: Jo Owens (USQ)
Joseph, what percentage of modellers do you think address uncertainty in their work?

Response from Joseph
every modeller addresses uncertainty in some way (see ref below)
The % of modellers quantifying uncertainty is probably still low (25%?), the % using scenarios in some way is probably higher (40%?). No real evidence for those numbers though- just a gut feeling.

Guillaume JHA, Helgeson C, Elsawah S, Jakeman AJ, Kummu M (2017) Toward Best Practice Framing of Uncertainty in Scientific Publications: A Review of Water Resources Research Abstracts. Water Resources Research, July. doi:10.1002/2017WR020609

Question for: Joseph

Question from: Lee Foster (Innovate Wisely Pty Ltd)
 can you please put the link into the chat box?

Response from Joseph - https://link.springer.com/book/10.1007/978-3-030-05252-2
The society: http://www.deepuncertainty.org/

Question for: Joseph
Question from: Matt Chesnais (Queensland Fire and Emergency Services)

What can be done where there is demonstrable robustness and confidence in the model but agreement is still low? How do you resolve this in decision making?

Response from Joseph - @matt chesnais - Dealing with disagreement is obviously a complex, case specific question! Robustness can help if we can show that the same decision or same outcomes are achieved regardless of the perspective taken (i.e. it's not just about robustness of the model). Adaptiveness can help if we can show that new issues will be able to be addressed as they emerge. Motivated reasoning is still an issue to get people to change their mind... This is an area where it is interesting to share practitioner experiences...

Question for:
Question from: Badin Gibbs (UQ)

@Joseph @Holger: Are there any examples where both a top-down and an adaptive approach have been applied to the same problem at the outset (cf., implementing adaption at some later stage as in Holger's first example)? If so, how different were decision options?

Response from Joseph - @badin - there's also quite a few studies comparing static vs adaptive approaches, and as you'd expect adaptive approaches tend to perform better (if the problem is suited to them)

Response from Holger – Top-down methods relate to scenario generation and adaptation to solution generation. So there are two different approaches to developing scenarios –top-down, which are driven by plausible changes in drivers of change (e.g. different carbon futures) and bottom-up, in which scenarios are tailored to stress test systems under the conditions their performance is most sensitive (vulnerable) to and two different approaches to developing solutions to cater to different scenarios (irrespective of how these were generated) – robust, where we develop "gold-plated" solutions that stand up to whatever scenario you expose them to and adaptive, where solutions are changed in response to new knowledge about which scenario is most likely.

Question for:
Question from: Jo Owens (USQ)

Would you have any suggestions to deal with trade-offs?

Response from Holger: There are different approaches to dealing with trade-offs:
- If the number of options is small, methods such as multi-criteria decision analysis (MCDA) can be used to take stakeholder groups through a formal, participatory process to arrive at an agreed-upon ranking of options.
- If the number of options is large, multi-objective optimisation methods can be used to identify the solutions that provide the optimal trade-offs between competing objectives, which can then be discussed by relevant stakeholder groups or subject to formal multi-criteria decision analysis or visualisation methods.

Question for:
Question from: Jim Fear (SEQ water)

Problem with adaptation is that you do not know whether climate change has occurred until the drought happens. So maybe having a well defined drought response plan is "better" than building in anticipation of a future drought caused by climate change?

Response from Tony Weber - Hi Jim, that's a good point, but the adaptive decision frameworks can actually set up the plan in exactly that way, that you have a response plan that address the lack of knowledge around climate change

Response from Joseph - @jim fear - agreed, it's not necessarily adaptation to climate change, it's adaptation to multiple plausible future conditions. The question is: how severe a drought are we prepared for?

Question for: Holger
Question from: Alvin Li (Water Technology)

Hi Holger, I didn't catch the slide of the R package you guys develop...just wondering what this package can be used? if you can tell us a bit more about it?

Response from Joseph - @alvin: https://cran.r-project.org/web/packages/foreSIGHT/index.html

Response from Holger
This is the link to foreSIGHT:https://CRAN.R-project.org/package=foreSIGHT

Question for:
Comment from: ajonesgill

just a comment - these "dotty" plots are very powerful! in my experience, visual analytics can be key to having decision makers accept and see this kind of modelling as useful

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Question for:
Question from: Kwabena Opoku

It was great joining today's webinar, hearing all these amazing presentations. Just a quick question, to Holger maybe, how do you modify and apply some of these models to developing countries settings, where issues of data availability and accessibility is a huge challenge?

