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High-resolution erosion modelling using the RUSLE

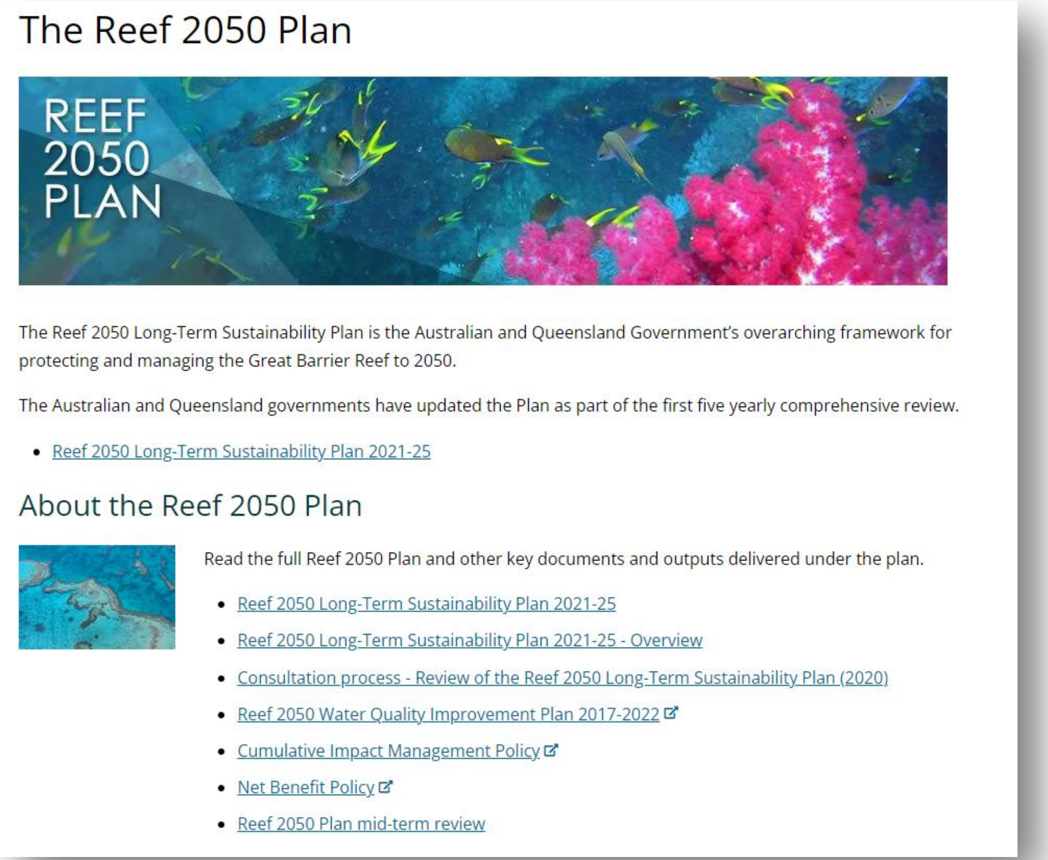
An application to open-cut coal operations under consideration of increased rainfall variability in climate change models

Dr Pascal Bolz

Background

Great barrier reef catchments and sources of pollution

- **Water quality in the Great Barrier Reef lagoon on the decline**
- **Agricultural sector main source of pollutants**
- **Reef 2050 also focussed on other land-based pollutant sources, e.g. mining industry**
    - Mining industry particularly scrutinised, but not a main contributor
    - Mining industry to take the lead on improving our understanding of local-scale erosion and improve the existing guidelines on Erosion and Sediment Control Practices (ESCP)
    - This presentation showcases some of the work done at the Centre for Water in the Minerals Industry as part of a project for the Australian Coal Industry Research Program (ACARP)


The Reef 2050 Plan

REEF 2050 PLAN

The Reef 2050 Long-Term Sustainability Plan is the Australian and Queensland Government's overarching framework for protecting and managing the Great Barrier Reef to 2050.

The Australian and Queensland governments have updated the Plan as part of the first five yearly comprehensive review.

- Reef 2050 Long-Term Sustainability Plan 2021-25

About the Reef 2050 Plan

Read the full Reef 2050 Plan and other key documents and outputs delivered under the plan.

