Land Use Impacts of Ecosystem Services in LCA

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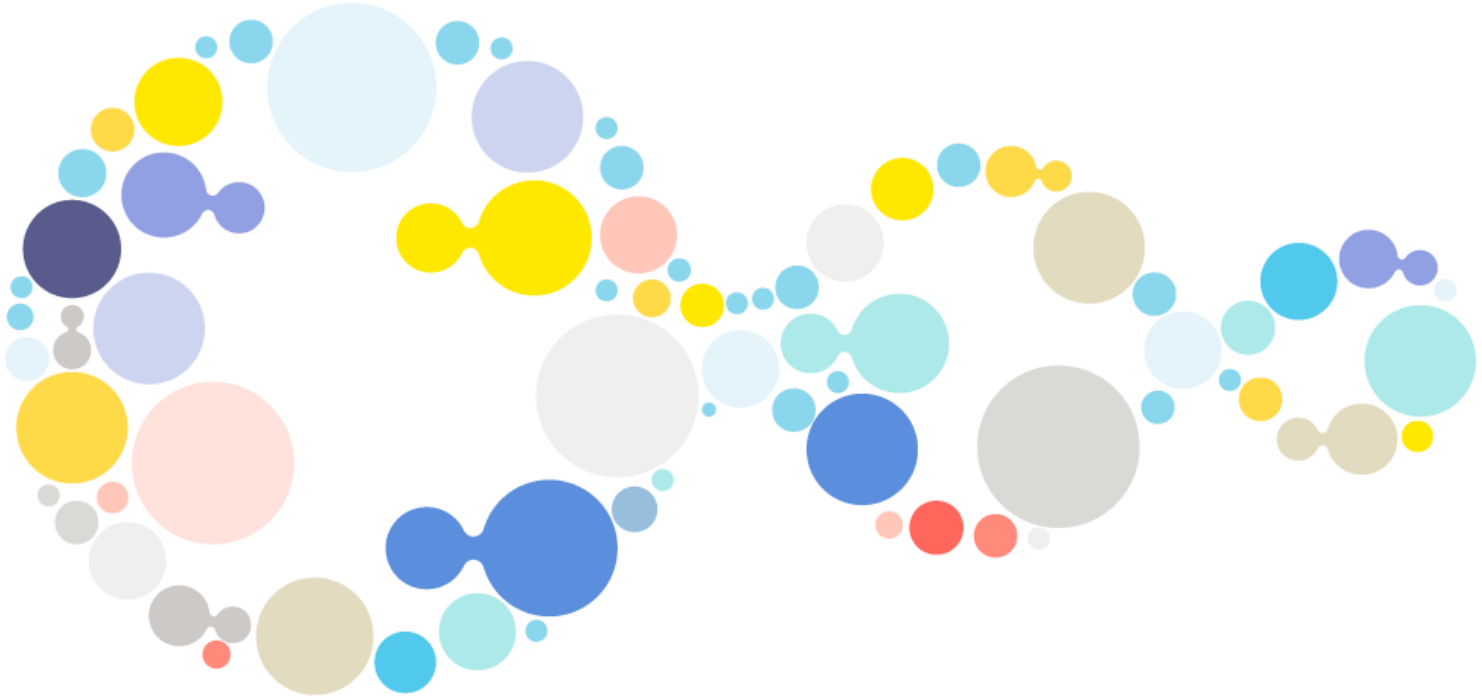


lifecycles.