Reply from Avril - @kwabena I think this is where things like Conditional probability networks can play a big role as they can take data and expert belief. Also big role for sensitivity analysis

Response from Holger - @kwabena start with the decision and sensitivity analysis is a good starting point

Response from Joseph:
To clarify further, exploratory modelling provides a framework within which models are used to reason about assumptions rather than provide predictions, and therefore does not rely on the model being correct or

having large amounts of data. Stress testing/vulnerability analysis of decisions and sensitivity analysis are examples of this type of approach.

Hodges, J. S. (1991). Six (or so) Things You Can Do With a Bad Model. Operations Research, 39(3), 355-365.
Bankes, Steve (1993). "Exploratory Modeling for Policy Analysis". Operations Research. 41 (3): 435–449. http://www.jstor.org/stable/171847

I've even argued that vulnerability analysis can help us tackle unknown unknowns:
https://i2insights.org/2019/11/19/vulnerability-analysis/

Question for:
Question from: Dan Botelho

@Holger, very nice presentation. We have seen some of the systems (along much of Aus SE) up to this last summer were failing. could we use this data now available to test/validate your bottom-up approach (when things are failing)? if so, are you doing something along those lines?

Response from Holger - @Dan Botelho, it would be great to have a discussion about this. We are very keen to test our approaches for different case studies.

Question from: Dwayne Honor
How do you get decision makers to value good adaptive decisions when the result means you may avoid intolerable outcomes meaning the "benefits" of the original decision are never rewarded (or go unnoticed)? i.e investing today in something that if successful means the intolerable outcome is never achieved

Response from Holger – This is a hard one, I wish I knew the answer to. The best I can do is to suggest developing models that provide the "evidence" on the benefits of adaptive approaches by simulating what would happen with and without adaptation.

Response from Joseph:
For me, the most important thing is aiming for long term cultural change rather than trying to exclusively influence a single decision. It's not about winning a single battle, which means there are a broad range of approaches that can be used.

An obvious opportunity, building on Holger's comment, is to build a culture of ex-post program evaluations, where what actually happened is compared to what might have happened (counterfactuals). Models have a particular role to play in predicting past consequences that were avoided.

More generally, it's beneficial to have anything that raises awareness of the decision forks that are faced over the time, and how past decisions have influenced the options now available.

An example in a technical context:
Zare F, Guillaume JHA, Jakeman AJ, Torabi O (2020). Reflective communication to improve problem-solving pathways: Key issues illustrated for an integrated environmental modelling case study. Environmental Modelling & Software, 126, 104645.
https://doi.org/10.1016/j.envsoft.2020.104645

Comment from Barbara Robson

one risk with BBNs is that they create very precise-looking answers, complete with very specific uncertainty estimates even when the input is very vague and hand-wavy. The approach can be very good if carefully implemented, but are so easy to build badly.

Response from Joseph - @barbara - agreed. This is an issue with uncertainty quantification generally - people take the bounds/distribution obtained as exact rather than recognising that it's also assumption dependent

Robustness Metrics:

McPhail C., Maier H.R., Kwakkel J.H., Giuliani M., Castelletti A. and Westra S. **Robustness metrics: How are they calculated, when should they be used and why do they give different results?** , *Earth's Future*, **6(2)**, 169-191, DOI:10.1002/2017EF000649

Robust and Adaptive Water Supply System Capacity Expansion:

Beh E.H.Y., Zheng F., Dandy G.C., Maier H.R. and Kapelan Z. (2017) **Robust optimization of water infrastructure planning under deep uncertainty using metamodels**, *Environmental Modelling and Software*, **93**, 92-105, DOI: 10.1016/j.envsoft.2017.03.013

Beh E.H.Y, Maier H.R. and Dandy G.C. (2015) **Scenario driven optimal sequencing under deep uncertainty**, *Environmental Modelling and Software*, **68**, 181-195, DOI:10.1016/j.envsoft.2015.02.006.

