

Appendix B: Essential social-ecological systems variables survey for the Tsitsa River Catchment sent to the transdisciplinary Tsitsa Project team, via google forms.

Essential Social-Ecological System Variables to monitor the Tsitsa River Catchment

Thank you for participating in this survey to collect a transdisciplinary array of opinions and knowledge about key variables to monitor social-ecological systems functioning of the Tsitsa River Catchment (TRC) in relation to the Tsitsa Project's vision "To support sustainable livelihoods for local people through integrated landscape management that strives for resilient social-ecological systems and which fosters equity in access to ecosystem services" (Biggs et al., 2018, p. 15).

This work combines a social-ecological systems (SES) approach and an essential variable (EV) approach. The SES approach is based on the conceptualization that you cannot construct a complex social-ecological system as a sum of its social and ecological parts. The EV approach is a filter to guide the selection of indicators to be monitored. The result is a focus on Essential Social-Ecological Systems Variables (ESESVs), considered critical to capture the social-ecological dynamics underpinning the trajectories of the TRC SES over time. There are usually a number of indicators associated with each EV. The biophysical, social and social-ecological indicators already selected through expert-driven disciplinary processes within the project are considered as potential inputs, as is the data gathered through my participatory transdisciplinary process.

Please read the accompanying background sheet for further background into my project, the basis for the variables included in this survey, and next steps of my research. Please feel free to reach out to me or my supervisors for more information or if you have any concerns about this survey (contact details on background document and information sheet).

* Indicates required question

1. Ethical Clearance *

I have ethical clearance to conduct this research through the Wits University Human Research Ethics Committee, and have emailed you a participant information sheet about the survey. If you are happy to participate, please tick the checkbox below.

Check all that apply.

Yes

Personal Details

2. 1. Name (this is optional and will remain confidential):

3. 2. Please briefly describe your role/position/involvement in the Tsitsa Project:

4. 3. Tick if you want to be acknowledged in derived publications

Check all that apply.

Yes, include my name in the acknowledgments

5. 4. Tick if you want to receive the results of this study

Check all that apply.

Yes, send me the results of this study

Social Ecological Essential Variable Selection Criteria

EVs have historically been sectoral, with the main selection criteria being feasibility, relevance and cost-effectiveness. This work contributes towards recent efforts applying EVs beyond sectoral approaches as cross-thematic and within complex social-ecological system domains. This requires a re-thinking of the selection criteria. The selection criteria of EVs for SESs must take into consideration the values and goals of those working in a particular system of interest. Both traditional and novel selection criteria are listed below for you to prioritize in relation to the context in which you work/ed in the Tsitsa River Catchment.

6. Please rate which potential criteria you believe are most important to guide the selection of Social Ecological Essential Variables for the TRC. The scale goes from 1 "least essential" to 5 "most essential" to monitor, with 0 being "not essential".

Mark only one oval per row.

	0 (Not essential)	1	2	3	4	5 (Most essential)
Feasible (the state or degree of being easily or conveniently done)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Relevant (indispensable/foundational for tracking system)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cost-Efficient	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Captures 'System Essence' (represents the key features, processes and interactions driving SES dynamics over time and space).	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Covers Social-Ecological Relations or Interactions (co-produced by the social and ecological)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Integrates existing observations from space and the ground	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Expert-Selected	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Resident-Selected	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Resident-Monitored	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Multi-purpose (at the nexus of many processes)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

7. Please select the 3 - 5 criteria that you would consider most important to guide selection of essential SES variables in the TRC

Check all that apply.

- Feasible
- Relevant
- Cost-efficient
- Captures system essence
- Covers social-ecological relations or interactions
- Integrates existing observations from space and the ground
- Expert-selected
- Resident-selected
- Resident-monitored
- Multi-purpose

8. Is there a selection criteria that is missing from this list that you consider important to consider?

Essential Social-Ecological Systems Variable Layer: Sustainable Livelihoods

There are 4 categories for consideration under the sustainable livelihoods banner, namely: grazing, cropping, forestry and access to natural resources. Each ESESV will be accompanied by a number of potential indicators for monitoring. Please punctuate each candidate ESESV and its potential indicators according to what you consider to be their relevance as "essential" to measure in order to understand and manage the Tsitsa River Catchment (TRC) social-ecological system (in relation to the vision of the Tsitsa Project: "To support sustainable livelihoods for local people through integrated landscape management that strives for resilient social-ecological systems and which fosters equity in access to ecosystem services").

The scale goes from 1 "least essential" to 5 "most essential" to monitor, with 0 being "not essential". Please keep your selection criteria to determine 'essentiality' from section 2 in mind.

9. Sustainable Livelihoods Candidate ESESV 1: Grazing

How essential do you consider grazing and rangeland sustainability, as a candidate ESESV, in the TRC?

Mark only one oval.