- Reef 2050 Long-Term Sustainability Plan 2021-25
- Reef 2050 Long-Term Sustainability Plan 2021-25 - Overview
- Consultation process - Review of the Reef 2050 Long-Term Sustainability Plan (2020)
- Reef 2050 Water Quality Improvement Plan 2017-2022
- Cumulative Impact Management Policy
- Net Benefit Policy
- Reef 2050 Plan mid-term review

Project goals

- Provide the mining industry with guidelines on how to assess (catchment based) site-scale soil loss
- Assess different erosion models and their applicability to the specifics of open-cut mine operations
- Delimit mine-affected against non mine-affected water on site based on detailed data on operational domains
- Assess required volumes and quality of sediment for better planning principles of sediment control structures based on the integration of catchment modelling, soil loss and operational domains

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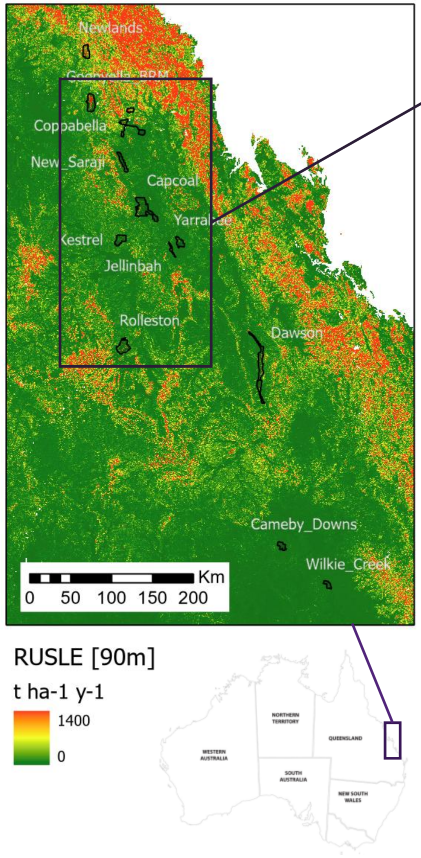
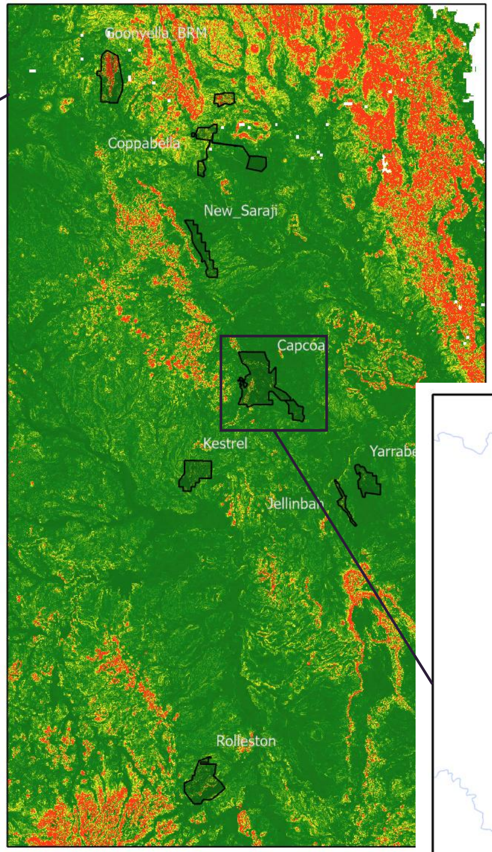
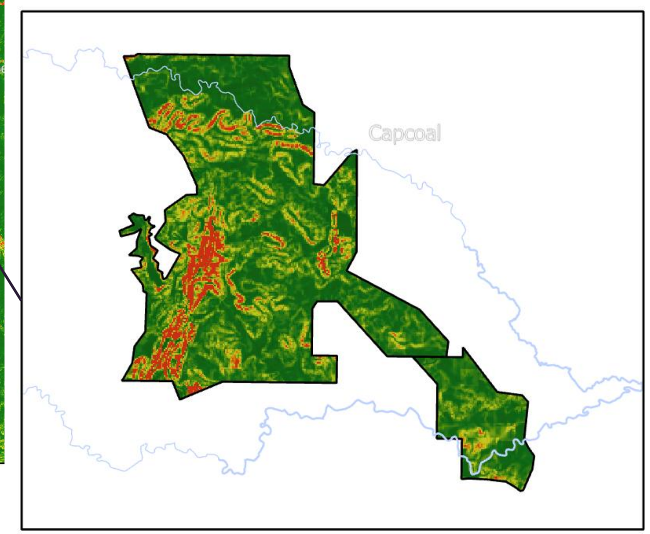
Regional soil loss modelling in QLD

Revised Universal Soil Loss Equation (RUSLE)







