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Interactive comment on "Community Based Early Warning Systems for flood risk mitigation in Nepal" *by* P. J. Smith et al.

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We (the authors) thank EM Stephens for her review of the paper and for the constructive suggestions. In the following response the response to the reviewers comments is given in *italics* for clarity.

This work has clear merit and is within the focus of the journal, though I would ask the authors to improve on how the two distinct sections (development of community-based early warning systems, and development of the probabilistic flood forecast) link together, especially given how moving from a deterministic to probabilistic approach will clearly influence how the early warning system is set-up.
The authors acknowledge that in the submitted manuscript there may appear a dis-connect between the two sections. We believe that revisions to the text (particularly in

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response to Recommendations 1, 4 & 6) can be used to address this and make the paper more appealing to a broader audience.

Recommendations

1. Sections 1 & 2 are quite general. I believe it would be beneficial to the paper for these sections to be more focussed on the case-study catchment, situating this information within the wider context of resilience building and flood hazard in Nepal where relevant.

   The more general nature of these sections was commented on positively by the second reviewer. However the authors agree that it may be constructive to introduce the case study earlier in the paper to focus the discussion if this could be done without losing the overview currently offered.

   Perhaps, we can use the Introduction section to build upon what we have already described and put an emphasis on Karnali basin in particular linking it to the revised Figure that highlights the real time rainfall and water level sensors as mentioned by Recommendation 2

2. Figure 1 is also quite general – I recommend editing it to highlight the case-study catchment, along with the location of the rain and river gauges. I'm not sure whether it is deliberate or just due to NHESS formatting, but the Figures should be included as close to where they are relevant as possible.

   We concur that this figure could provide the requested detail of the study catchment. While we will attempt to alter the figure positioning we consider this a production issue for the journal.

3. Table 1 includes information on minimum data requirements for the application of the methodology. It would be interesting in Sections 3.1.1-3.1.3 if there could be

some discussion of the minimum requirements for each of these components for establishing a community-based early warning system.

This information could be included (perhaps through an expansion of Table 1 referenced in Section 3) and would make a significant contribution to improving the paper.

4. Depending on the target audience of this paper, the flow of the text could perhaps be improved by moving Section 4.1 to a Supplementary Information file, and providing a summary for a lay-person. The important message for a practitioner is perhaps that this model is available via an R package and GUI, and can be applied to anywhere where there is gauged data? In some ways having an overly technical explanation might hinder the uptake of the model for future applications!

   Section 4.1 has tried to strike a balance between providing adequate details of the methodology for the user to understand the forecasting methodology (and hence interpret its use, data requirements and application) while not being overly technical. In light of the reviewers comments this balance can be revised and the key messages (as correctly identified by the reviewer) highlighted. A more detailed description could be placed in the supplementary information or left for the reader to find in references provided.

5. For Table 1, are these the minimum data requirements for the calibration period of the model, or for both the calibration and evaluation periods?

   These are the minimum requirements that have been found to be useful both in practice and in offline experiments. When the amount of data available is at or close to these amounts, the authors would not suggest a 'fixed' division into calibration and evaluation periods as often used in hydrology. Instead the authors have found it more useful to use a cross validation approach. In this, the performance of the model for each event is evaluated using parameters estimated from the remainder of the data. This would be expanded upon in the text.

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6. I feel that there is a section missing on how these newly-developed probabilistic forecasts can be applied. The forecast provides the probability of exceeding a warning threshold. Section 3.1 describes aspects such as dissemination and communication, and response capability. How has the CBEWS had to be adapted to enable decisions to be made from probabilistic forecasts? Has the community received training in probabilistic forecasts, or have procedures been put in place so that the community can follow them without needing to interpret the probability themselves? Answering these kind of questions would be really valuable to the academic and practitioner communities working on Early Warning Systems.

   We concur that a more focused discussion of these issues is required in the paper. However any such discussion should be preceded by acknowledgment of the fact that these procedures are evolving. For the 2016 monsoon, the Nepal Department of Hydrology and Meteorology (DHM) are testing a 'top down' communication strategy, whereby the DHM Central Office would provide advisories to its Basin Offices, which in turn would be passed to district stakeholders including District Emergency Operation Centers (DEOC), security forces and Community Groups. These are well established communication channels on services manned 24/7 during the monsoon season.

   The probabilistic forecasts provide information regarding the water levels for the next 5 hours and the specifically the probability of water levels hitting identified danger and warning levels. For now, these forecasts would provide enhanced early awareness so that communities downstream and government stakeholders can be primed to remain alert regarding an incoming flood in the next few hours.

   It remains to be seen if such an approach to disseminating the forecast information is successful and it is hoped to attempt a more direct approach to communicating the forecasts to communities in future years, based on the experience from the pilot in Monsoon 2016. We will provide this context in the paper.

7. The conclusion would benefit from some additional discussion on the wider context of the work carried out. What are the key messages for the development of probabilistic forecasts / CBEWS elsewhere? Could the methodology be easily applied elsewhere? Would it achieve the same increase in warning lead-time? (Presumably dependent on catchment size and driver of flood?)

   The authors are happy to add such discussion. The methodology used is quite general but is reliant upon community engagement and relevant real time data (as discussed elsewhere in the paper) to allow for the forecasting. Currently models are being developed for both the major (large) river basins of Nepal such as the Koshi and Narayani as well as for smaller basins such as Babai, West Rapti and Kankai to augment existing Community based early Warning Systems. The lead time available will vary by locations and is dependent upon many factors including the dominant channel and geophysical characteristics and spatial distribution of the gauged sites.

Specific Comments

A number of textual corrections to spelling and grammar highlighted by the reviewer are accepted and do not feature below.

P2L5: At this point it would be helpful to define what a Community Based Early Warning System is.
This would be included in the response to Recommendation 1

Fig2: It would be helpful if Fig1 showed where the gauges are located. P4L27: Could the map in Fig1 also show the location of the other Practical Action CBEWS projects?
We concur, see the response to Recommendation 2

P5L3: Could there be a brief description of what a Community Risk Assessment involves? Who leads these assessments? How are they carried out?

Yes this can be added. Community Risk Assessments are a form of Participatory Vulnerability and Capacity Assessment (PVCA) - participatory risk assessment and mapping processes involving the communities.

3.1.3 to 3.1.4: This is touched upon slightly; there are clear procedures to follow, what is done to ensure that these procedures are followed? Is anyone held accountable if they are not?

This can be addressed in a revised Section 3 with more focus on the target location as described above.

P7L8: Why did it fail? (and later, perhaps discuss/ comment on if the model-based methodology would have continued to work in this situation)

The failure of the CBEWS in Babai was primarily due to the water level gauge station used for triggering alerts being washed away during high floods. Due to this, communities and stakeholders downstream were deprived of critical information regarding when water levels crossing warning and danger levels. Compounding this, the gauge reader was unable to access the gauge station to provide a manual assessment of the flows (he was trapped between torrents of water in the trail leading to the station) and damaged his cell phone leaving him unable to contact communities, security forces and district authorities in a timely manner. This led to delays in response and rescue operations which contributed to more than 20 people losing their lives. A further contributing factor was that floodwaters entered places that were deemed safe in past risk mapping exercises and caught communities by surprise.

In the situation where data from the gauge whose water levels are being forecast is lost the model will continue to be evaluated and forecasts generated, but without the benefit of data assimilation. This will typically result in a decrease in the forecast quality. The model will however fail to deliver forecasts if the gauge(s) providing the input data (typically precipitation) fail to provide data.

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