0 1 2 3 4 5

0 (N 5 (Most essential)

10. In terms of monitoring grazing and rangeland sustainability, please indicate how essential you consider the following as potential indicators associated with grazing.

Mark only one oval per row.

	0 (Not essential)	1	2	3	4	5 (Most essential)
Potential indicator 1.1: Livestock density (by type)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Potential indicator 1.2: Rangeland vegetation cover (%)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Potential indicator 1.3: Livestock production (products generated by livestock)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Potential indicator 1.4: Livestock theft	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Potential indicator 1.5: Rangeland condition	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Potential indicator 1.6: Natural resource income equivalent from livestock (financial equivalent)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Potential indicator 1.7: Livestock Management

Potential indicator 1.8: Export/sale rates of agricultural products

11. Would you modify the candidate ESESV for grazing as 'grazing and rangeland sustainability'? If so, please specify?

Similarly would you add/modify any monitoring indicators associated with grazing?

12. **Sustainable Livelihoods Candidate ESESV 2: Cropping**

How essential do you consider cropping sustainability as a candidate ESESV, in the TRC?

Mark only one oval.

0 1 2 3 4 5

0 (N 5 (Most essential)

13. In terms of monitoring cropping sustainability, please indicate how essential you consider the following as potential indicators associated with cropping.

Mark only one oval per row.

	0 (Not essential)	1	2	3	4	5 (Most essential)
Potential indicator 2.1: Proportion of agricultural area under productive, sustainable agriculture	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Potential indicator 2.2: Natural Resource Income Equivalent (financial) from cropping	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Potential indicator 2.3: Ratio between 'sufficiently covered' cropland and the total crop land	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Potential indicator 2.4: Cropland production (products generated by cropping)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

14. Would you modify the candidate ESESV for cropping as 'cropping sustainability'? If so, please specify?

Similarly would you add/modify any monitoring indicators associated with cropping?

15. **Sustainable Livelihoods Candidate ESESV 3: Forestry**

How essential do you consider forestry sustainability, as a candidate ESESV, in the TRC?

Mark only one oval.

0 1 2 3 4 5

0 (N 5 (Most essential)

16. In terms of monitoring forestry sustainability, please indicate how essential you consider the following as potential indicators associated with forestry.

Mark only one oval per row.

	0 (Not essential)	1	2	3	4	5 (Most essential)
Potential indicator 3.1: Forest area as a proportion of total land area	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Potential indicator 3.2: Progress towards sustainable forest management (methods of forestry)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Potential indicator 3.3: Natural resource income equivalent from forestry products (Financial equivalent)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

17. Would you add to/modify the candidate ESESV for forestry as 'forestry sustainability'? If so, please specify?

Similarly would you add/modify any monitoring indicators associated with forestry?

18. **Sustainable Livelihoods Candidate ESESV 4: Access to Natural Resources**

How essential do you consider access to natural resources, as a candidate ESESV, in the TRC?

Mark only one oval.

0 1 2 3 4 5

0 (N 5 (Most essential)

19. In terms of monitoring access to natural resources, please indicate how essential you consider the following as potential indicators.

Mark only one oval per row.

	0 (Not essential)	1	2	3	4	5 (Most essential)
Potential indicator 4.1: Access to natural resources (food types & sources, firewood, thatch, medicinal plants, sand for building, etc.)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Potential indicator 4.2: Access to potable water	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

20. Would you modify the candidate ESESV for 'access to natural resources'? If so, please specify?

Similarly would you add/modify any monitoring indicators associated with access to natural resources?

21. Would you add any of other candidate ESESVs for 'sustainable livelihoods'?
If so, please specify?

Essential Social-Ecological Systems Variable Layer: Natural Resource Governance

Each ESESV will be accompanied by a number of potential indicators for monitoring. Please punctuate each candidate ESESV and its potential indicators according to what you consider to be their relevance as "essential" to measure in order to understand and manage the Tsitsa River Catchment social-ecological system (in relation to the vision of the Tsitsa Project "To support sustainable livelihoods for local people through integrated landscape management that strives for resilient social-ecological systems and which fosters equity in access to ecosystem services").

The scale goes from 1 "least essential" to 5 "most essential" to monitor, with 0 being "not essential". Please keep your selection criteria to determine 'essentiality' from section 2 in mind.

22. **Polycentric Natural Resource Governance Candidate ESESV**
5: Participation in natural resource governance

How essential do you consider participation in natural resource governance, as a candidate ESESV, in the TRC?

Mark only one oval.

0 1 2 3 4 5

0 (N 5 (Most essential)

23. In terms of monitoring participation in natural resource governance, please indicate how essential you consider the following as potential indicators.

Mark only one oval per row.

	0 (Not essential)	1	2	3	4	5 (Most essential)
Potential indicator 5.1: Land user participation in NRM governance structures	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Potential indicator 5.2: Women and youth participation in NRM governance structures	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Potential indicator 5.3: Sense of inclusion- percentage of land users satisfied their voices are represented in decision making and planning processes of the catchment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Potential indicator 5.4: Participation in sustainable land-use management	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

24. Would you modify the candidate ESESV 'participation in natural resource governance', or add another candidate ESESV associated with polycentric natural resource governance? If so, please specify?