Background

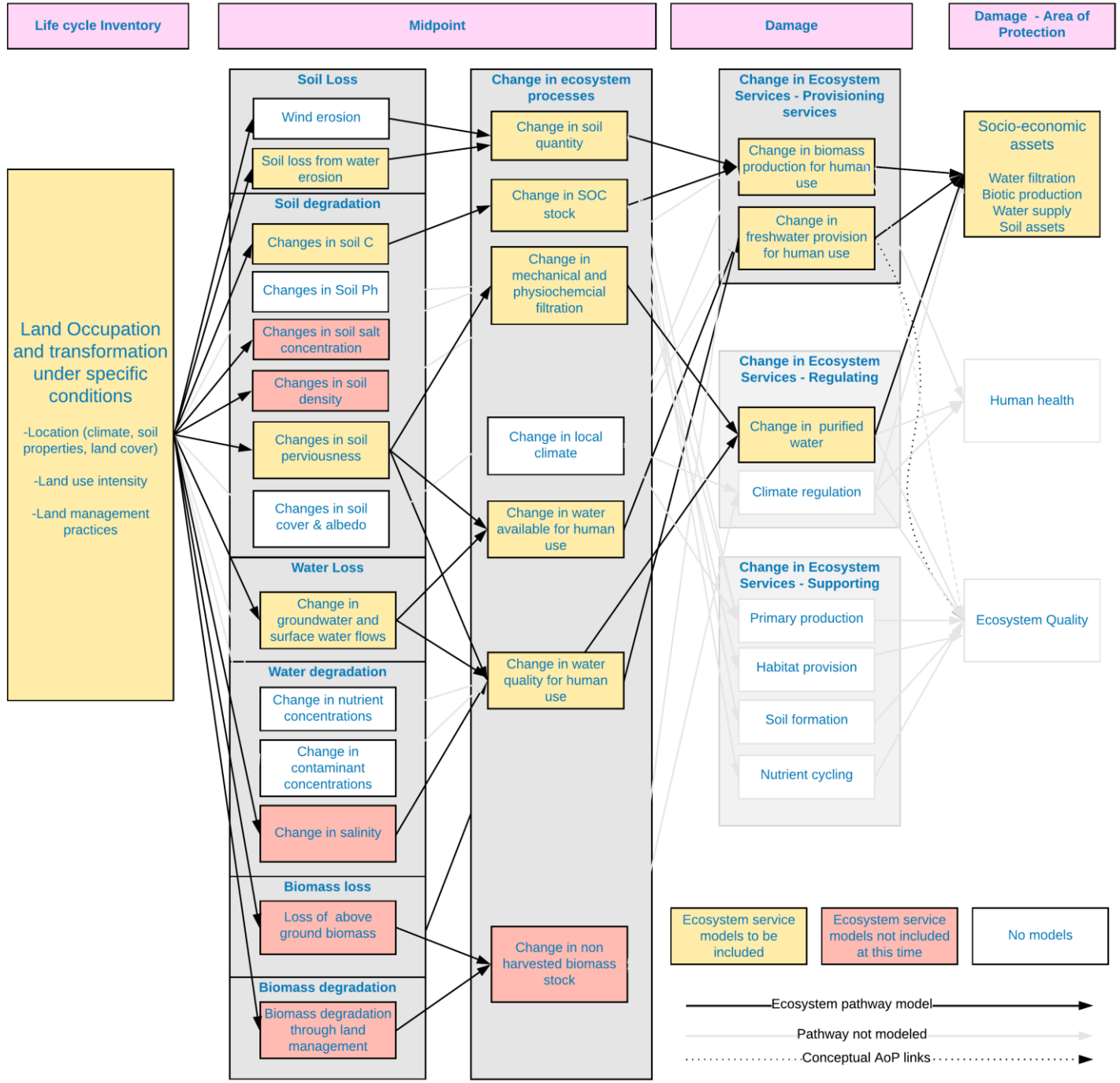
- Global pressures on land use
  - Expanding population and increasing demand for meat
  - Increase demand for biofuels, biomaterials and carbon storage.

- ES damages will either
  - Take economic resources of government which will compete with better uses
  - Not be address and results in ecosystem quality and human health damage

Where are ecosystem service inputs

- Biobased products often compared with synthetic non- biobased
  - Biobased will usually have impacts of ecosystem service

- Provide some basis for net positive movement, regenerative agriculture
  - Actually measuring if productive compacity is increasing.

