Mainstreaming and Modelling: A systematic review into how gender analysis could inform hydrological modelling

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Good morning and thank you all very much for coming.

When I first started at CSIRO I came to look at gender and water. SDIP has ambitious gender objectives and has done some good work in this field. But one under-explored realm is if gender can be mainstreamed into the hydrological modelling processes themselves. There is often a disconnect between technical modelling work and the social science theories of gender and I wanted to investigate how these fields could inform each other.

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It has been well established in literature that water management outcomes can have different impacts on men and women. But accounting for those affects in a biophysical model is a complicated process. Gender relationships are cross-cutting, complex and heterogenous and human behaviour can be unpredictable. Social science can be a powerful tool that gives biophysical information context and makes it be more useful. But can it be mobilised in a model?

I wanted to tackle this discipline divide directly. Nicky Grigg, one of our senior research scientists, suggested that I do this by looking at the different steps involved in hydrological modelling. This fits gender mainstreaming practice well. Our partner ICIMOD says 'a programming process is gender sensitive when the gender dimension is systematically integrated into every step of the process'[1]. I applied that idea to Black et al.'s Guideline of Water Management Modelling written in 2011.

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I used the steps of this guideline to explore if and how each step of the modelling process could consider gender dynamics. A few hydrological modelling guidelines exist but I chose to use this guide because it follows an IWRM approach. ---*slide*--- IWRM is the influential concept of Integrated Water Resource Management, which was introduced in 1992. Its third

[1] Leduc and Ahmad 2009, 1
[2] Escobar et al. 2017, 5f
[3] Sustainable Development Investment Portfolio 2017

principle emphasises the importance of women to water management. Furthermore, it is clear and accessible. It is specific to water management and it is fit for purpose for CSIRO's work due to the authorship. For those of you who aren't aware one of the authors is Peter Wallbrink is our current Research Director for Basin Management Outcomes. It is also widely recognised as strong guiding principles. It is an eWater document, eWater is a significant actor in the Australian water scene.

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The foundation thinking of my work was this:

Hydrological models are often used to test water management decisions. These decisions are often hugely significant.

- They can be decisions surrounding major infrastructure investments that will last decades.
- Or decisions that require making trade-offs between people's livelihoods.
- Or ensuring drinking water is keeping up with your city's populations.

The information they provide can be powerful and is often essential. Given these high stakes, it is important to understand what the model output actually means.

- Models are not perfect reproductions of the real world. The real world is simplified in models for specific purposes. So, understanding model result means understanding how the real system is perceived, defined and idealised.
- And what does that mean for interpreting the results?
- When a model is used to help decide on solutions, what values are being used to measure performance?
- When a model shows costs and benefits, where are those costs and benefits being felt? Do you know the distribution of them? How do you know that you aren't entrenching disadvantage for one group or another, how do you know that benefits are being spread equitably?

This information has the potential to change what the model output means and thus, how that information is used for making a decision.

Answering those questions is complicated but it is also an exciting opportunity and there is demand to do so in the gender water space.

In 2017, DFAT announced their Water for Women Fund which will invest $110.6 million over 5 years in WASH programmes that target gender equality.

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And last year a team from Stockholm Environmental Institute sent out a survey to users of their water and energy planning models. Of the 204 respondents (of which 75% were researchers), 88% said that gender and social equity aspects should be included in their modelling research. Implying, there are is a drive to understand the links between models and gender.

Despite 88% of respondents saying that 'gender and social equity aspects should be included' only 7% said they were currently doing so[2]. Despite the good will that surrounds gender and water, there has been little work done to conduct gender analysis of the hydrological modelling work that the water sector does. I hope to somewhat explore that gap and to signpost where future investigation could go.

SDIP also aims to address gender and water issues. Our website explains that we have 'the goal of increasing water, food and energy security in South Asia, targeting the poorest and most vulnerable, particularly women and girls'[3]. We also ascribe to IWRM and thus the 3rd principle around gender. So I think we are in a good position to bring our skills to this research.

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I focused on the modelling steps of *problem definition, option modelling* and *identifying preferred option*. I found this method to be hugely useful for structuring my gender analysis of modelling but it is important to note that these steps involve more than just the actual model, they include how the system is perceived and how modelling results are used.

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[2] Escobar et al. 2017, 5f
[3] Sustainable Development Investment Portfolio 2017

Who's definition?

One of the ways I reflected on gender and models was to discover the role of values in modelling. While scientists are supposed to be apolitical actors, we are still individuals with our own perspectives and world views. In 2005, when Nancarrow wrote about her experience with modelling she asked: 'Why is the researcher's definition of the problem the right one?'