Public domain data from QSpatial 90m pixel resolution

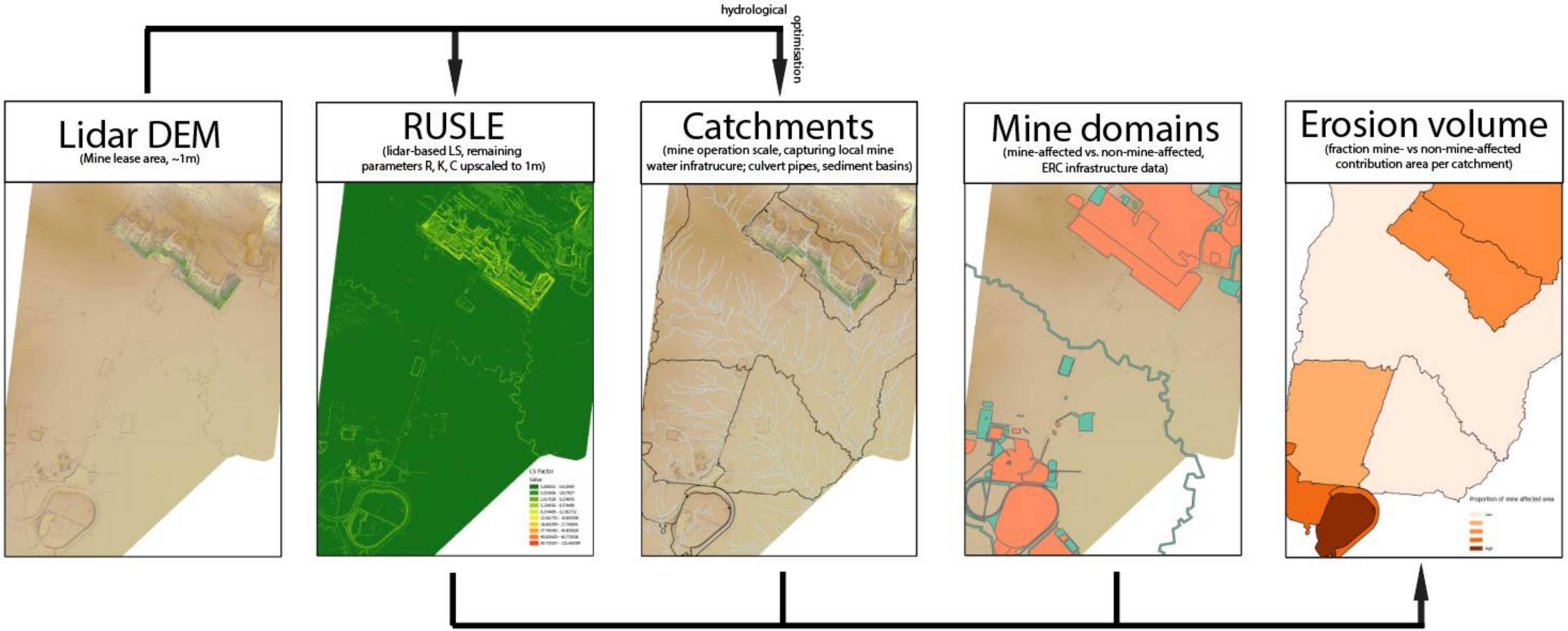
- **RUSLE is an empirical erosion model developed for the agricultural sector**
- **Limitations: gully erosion, dispersive soils, sediment deposition**
- **Commonly applied at regional scale with resolutions ~30m (DSM)**
- **RUSLE has the potential to be applied at local scale with higher resolution**

A = R x K x LS x C

A: average annual potential soil loss (tons/hectare/year)
R: rainfall-runoff erosivity factor
K: soil erodibility factor
LS: slope length and degree factor
C: land-cover management factor

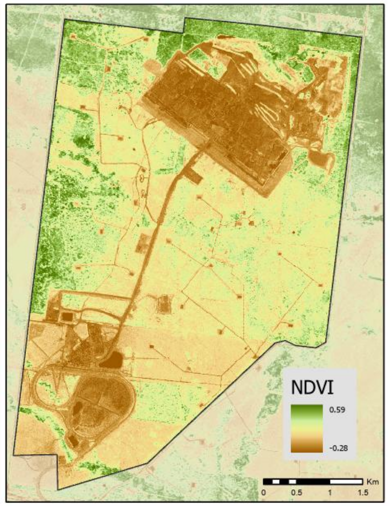
Site-scale soil loss modelling

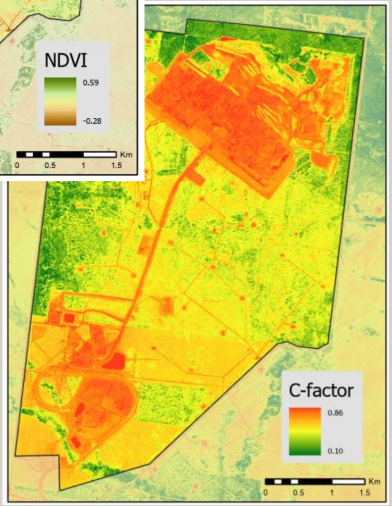
Components of developed workflow



Methods (RUSLE)

Cover management (C-Factor)
3m native resolution (4band from Planet)