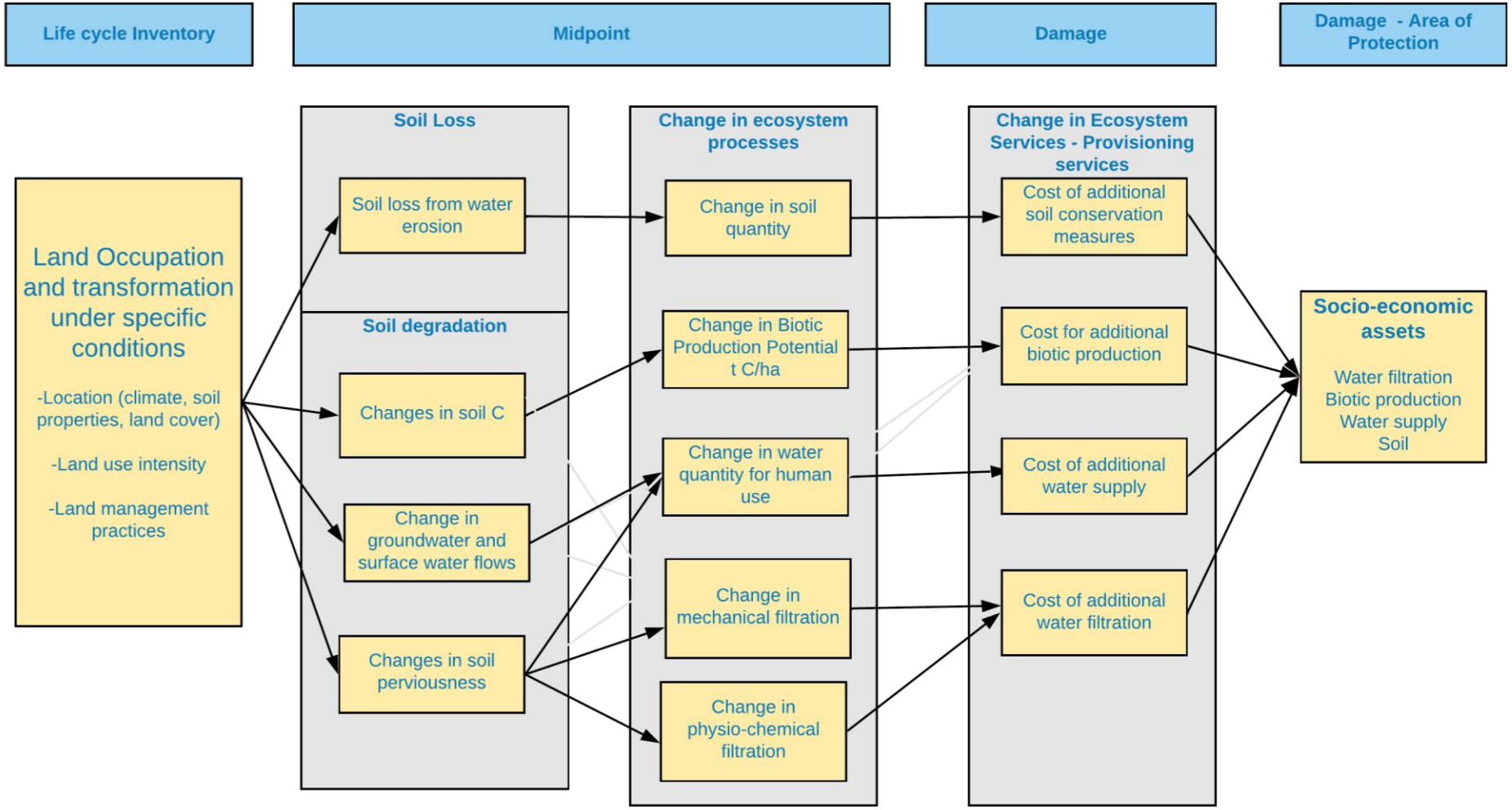

Life cycle Inventory
Midpoint
Damage
Damage - Area of Protection
Land Occupation and transformation under specific conditions
-Location (climate, soil properties, land cover)
-Land use intensity
-Land management practices
Soil Loss
Wind erosion
Soil loss from water erosion
Soil degradation
Changes in soil C
Changes in Soil Ph
Changes in soil salt concentration
Changes in soil density
Changes in soil perviousness
Changes in soil cover & albedo
Water Loss
Change in groundwater and surface water flows
Water degradation
Change in nutrient concentrations
Change in contaminant concentrations
Change in salinity
Biomass loss
Loss of above ground biomass
Biomass degradation
Biomass degradation through land management
Change in ecosystem processes
Change in soil quantity
Change in SOC stock
Change in mechanical and physiochemcial filtration
Change in local climate
Change in water available for human use
Change in water quality for human use
Change in non harvested biomass stock
Change in Ecosystem Services - Provisioning services
Change in biomass production for human use
Change in freshwater provision for human use
Change in Ecosystem Services - Regulating
Change in purified water
Climate regulation
Change in Ecosystem Services - Supporting
Primary production
Habitat provision
Soil formation
Nutrient cycling
Socio-economic assets
Water filtration
Biotic production
Water supply
Soil assets
Human health
Ecosystem Quality
Ecosystem service models to be included
Ecosystem service models not included at this time
No models
Ecosystem pathway model
Pathway not modeled
Conceptual AoP links