I wanted to interrogate how systems are perceived and defined within hydrological models, to understand if this could have a gender impact. This has been done previously in macroeconomic models. For example, in 1995, Walters showed that economic models that were created through a masculine perspective didn't recognise unpaid work despite its importance to running of economies[4]. From his gender-analysis, Walters proposed a model that simulated a reproductive sector[5]. Thus, altering the economic system as a whole.

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Likewise, in 2015 Fontana created conceptual models of bio-economic systems through a gendered lens to ensure this was a part of how the system was understood.

This work emphasised to me the importance of stakeholder engagement in ensuring different perspectives are brought into the definition of the problem. I explored why gender analysis should be done to understand how local norms can amplify or silence voices so that these can be accounted for in consultation sessions.

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While understanding perspectives and values is instrumental at the start of the modelling process, it is also important for the very end when identifying the preferred option. If models are using solution optimisation or Multiple Criteria Decision Analysis (MCDA)'[6] then they are the determining success of options based on set performance criteria and weightings decided on by people. For example, in 2003, Joubert, Stewart and Eberhard

[4] Walters 1995, 1870
[5] Walters 1995, 1870
[6] Belton and Stewart 2002, 135

conducted a study aimed at evaluating options for water supply augmentation and demand management for Cape Town, South Africa[7].

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Within this study, the various lists of options were provided to the MCDA consultancy team by the city council's consulting engineers[8]. From there, a preliminary set of criteria which fell into five different umbrellas of concerns were developed by the project leaders, relevant experts and 'others'[9]. ---*slide*---

They then used *swing weighting* to decide how important each criterion was. This process means the decision makers get to decide how performance is measured and how important criteria are in relation to each other. Different perspectives on what is important has the potential to impact which solution is chosen because they may define success or efficiently differently. Participatory Multi-Criteria Decision Analysis was developed in response to that critique in 2007[10]. To ensure solutions are being judged on what matters to the people that the model is supposed to be serving.

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- System
- Solutions

Does it come into the technical?

- Does it ever change the pure bio-physical?
- Only when it changes the importance, calibration?

Beyond this I looked at the actual building of the model to see if gender analysis could inform any of the steps.

For example, calibration.

Calibrating a model involves adjusting a model's parameter values until the results of the model adequately reflects the observational data it is trying to mimic. For example, when

[7] Joubert, Stewart and Eberhard 2003, 17
[8] Joubert, Stewart and Eberhard 2003, 18
[9] Joubert, Stewart and Eberhard 2003, 18
[10] Scott 2007

creating a flood hydrograph, the most important data for the model is the high flow events, so you want to make sure the model is getting those right.

But how do you choose what data you want to mimic? ---*slide*---

This involves a choice regarding which data is the most important and that choice is not always straightforward. For example, hydrological models are often calibrated to ensure annual average flows are consistent with observations. However, for eco-hydrological applications, literature shows that the most important factors for ecosystem health tend to be flow regimes and flow events[11]. So, depending on what the end use of the model was, the calibration choice will need to be different.

The table in the slides shows which elements are usually the most important for different uses.

Likewise, there is the possibility that the type or timing of flow that is most important may be different for different people.

In the Chhattis Mauja irrigation system in Nepal, Zwarteveen (1997) found that despite men and women working cooperatively as co-farmers, they tended to have different priorities around water flow conditions[12]. This is because their work made them aware of the role of different flow regimes, men tended to care about water arriving at the start of the season while women also stressed the importance of ongoing access to water throughout the irrigation season. So, if you wanted to model this system, there are different gendered perspectives on which part of the flow is most important for farming. Not only does that affect your choice of calibration method, it also affects what variables or metrics you report and analysise when communicating and interpreting model results.

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Methods to disaggregate effects?

- Scenarios
- Escobar
- Decision variables

[11] Bunn and Arthington 2002
[12] Zwarteveen 1997, 1338

- Trophic complexity

If part of a model's objective, is *human development*, especially with an emphasis on gender or the poor, ensuring it is 'fit for purpose' requires considering how well the output reflects the total population it is looking at.

When a model is being used to help make a decision or choose a solution based on costs or benefits, then ensuring that that decisions have equitable benefits requires knowing something to do with the *distribution* of costs and benefits. But how would you discover that at any large scale?

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Escobar et al. proposed a method of doing so in 2017. They proposed you could construct gender-specific *user profiles* that relate a certain livelihood type (i.e. woman, this catchment, working in this industry, of this class) and then examine that user-profile's relationship with water. Then you could quantify how many people fit that user-profile and where they are (using census data) and thus have the model show disaggregated effects of a water management change.