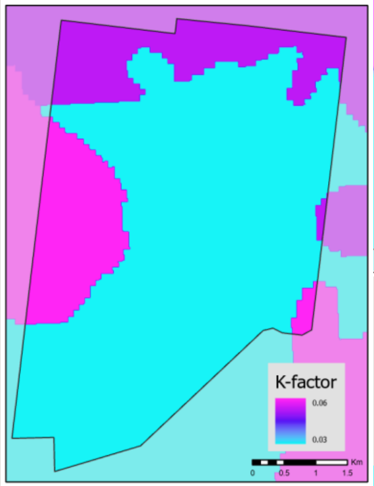


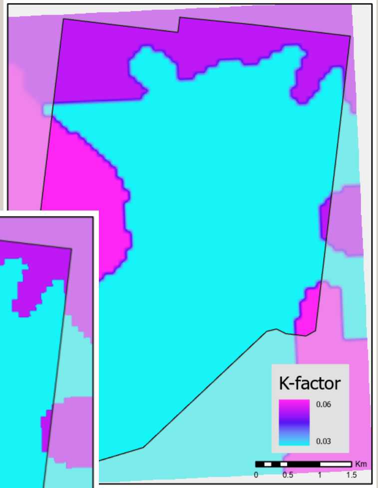


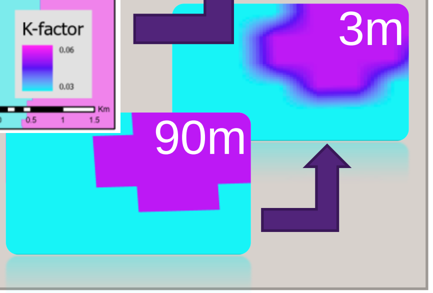
Method after Yang 2014 using monthly coefficients

Processed from “native” data

Soil erodibility (K-factor): derived from regional public domain data

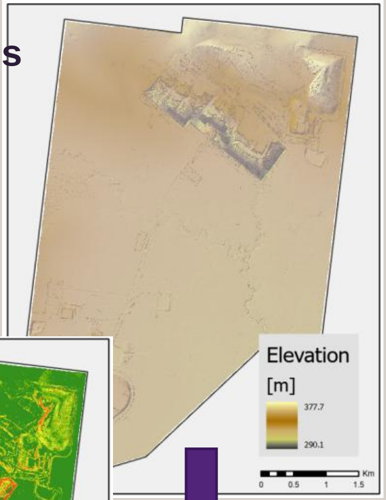


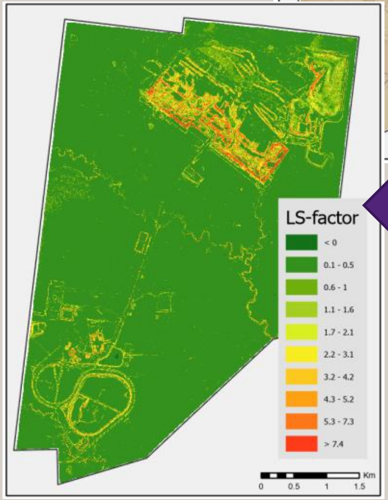




Processed from regional data

Length and slope steepness (LS-Factor)
LiDAR dataset from site operation (1m)

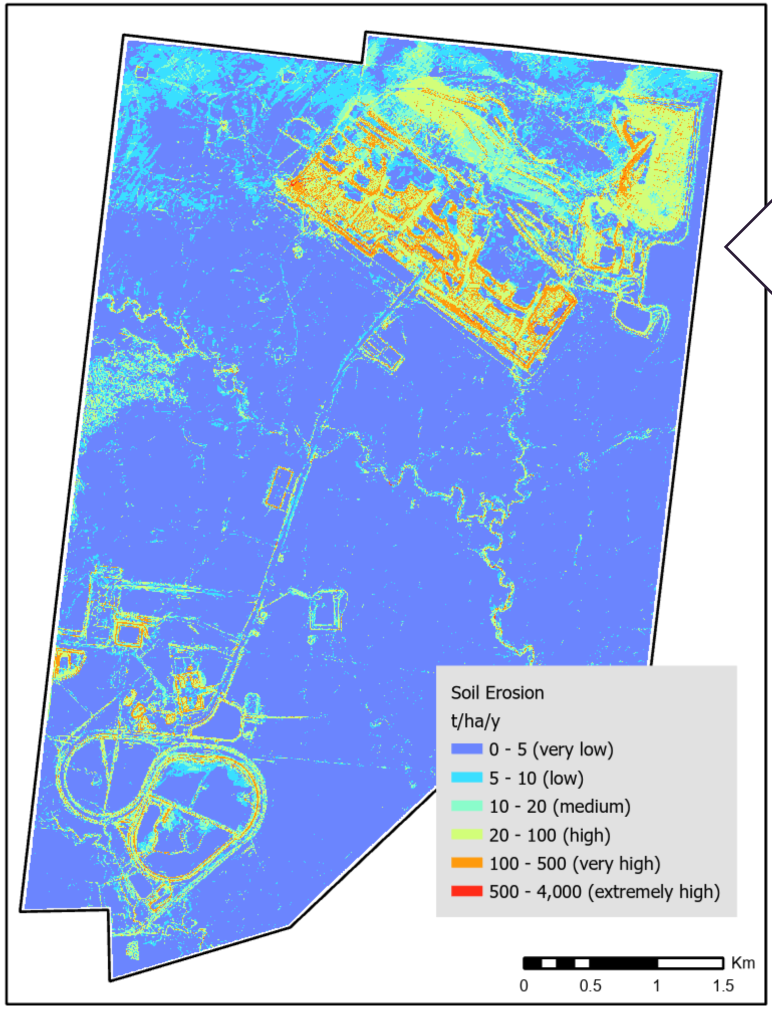




Method after Moore et al.(’91) as implemented in SAGA (also accessible via QGIS)