Model selection

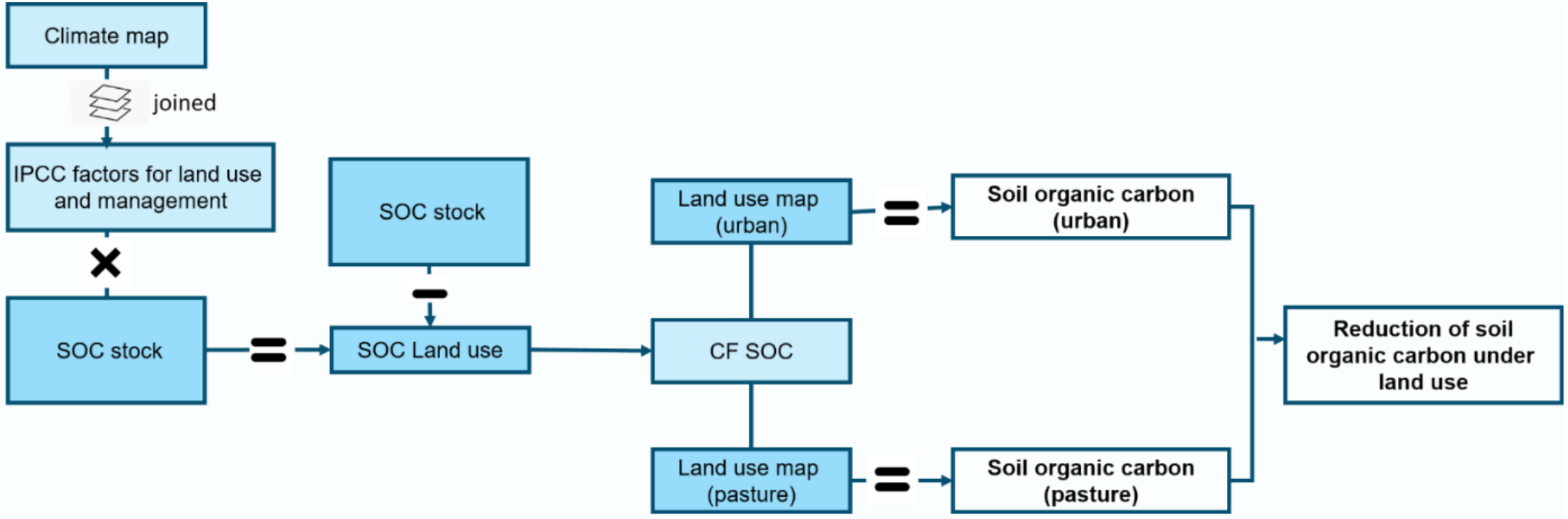
After initial review of methods and results from Vidal et.al (2017), five impact categories have been selected.

- Soil organic carbon(SOC)
- Erosion Reduction (ERP)
- Groundwater Regeneration (GR)
- Mechanical filtration (MF)
- Physicochemical Filtration (PCF)

Pathways for 5 methods



Soil Organic Carbon



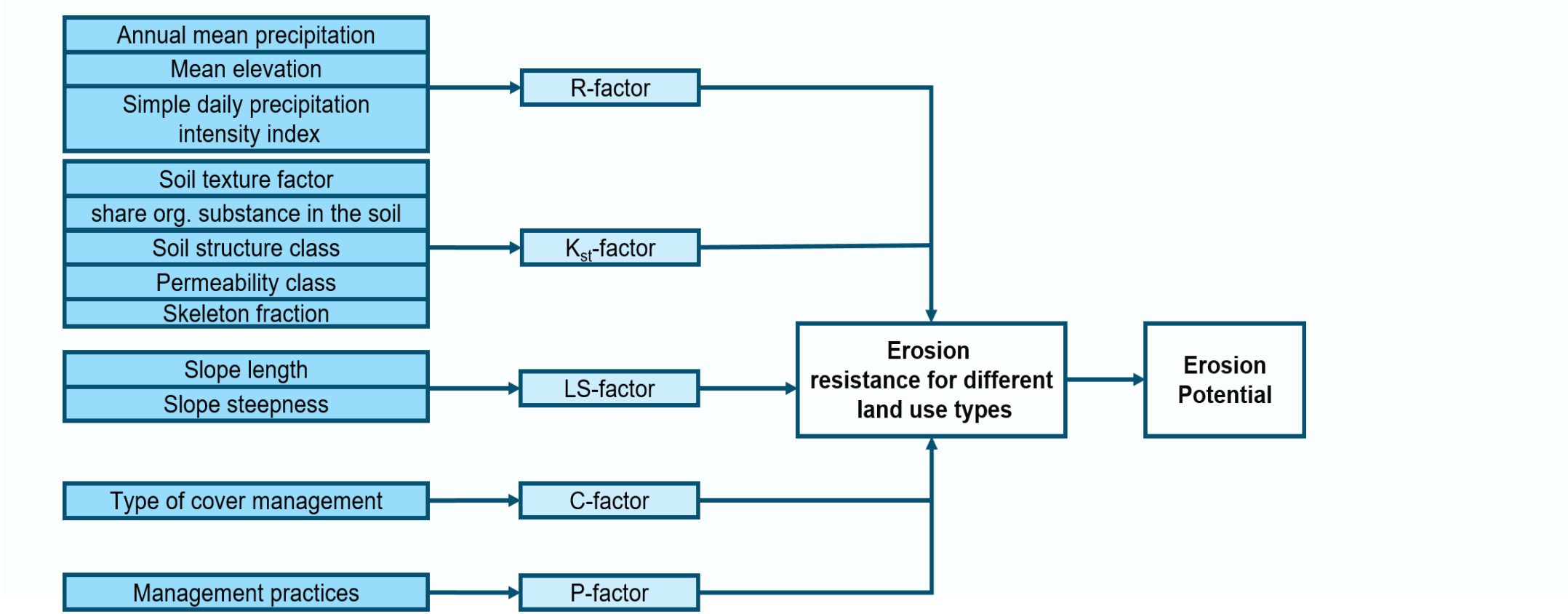
IPCC, 2019. 2019 refinement to the 2006 IPCC guidelines for national greenhouse gas inventories, in: Buendia, E.C., Tanabe, K., Kranjc, A., Baasansuren, J., Fukuda, M., Ngarize, S., Osako, A., Pyrozhenko, Y., Shermanau, P., Federici, S. (Eds.), . IPCC, Switzerland.