Beh E.H.Y, Maier H.R. and Dandy G.C. (2015) **Adaptive, multi-objective optimal sequencing approach for urban water supply augmentation under deep uncertainty**, *Water Resources Research*, **51(3)**, 1529-1551, DOI:10.1002/2014WR016254.

Paton F.L., Maier H.R. and Dandy G.C. (2014) **Including adaptation and mitigation responses to climate change in a multi-objective evolutionary algorithm framework for urban water supply systems incorporating GHG emissions**, *Water Resources Research*, **50(8)**, 6285-6304, DOI:10.1002/2013WR015195.

Paton F.L., Dandy G.C. and Maier H.R. (2014) **Integrated framework for assessing urban water supply security of systems with non-traditional sources under climate change**, *Environmental Modelling and Software*, **60**, 302-319, DOI: 10.1016/j.envsoft.2014.06.018

Paton F.L., Maier H.R. and Dandy G.C. (2013) **Relative magnitudes of sources of uncertainty in assessing climate change impacts on water supply security for the southern Adelaide water supply system**, *Water Resources Research*, **49(3)**, 1643-1667, doi:10.1002/wrcr.20153

Bottom-Up Climate Impact Assessment:

Guidici F., Castelletti A., Giuliani M. and Maier H.R. (2020) **An active learning approach for identifying the smallest subset of informative scenarios for robust planning under deep uncertainty**, *Environmental Modelling and Software*, **127(5)**, 104681, DOI: 10.1016/j.envsoft.2020.104681

Culley S., Bennett B., Westra S. and Maier H.R. (2019) **Generating realistic perturbed hydro-meteorological time series to inform scenario-neutral climate impact assessments**, *Journal of Hydrology*, 576, 111-122, DOI: 10.1016/j.jhydrol.2019.06.005

Guo D., Westra S. and Maier H.R. (2018) **An inverse approach to perturb historical rainfall data for scenario-neutral climate impact studies**, *Journal of Hydrology*, **556**, 887-890, DOI:10.1016/j.jhydrol.2016.03.025

Guo D., Westra S. and Maier H.R. (2017) **Use of a scenario-neutral approach to identify the key hydro-meteorological attributes that impact runoff from a natural catchment** , *Journal of Hydrology*, **554**, 317-330, DOI: 10.1016/j.jhydrol.2017.09.021

Culley S., Noble S., Yates A., Timbs M., Westra S., Maier H.R., Giuliani M. and Castelletti, A. (2016) **A bottom-up approach to identifying the maximum operational adaptive capacity of water resource systems to a changing climate** , *Water Resources Research*, **52(9)**, 6751-6768, DOI: 10.1002/2015WR018253.

Integrated Narrative Scenario Development:

Riddell G.A., van Delden H., Maier H.R, Zecchin A.C. (2020) **Tomorrow's disasters - embedding foresight principles into disaster risk assessment and treatment** , *International Journal of Disaster Risk Reduction*, **45**, 101437, DOI:10.1016/j.ijdrr.2019.101437

Riddell G.A., van Delden H., Maier H.R, Zecchin A.C. (2019) **Exploratory scenario analysis for disaster risk reduction: Considering alternative pathways in disaster risk assessment** , *International Journal of Disaster Risk Reduction*, **39,** 101230**,** DOI:10.1016/j.ijdrr.2019.101230.

Riddell G.A., van Delden H., Dandy G.C., Zecchin A.C. and Maier H.R. (2018) **Enhancing the policy relevance of exploratory scenarios: Generic approach and application to disaster risk reduction** , *Futures*, **99**, 1-15, DOI:10.1016/j.futures.2018.03.006.

Inclusion of Stakeholders in Decision Processes:

Di Matteo M., Maier H.R. and Dandy G.C. (2019) **Many-objective portfolio optimization approach for stormwater management project selection encouraging decision maker buy-in** , *Environmental Modelling and Software*, **111**, 340-355, DOI: 10.1016/j.envsoft.2018.09.008

Wu W., Maier H.R., Dandy G.C., Leonard R., Bellette K., Cuddy S. and Maheepala S. (2016) **Including stakeholder input in formulating and solving real-world optimisation problems: generic framework and case study** , *Environmental Modelling and Software*, 79, 197-213, DOI:10.1016/j.envsoft.2016.02.012.