Processed from “native” data

Site-scale soil loss model



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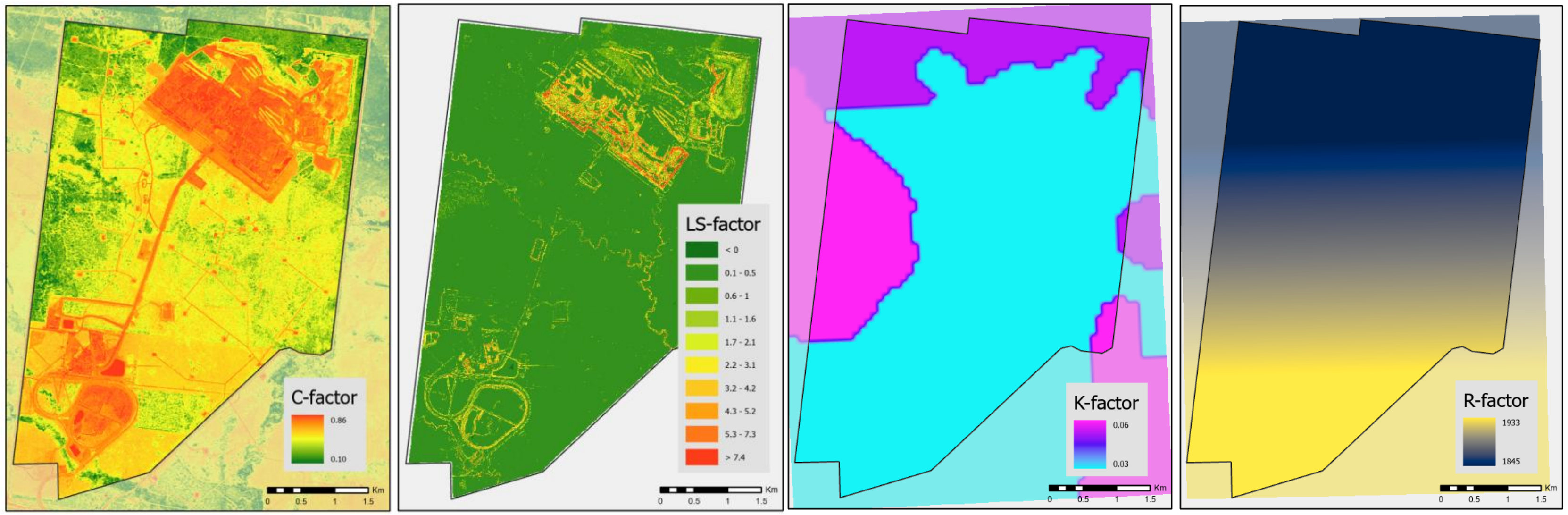
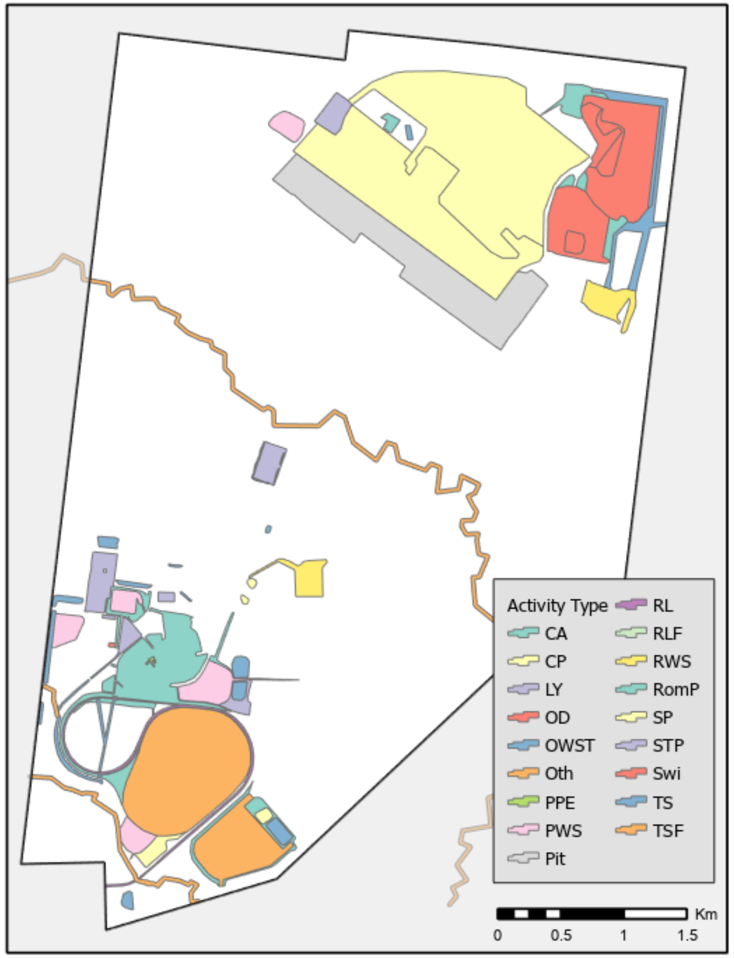
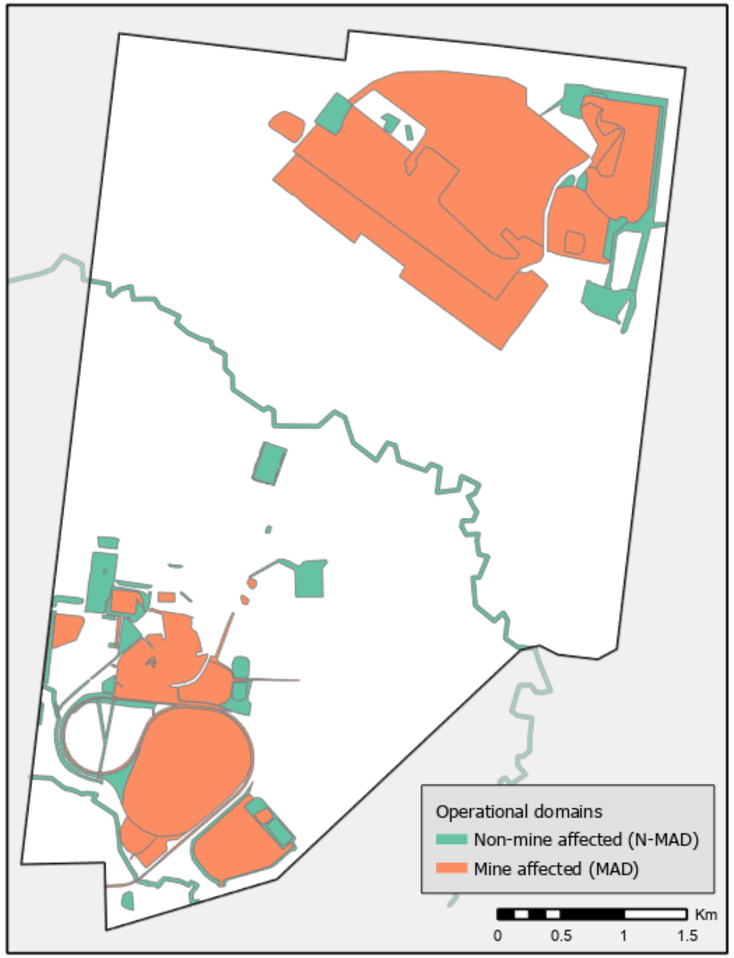