IPCC. 2006. "2006 IPCC Guidelines for National Greenhouse Gas Inventories." In.: The Intergovernmental Panel on Climate Change.

Brandão, Miguel, and Llorenç Milà i Canals. 2013. 'Global characterisation factors to assess land use impacts on biotic production', *The International Journal of Life Cycle Assessment*, 18: 1243-52.

De Laurentiis V, Maier S, Horn R, Uusitalo V, Hiederer R, Bessou C, Morais T, Grant T, Milà i Canals L, Sala S. Soil organic carbon as an indicator of land use impacts in life cycle assessment. Submitted for publication

Erosion



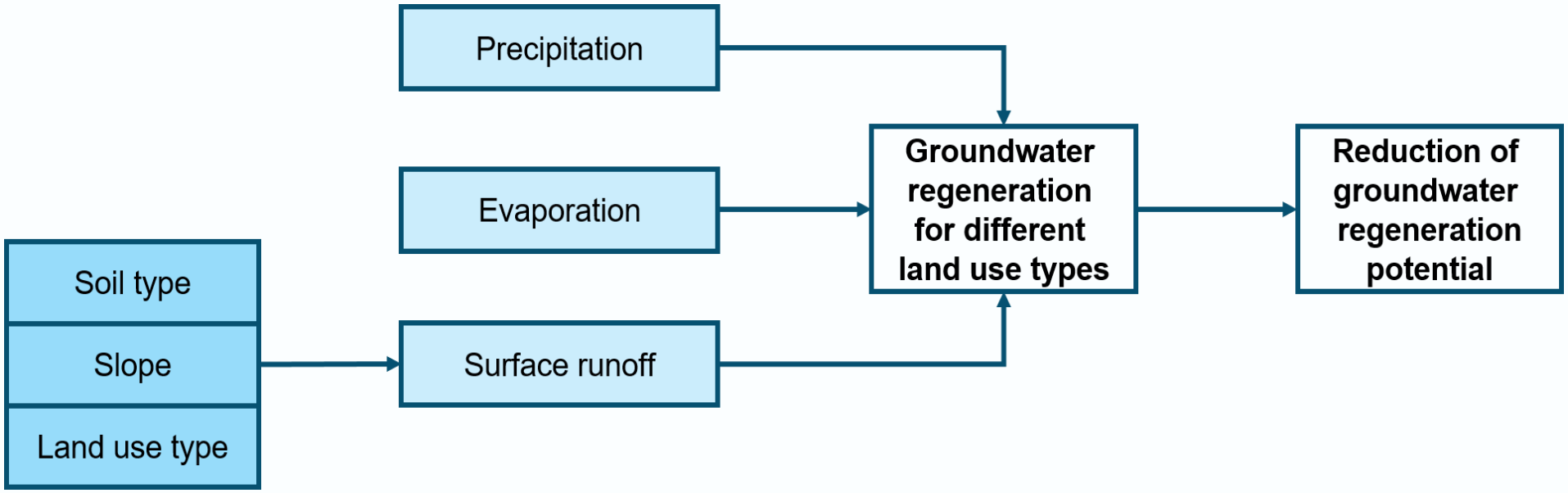
Bos, U., Horn, R., Beck, T., Lindner, J. P., & Fischer, M. (2016). LANCA-Characterization Factors for Life Cycle Impact Assessment. Fraunhofer Verlag.

Bos, Ulrike; Maier, Stephanie D.; Horn, Rafael; Leistner, Philip; Finkbeiner, Matthias (2020): A GIS based method to calculate regionalized land use characterization factors for life cycle impact assessment using LANCA®. In Int J Life Cycle Assess 25 (7), pp. 1259–1277. DOI: 10.1007/s11367-020-01730-y.

Borrelli, P., Robinson, D.A., Fleischer, L.R. et al. An assessment of the global impact of 21st century land use change on soil erosion. Nat Commun 8, 2013 (2017). https://doi.org/10.1038/s41467-017-02142-7

Hurtt, G.C.; Chini, L.P.; Frolking, S.; Betts, R.A.; Feddema, J.; Fischer, G.; Fisk, J.P.; Hibbard, K.; Houghton, R.A.; Janetos, A.; et al. Harmonization of land-use sce-narios for the period 1500–2100: 600 years of global gridded annual land-use transi-tions, wood harvest, and resulting secondary lands. Climatic Change 2011, 109, 117–161, doi:10.1007/s10584-011-0153-2.