Similarly would you add/modify any monitoring indicators associated with polycentric natural resource governance?

Essential Social-Ecological Systems Variable Layer: Human impacts on the land

There are 2 categories for consideration under the 'human actions on the land' layer, namely: land cover & condition, and soil erosion (related to human actions on the land) . Each candidate ESESV will be accompanied by a number of potential indicators for monitoring. Please punctuate each candidate ESESV and its potential indicators according to what you consider to be their relevance as "essential" to measure in order to understand and manage the Tsitsa River Catchment social-ecological system (in relation to the vision of the Tsitsa Project "To support sustainable livelihoods for local people through integrated landscape management that strives for resilient social-ecological systems and which fosters equity in access to ecosystem services").

The scale goes from 1 "least essential" to 5 "most essential" to monitor, with 0 being "not essential". Please keep your selection criteria to determine 'essentiality' from section 2 in mind.

25. **Human impacts on the land Candidate ESESV 6: Land cover and condition**

How essential do you consider land cover and condition, as a candidate ESESV, in the TRC?

Mark only one oval.

0 1 2 3 4 5

0 (N 5 (Most essential)

26. In terms of monitoring land cover and condition, please indicate how essential you consider the following as potential indicators of land cover and condition.

Mark only one oval per row.

	0 (Not essential)	1	2	3	4	5 (Most essential)
Potential indicator 6.1: Woody Invasive Species cover	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Potential indicator 6.2: Grassland condition	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Potential Indicator 6.3: Landscape Function	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Potential indicator 6.4: Land cover change	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Potential indicator 6.5: Land use intensity	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

27. Would you modify the candidate ESESV 'land cover and condition'? If so, please specify?

Similarly would you add/modify any monitoring indicators associated with land cover and condition?

28. **Human impacts on the land Candidate ESESV 7: Soil Erosion (related to human actions on the land)**

How essential do you consider soil erosion (related to human actions on the land), as a candidate ESESV, in the TRC?

Mark only one oval.

1 2 3 4 5

29. In terms of monitoring soil erosion, please indicate how essential you consider the following as potential indicators of soil erosion (related to human actions on the land)

Mark only one oval per row.

	0 (Not essential)	1	2	3	4	5 (Most essential)
Potential indicator 7.1: Soil Erosion (by anthropogenic practices)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Potential indicator 7.2: Soil Erosion as an (abiotic-economic*) ecosystem disservice	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Potential indicator 7.3: Mass stabilization and control of erosion rates	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

30. Would you modify the candidate ESESV 'soil erosion related to human impacts'? If so, please specify?

Similarly would you add/modify any monitoring indicators associated with land cover and condition?

31. Would you add any other candidate ESESVs for human actions on the land?
If so, please specify?

Essential Social-Ecological Systems Variable Layer: Climate Change Adaptation

Each ESESV will be accompanied by a number of potential indicators for monitoring. Please punctuate each candidate ESESV and its potential indicators according to what you consider to be their relevance as "essential" to measure in order to understand and manage the Tsitsa River Catchment social-ecological system (in relation to the vision of the Tsitsa Project "To support sustainable livelihoods for local people through integrated landscape management that strives for resilient social-ecological systems and which fosters equity in access to ecosystem services").

The scale goes from 1 "least essential" to 5 "most essential" to monitor, with 0 being "not essential". Please keep your selection criteria to determine 'essentiality' from section 2 in mind.

32. **Climate Change Adaptation Candidate ESESV 8: Climate Change Adaptation**

How essential do you consider climate change adaptation, as a candidate ESESV, in the TRC?

Mark only one oval.

0 1 2 3 4 5

0 (N 5 (Most essential)

33. In terms of climate change adaptation, please indicate how essential you consider the following as potential indicators of climate change adaptation.

Mark only one oval per row.

	0 (Not essential)	1	2	3	4	5 (Most essential)
Potential indicator 8.1: Interventions to manage the grassland	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Potential indicator 8.2: Interventions to grow climate smart crops	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Potential indicator 8.3: Interventions to store, capture and protect water	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Potential indicator 8.4: Interventions to alleviate heat stress (for humans and livestock)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

- 34. Would you modify the candidate EESV 'climate change adaptation', or add another candidate EESV associated with climate change? If so, please specify?

Similarly would you add/modify any monitoring indicators associated with climate change adaptation?

Overall Comments and Suggestions

- 35. Are there any EESVs or associated indicators that are missing from this survey which you feel are essential to understand and monitor the social-ecological systems functioning of the TRC? Please specify

- 36. Please feel free to share any ideas, questions, comments or suggestions related to this survey on the essential social-ecological system variables and monitoring of the TRC.

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