Operational domains

Mine-affected and non mine-affected site domains



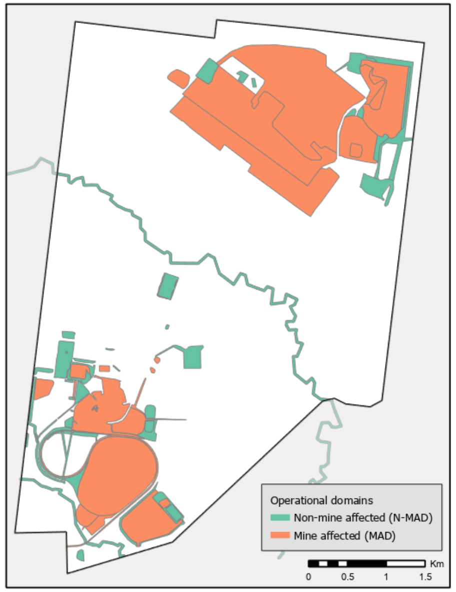


ACT_TYPE	Domain Value Description	MAD	N-MAD		ACT_TYPE	Domain Value Description	MAD	N-MAD
AT	Access track		x		Pit	Pit	x	
BH	Bore hole		x		PL	Power line		x
BP	Borrow pit		x		PPE	Processing plant and equipment	x	
Bui	Building		x		PWS	Process water storage	x	
CA	Cleared area		x		Ramp	Ramp	x	
Camp	Camp		x		RL	Rail line	x	
CDA	Co-disposal area	x			RLF	Rail loading facility	x	
Con	Conveyor	x			Road	Road	x	
CP	Concrete pad		x		RomP	Run of Mine (ROM) Pad	x	
CT	Communication tower		x		RS	Regulated structure		x
DH	Drillhole		x		RWS	Raw water storage		x
EOWS	Evaporation and other unlined water storage				SBH	Silo/bin/hopper	x	
Fen	Fence		x		SP	Spoil pile	x	
GI	Gas infrastructure		x		STP	Sewage treatment plant	x	
HLP	Heap leach pad	x			Sub	Subsidence		x
HR	Mine haul road	x			Subt	Substation		x
LF	Landfill		x		Swi	Switchyard		x
LY	Laydown yard		x		Tank	Tank		x
OD	Overburden dump	x			TS	Topsoil stockpile		x
Oth	Other		x		TSF	Tailings storage facility	x	
OWS	Other water storage				UW	Underground workings		x
OWST	Other water structures		x		VS	Ventilation shafts		x
Pip	Pipeline		x		WRD	Waste rock dump	x	