Groundwater Regeneration



Bos, U., Horn, R., Beck, T., Lindner, J. P., & Fischer, M. (2016). LANCA-Characterization Factors for Life Cycle Impact Assessment. Fraunhofer Verlag.

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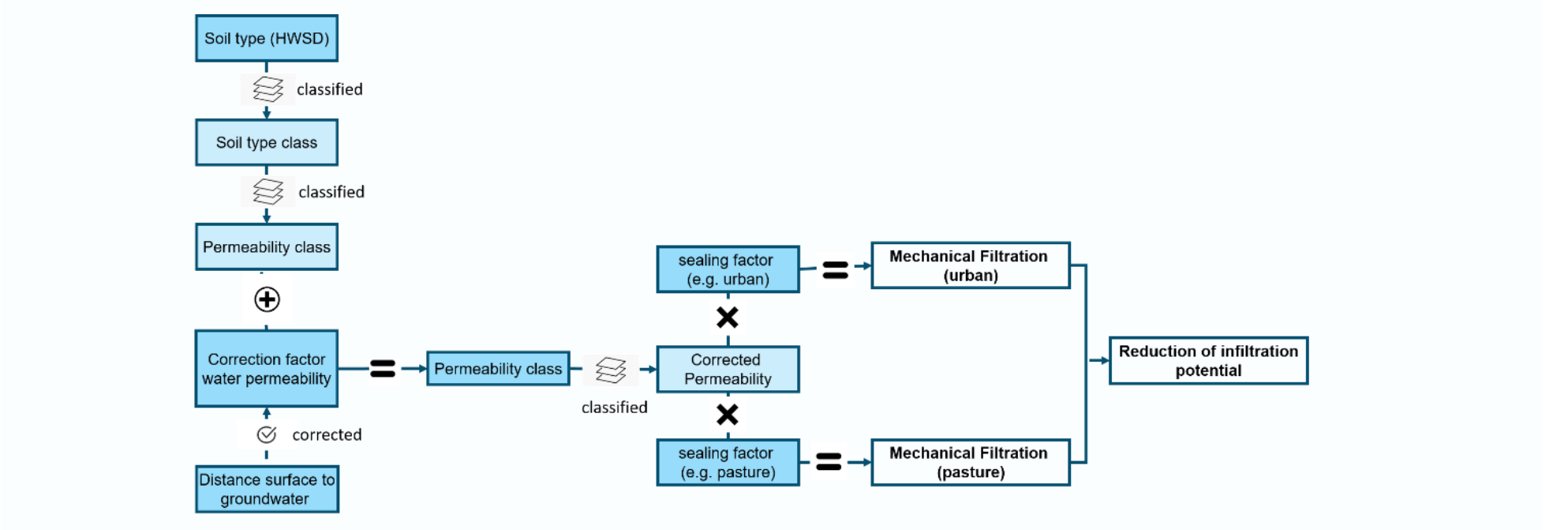
Mechanical Filtration



Bos, U., Horn, R., Beck, T., Lindner, J. P., & Fischer, M. (2016). LANCA-Characterization Factors for Life Cycle Impact Assessment. Fraunhofer Verlag.

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General Formula for endpoint calculation

$$AoP(\$) = CFs \times ECF \times XF$$

- Where:

  CFs = Midpoint Characterisation factor

  ECF = economic conversion factors

  XF = allocation to final ecosystem service

From Cao, Viêt, Manuele Margni, Basil D Favis, and Louise Deschênes. 2015. 'Aggregated indicator to assess land use impacts in life cycle assessment (LCA) based on the economic value of ecosystem services', *Journal of Cleaner Production*, 94: 56-66.Boulay, Anne-Marie, Cécile Bulle, Jean-Baptiste Bayart, Louise Deschênes, and Manuele Margni. 2011. 'Regional Characterization of Freshwater Use in LCA: Modeling Direct Impacts on Human Health', *Environmental Science & Technology*, 45: 8948-57.

