Response to reviewers

Dear Editor

We have addressed the remaining concern in the current version of the manuscript.

<table>
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<th>Comments</th>
<th>Response</th>
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<td>The text is reading well, and the authors have addressed all of my comments. The authors have clearly undertaken a very challenging task of parsing their original manuscript into two separate companion papers, and have done this admirably. I commend them for taking a step back at this late stage and synthesizing the text and redirecting their storyline.</td>
<td>Thank you for the positive evaluation of the most recent version of the manuscript</td>
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My remaining concerns are:

(1) the phrasing of section 3.2, Numerical Examples (lines 372 – 380)

In section 3.2, the phrasing is a little confusing – leading with the method instead of why it was done. Monte Carlo simulations are tools used for different purposes – it would be helpful to know the purpose upfront in this paragraph.

The section now reads:

“For visualizing the effects of stochastic rainfall on river flow according to equation [1] a spreadsheet model that is available from the authors on request was used in ‘Monte Carlo’ simulations. Fixed values for $F_p$ were used in combination with a stochastic $Q_a$ value. The latter was obtained from a random generator (rand) with two settings for a (truncated) sinus-based daily rainfall probability: A) one for situations that have approximately 120 rainy days, and an annual $Q$ of around 1600 mm, and B) one that leads to around 45 rainy days and an annual total around 600 mm. Maximum daily $Q_{a,t}$ was chosen as 60 mm in both cases. For the figures, realizations for various $F_p$ values were retained that were within 10% of this number of rainy days and annual flow total, to focus on the effects of $F_p$ as such.”

(2) Figures // Part I:

- Minor, but Figure 1 part B could be cleaned up, e.g., lines in alignment (if desired), etc

Thanks, we have simplified it

- Figure 3: Correct subscript on all Fp’s, use $Q_a$ instead of $Q_{add}$ (or make consistent between figures and captions), words instead of abbreviations (e.g., StDev), Day of year starting from when (if Jan 1 – use Julian Day instead)

Thanks, we have checked figures and text for consistency on $Q_a$ vs $Q_{add}$ and hope all $F_p$’s now have the p as subscript; we shifted to Julian day and spelled out the abbreviations.

- Figures 3 and 4 refer to discharge using different words – keep consistency

We adopted discharge as the standard term

- Figures 6 and 7: Correct subscript with the p in Fp

thanks

Part II:

- Figure 2: Axis title and axis are overlapping, clarify time step of values shown

Adjusted
- Figure 4b: impossible to distinguish the six points as shown – could you jitter them, or show them next to each other? If this is the point, that’s fine too.

- Figures 5 & 6: define abbreviations in legend or spell out – I couldn’t find if they were used elsewhere in a Table or the paper

- Figure 8: consider coloring the text for the line fits by the colors corresponding to catchments

We made the points larger, so they can be distinguished

Done

Thanks, done

We have combined figures 8 and 9 of part 1 to ensure they are presented at the same size.

The final set of figures is:

**Figures Part I:**

A. Interests ↔ Understanding ↔ Metrics

multistakeholder resource management processes

- Monitoring
- Diagnosis
- Tradeoff analysis
- Innovation
- Scenarios
- Negotiations

Basis of current land use policies: Deforestation → increased flood risk

- Forestry perspective

Deforestation → increased flood risk

- Ecological perspective

Deforestation → increased flood risk

- Engineering perspective

Deforestation → increased flood risk

Relationship between land cover & river flow depends on complex interactions, non-linearities, partial reversibility, climate variability

Engineering of river storage and flow can control all relevant risks, once these are quantified

Climate Change adaptation view

Local land users want river flow to be predictable but also like to have flexibility in how land use is regulated as part of ecosystem services management

VII) Basis, as ‘boundary object’, of ‘performance-based’ contracts and widely supported commitments to resolve ‘issues’.

V) Match with local knowledge and existing policy frameworks.

VI) Empowerment of local stakeholders of resource management through boundary work, bridging local knowledge, science, and policymaking, and supporting negotiations among stakeholders; basis for wider monitoring and evaluation of conditions and trends, enhancing transparency of governance.