Obviously, there would be challenges in using this methodology. It would require significant amounts of data to create rigorous, intersectional user-profiles and you would have to be able to estimate how those user groups interacted with water. This would introduce uncertainty into the model through:

- data restrictions
- generalisation about user-profiles
- and theories of how those user-profiles interacted with water.

It would also make the model quite complex.

In order to create these *user-profiles* in a rigorous way you would need information about the way different people relate to water. This is similar to information needs that the Cultural Flows Research Projects has required in Australia.

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The Cultural Flows Research Project is a group of Indigenous leaders quantifying Indigenous water needs and interests across Australia. Their work deals with similar issues in quantifying diversity in needs across different Indigenous groups, kinships structure and gender under those. However, they already produced some strong work that has involved systematically accounting for Indigenous relations with water across that heterogeneity. Likewise, a systematic analysis of different people's water needs, and interests would need to be conducted for Escobar et al. *user-profiles* method.

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Another method of centralising gender in the model could be to build in social science theories of how gender and water are related. While social interactions are complex and diverse, trends and similarities can be found across them by comparing case studies *that are relevant to the context you are looking at*. This is how social science creates theories of behaviour. These theories have been used in US military agent-based models.

For example, across a wide-range of contexts, a well-recognised element of food insecurity is consumption smoothing. Women have been observed in numerous contexts sacrificing their own food consumption in terms of quality or quantity in order to smooth drops in consumption by their families. Once this phenomenon is known, this trend could be built into the model as a decision variable. This could reveal a gender disaggregated cost of decreased food production.

Of course, this comes with its own uncertainty. This wouldn't affect all men and women equally, how well does it reflect experiences of families? Which numbers do you use to show this relationship? What if there is disagreement between social theories?

Both of these methods try to address the model's construction to explore the *distribution* of costs and benefits to ensure that they are being spread equally. Both have uncertainty in them.

Conclusion

- It's complicated…
- Sometimes it won't be worth it

What is clear is that this process would be very complex. When discussing economic models, Collier (1990) wrote 'sometimes gender disaggregation will not add enough [to a model] to be worthwhile. However, for some topics, it will be useful and for others essential'[13]. How do you know when gender disaggregation is essential? Especially when adding that complexity to the model can add run time and increase model uncertainty. To deal with this issue, I appropriated the ecosystem concept of 'trophic complexity' and proposed a method that could be attached Escobar et al. *user-profiles* method.

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Ecosystem models deal with ecosystem complexity by grouping similar acting species together in 'functional groups'. This is similar to the 'user profiles' that Escobar et al. suggested. The optimum trophic complexity is how simplified a food web can be before the aggregated 'functional groups' no longer have predictive ability. Fulton et al. (2003) compared models of different trophic complexities to check their validity. Likewise, models of different levels of gender disaggregation could be compared to ensure that a model was not simplified to the point that it no longer captured differences between them.

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These methods are complicated. Where gender relationships may not be fully understood, using them may not be possible. Sometimes including social dynamics in a model will not be useful and sometimes it will be impossible due to time and resource constraints.

So, I think it is also important to ask how does **not** including them affect uncertainty and risk analysis? If social dynamics are not included in a model that is designed to aid human development, then I think other questions need to be asked in terms of how a model is used and understood:

a. How sure are you that the solutions or the costs and benefits shown are accounting for all people?
b. Where uncertainty about effect distributions are high, then what other forms of information can be used to minimise this uncertainty?

[13] Collier, 1990, 145 – 150 : Quoted in Elson 1995, 1860

c. And where this uncertainty is unacceptably high, and cannot be reduced, then how useful is the model's output for development decision making?

I think that this uncertainty should be understood as significant and be built into the risk assessment process.

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1. <u>Ending</u>

Before I finish, I want to give my work and myself some context. I am a hydrology student. I am not a gender expert, nor am I a modelling expert. To complete my work I had to learn about gender theories and found myself challenged to deal with complex and sometimes confronting ideas about social identity. I also had to learn about modelling and its objectives and requirements and how complex it can be. I have learnt a lot while I've been here, and I have come to respect the wealth of knowledge that SDIP's members have. I've brought my thinking and learning on different disciplines together, in the hope that it will help traverse the canyon that exists between disciplines so that the knowledge can be amalgamated to create innovative and powerful work.

I want to thank the SDIP team for providing me with this opportunity, its helped me grow tremendously and I hope I have also provided the team with some useful and interesting work. In particular, I want to thank my supervisors Joyce and Nicky. They have been absolutely amazing in lending me their knowledge and encouragement. And I'd also like to thank Toby for the friendship and support he provided me with while I've been there.

And again thank you all very much for coming.