Example of effect factor

SOC Effect Factor

SOC endpoint calculation

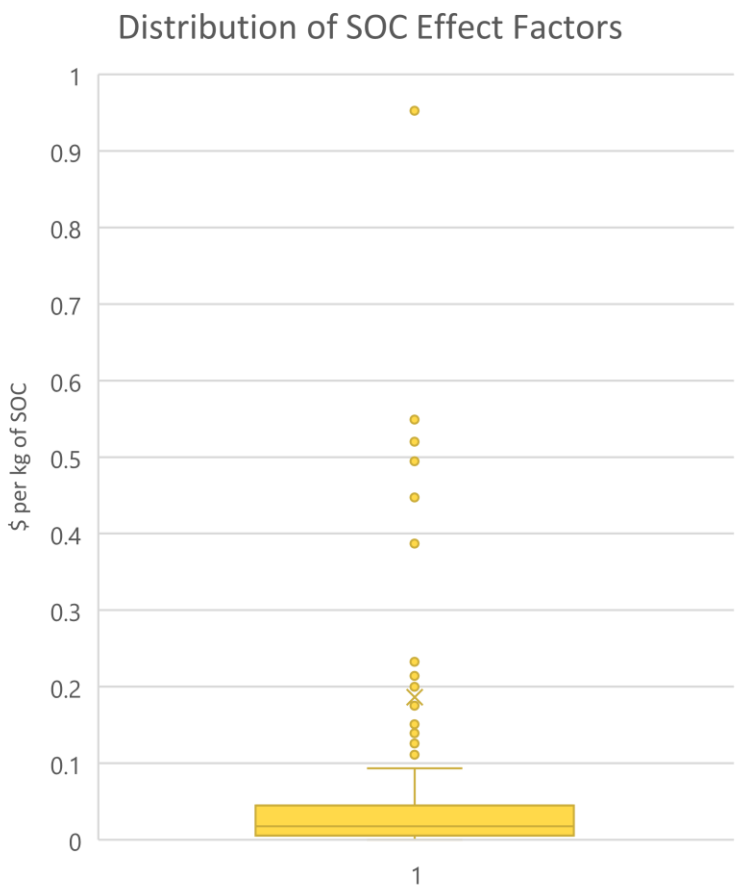
Proposed by Cao et al Updated to values to 2020 data.

$$\frac{Total\ annual\ revenue\ from\ crops\ per\ country}{Total\ soil\ organic\ carbon\ of\ arable\ land} = \$\ per\ tC\ per\ Year$$