Figure 1. A. Multiple perspectives on the way flood risk is to be understood, monitored and handled according to different knowledge systems; B. Basic requirements for a ‘metric’ to be used in public discussions of natural resource management issues that deserve to be resolved and acted upon (modified from van Noordwijk et al., 2016)
Figure 2. Steps in a causal pathway that relates the salience of ‘avoided flood damage as ecosystem service’ to the interaction of exposure (1; being in the wrong place at critical times), hazard (2; spatially explicit flood frequency and duration) and human determinants of vulnerability (3); the hazard component depends, in common scientific analysis, on the pattern of river flow described in a hydrograph (4), which in turn is understood to be influenced by conditions along the river channel (5), precipitation and potential evapotranspiration ($E_{\text{pot}}$ as climatic factors (6) and the condition in the watershed (7) determining evapotranspiration ($E_{\text{act}}$), temporary water storage ($\Delta S$) and water partitioning over overland flow and infiltration; these watershed functions in turn depend on the interaction of terrain (topography, soils, geology), vegetation and human land use; current understanding of a two-way interaction between vegetation and rainfall adds further complexity (8)
Figure 3. Example of the derivation of best fitting $F_{p,try}$ value for an example hydrograph (A) on the basis of the inferred $Q_a$ distribution (cumulative frequency in B), and three properties of this distribution (C): its sum, frequency of negative values and standard deviation; the $F_{p,try}$ minimum of the latter is derived from the parameters of a fitted quadratic equation.

\[ y = 3.4594x^2 - 6.3606x + 4.0163 \]

$R^2 = 1$, minimum at $x = 0.919$

- Standard deviation $Q_{a,t} - 10$
- Fraction negative $Q_{a,t}$ estimates
- Sum $Q_{a,t}$ / 2000
A. 120 rainy days, Discharge ~ 1600 mm year\(^{-1}\)

![Graphs showing effects of different Fp parameters on hydrographs of daily river flow generated by a random rainfall generator, with persistent and additional flow components indicated, for two settings with total rainfall of approximately 1600 and 600 mm/yr (NB river flow is here expressed as mm d\(^{-1}\) rather than as m\(^3\) s\(^{-1}\) as in figure 3)](image)

B. 45 rainy days, Discharge ~ 600 mm year\(^{-1}\)

Figure 4. Effects of the Fp parameter on hydrographs of daily river flow generated by a random rainfall generator, with persistent and additional flow components indicated, for two settings with total rainfall of approximately 1600 and 600 mm/yr (NB river flow is here expressed as mm d\(^{-1}\) rather than as m\(^3\) s\(^{-1}\) as in figure 3)
Figure 5 A and B Temporal autocorrelation of river flow for the same simulations as Figure 4; the lower envelope of the points indicated slope $F_p$, the points above this line the effect of fresh additions to river flow
Figure 6. A. Effects of flow persistence on the relative flood protection (decrease in maximum flow measured over a 1 – 5 d period relative to a case with $F_p = 0$ (a few small negative points were replaced by small positive values to allow the exponential fit); B and C. effects of a decrease in flow persistence on the volume of water involved in peak flows (B; relative to the volume at $F_p$ is 0.6 – 0.9) and in the duration (in d) of floods (C).
Figure 7. Comparison of base flow separation of a hydrograph according to the flow persistence method (A) and two common flow separation methods, respectively with fixed (B) and sliding intervals (C)
Figure 8. A) Comparison of yearly data for four Southeast Asian watersheds analysed with common flow separation methods (average of results in Fig. 7) and the flow persistence method and comparison of the Richards-Baker Flashiness Index (Baker et al., 2004) and the flow persistence metric $F_p$ for B) four Southeast Asian watersheds, C) a series of hydrographs as in Fig. 4A, with 5 replicates per $F_p$ value.

Part II:
Figure 1. Location of the four watersheds in the agroecological zones of Southeast Asia (water towers are defined on the basis of ability to generate river flow and being in the upper part of a watershed)
Figure 2. Flow persistence ($F_p$) estimates derived from measurements in four Southeast Asian watersheds, separately for the wettest and driest 3-month periods of the year.
Figure 3. Inter- (A) and intra- (B) annual variation in the $F_p$ parameter derived from empirical versus modelled flow: for the four test sites on annual basis (A) or three-monthly basis (B)
Figure 4 Effects on flow persistence of changes in A) the mean rainfall intensity and B) the land use change scenarios of Table 4 across the four watersheds.
Figure 5. Effects of land cover change scenarios (Table 4) on the flow persistence value in four watersheds, modelled in GenRiver over a 20-year time-period, based on actual rainfall records; the left side panels show average water balance for each land cover scenario, the middle panels
the $F_p$ values per year and land use, the right-side panels the derived frequency distributions (best fitting Weibull distribution)

Figure 6. Frequency distribution of expected difference in $F_p$ in ‘paired plot’ comparisons where land cover is the only variable; left panels: all scenarios compared to ‘Reforestation’, right panel: all scenarios compared to degradation; graphs are based on a kernel density estimation (smoothing) approach
Figure 7. Correlations of $F_p$ with fractions of rainfall that take overland flow and interflow pathways through the watershed, across all years and land use scenarios of Figure App2.

Figure 8. Relationship between $F_p$ value and R-B Flashiness index across years in four Southeast Asian watersheds under a ‘natural forest’ and ‘degradation’ scenario, simulated with the GenRiver model.