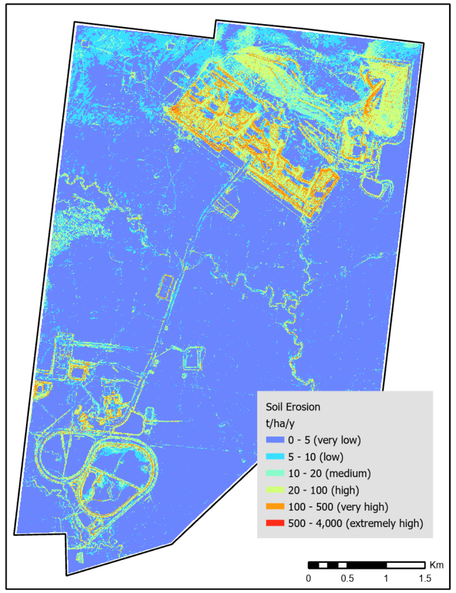
Data integration

Catchment modelling

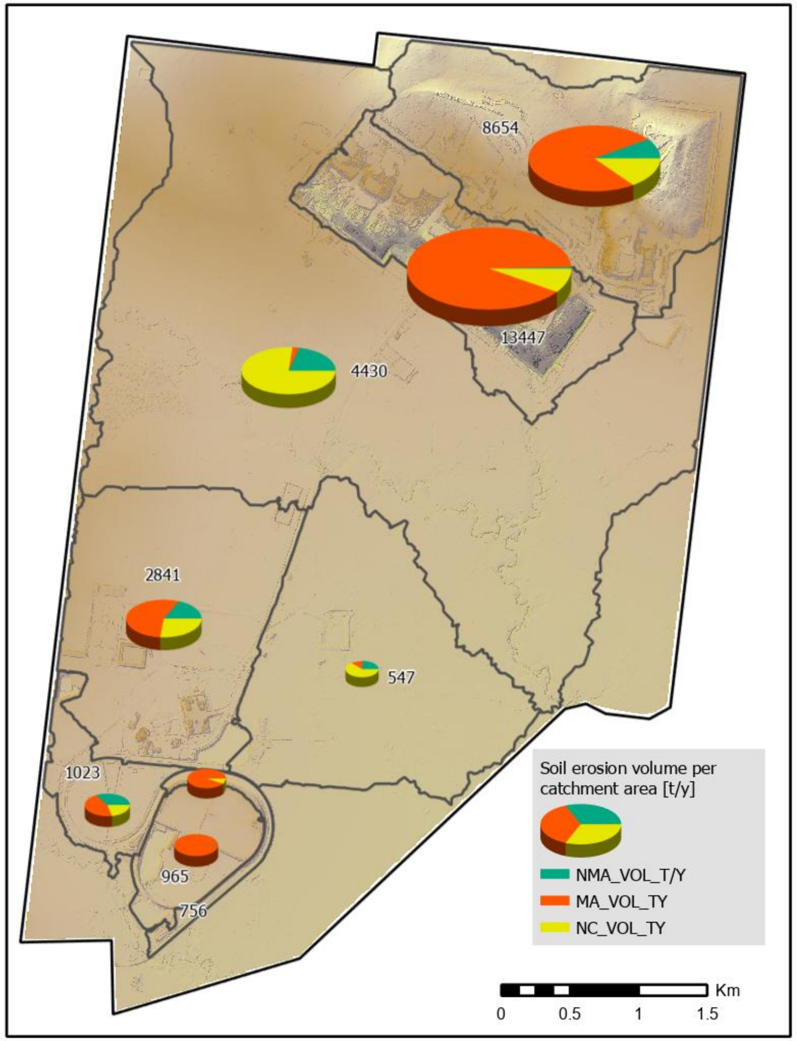
Operational domains



Erosion volumes

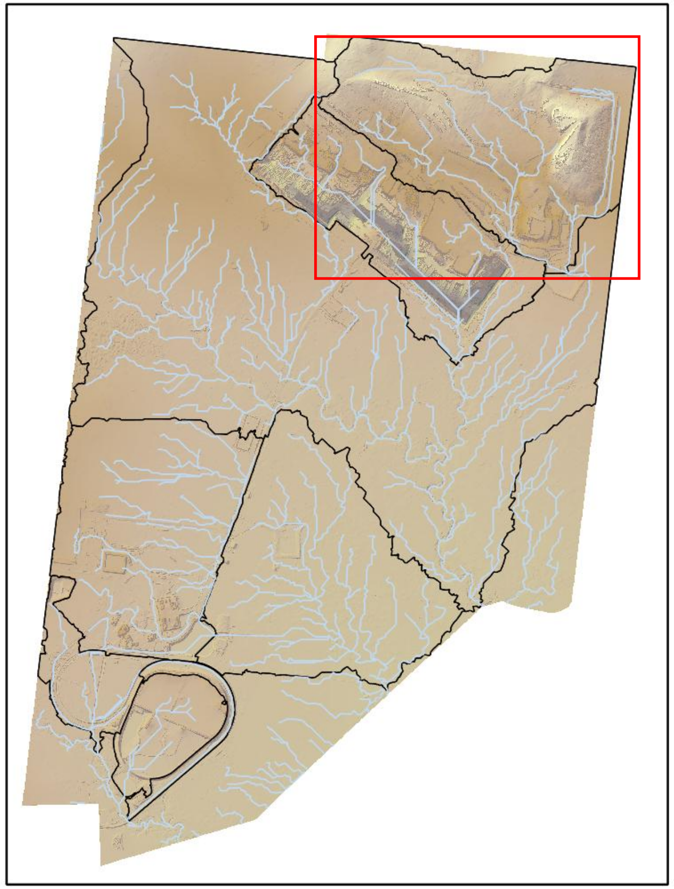


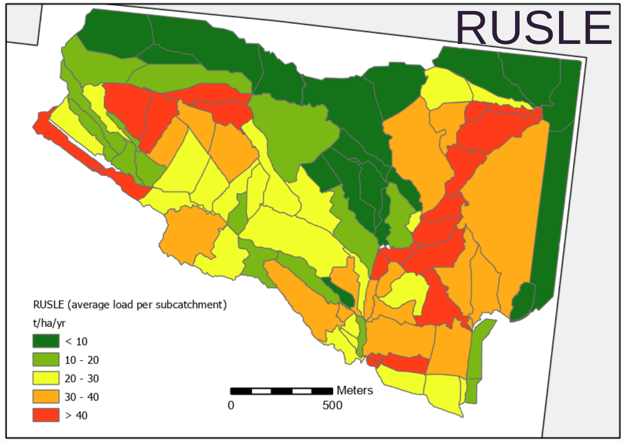