XF is 100% from final ecosystem service as is measuring agricultural production

SOC deficit midpoint and effect factor

Mid-point characterisation factor



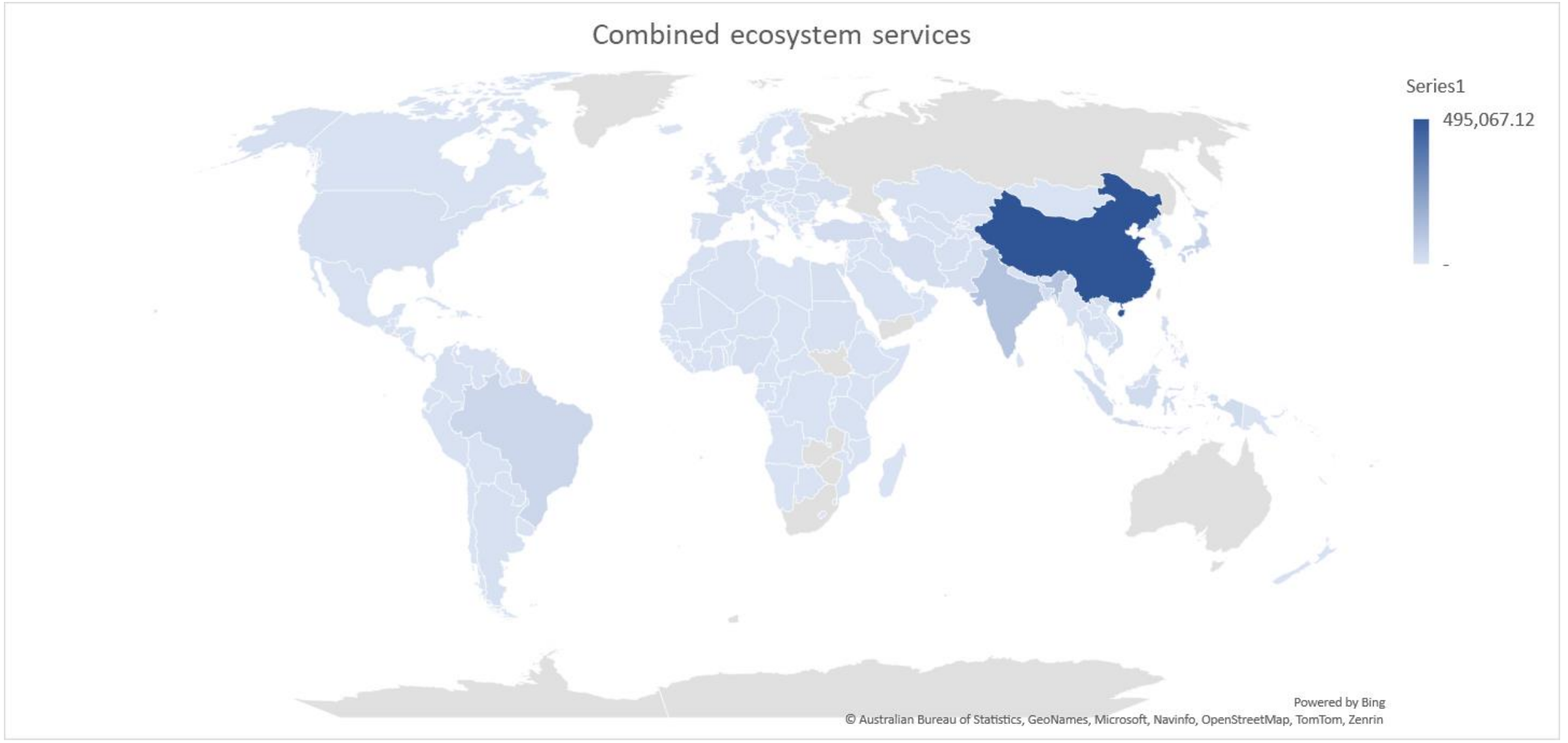
Effect factor

Results for global normalisation

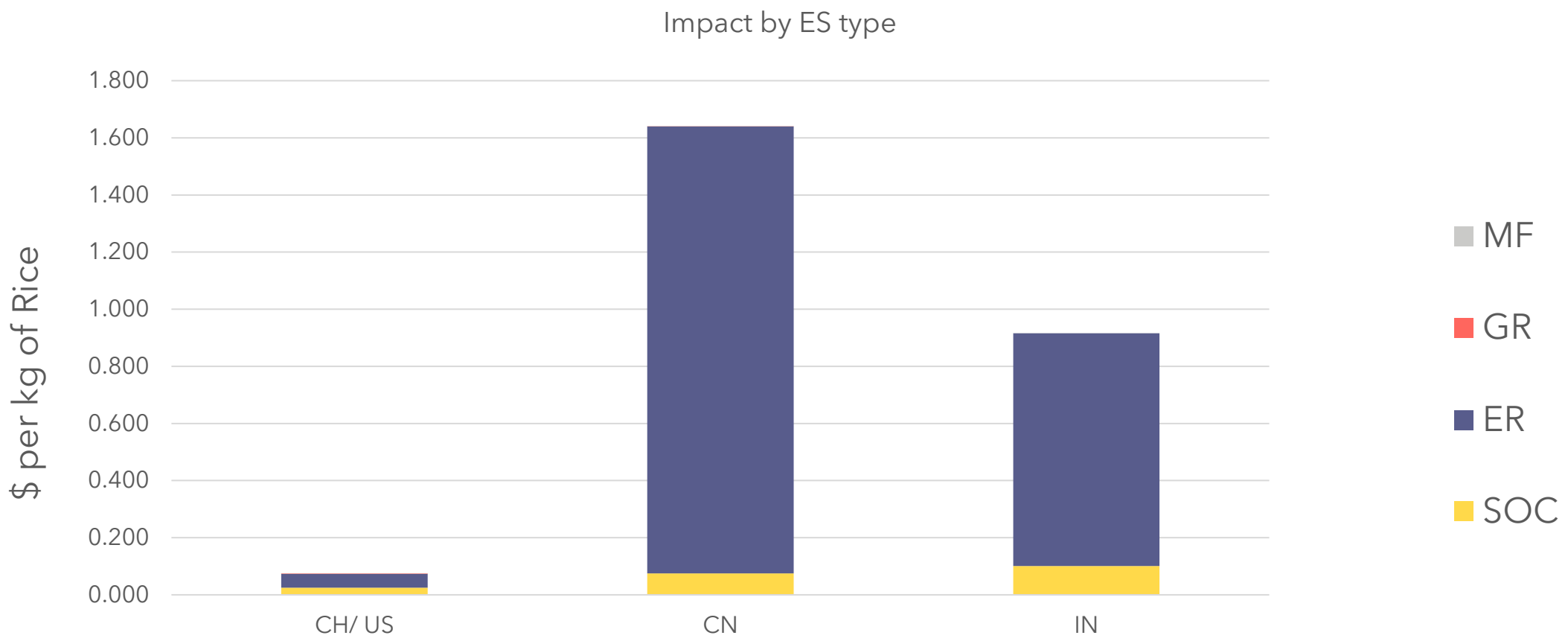
	pasture/meadow	arable	urban	forest	unspecified	Total
SOC Occ.	386,381	381,400	209,531	-		977,311
ER Occ.	581	7,685	1,113			9,379
GR Occ.	111,731	88,836	24,356			224,922
MF Occ.	1,932	24,974	1,054			27,959
SOC Trans.	- 95	966	1,937	-	501	3,309
ER Trans.	- 3	- 9	8	- 0	- 13	- 16
GR Trans.	385	- 146	269	- 22	- 191	296
MF Trans.	6	- 6	12	- 8	1	5
Total	500,918	503,701	238,279	- 30	298	1,242,897

Total ES impacts from land use per country – total

ES impacts from land use per country – area normalised



Case study on Rice Production and in three regions



Conclusions

- Ecosystem service damage from land use included in model account for approximately 1/3 of total annual value of global food production.

- Additional work required to expand to look at other land use effects