Quantification of sediment quality

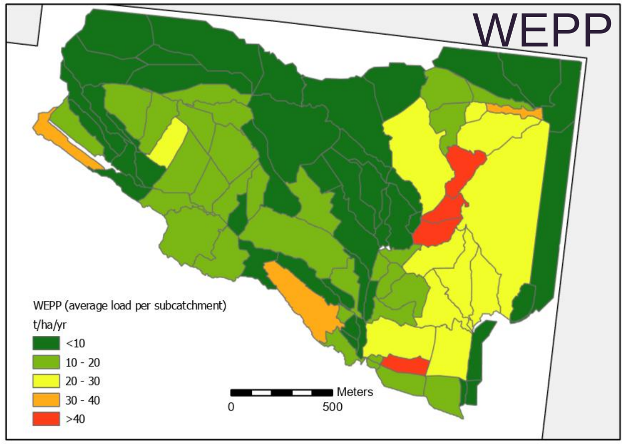


NMA: Non-mine affected sediment
MA: Mine-affected sediment
NC: Not classified

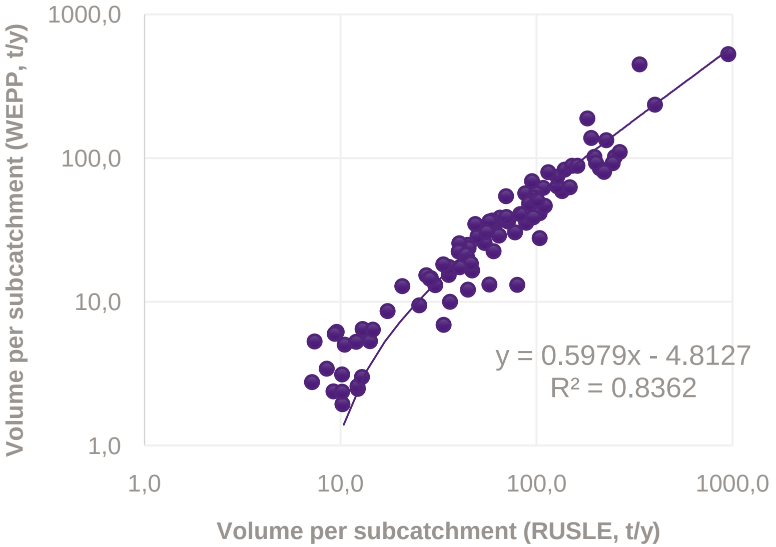
RUSLE vs WEPP



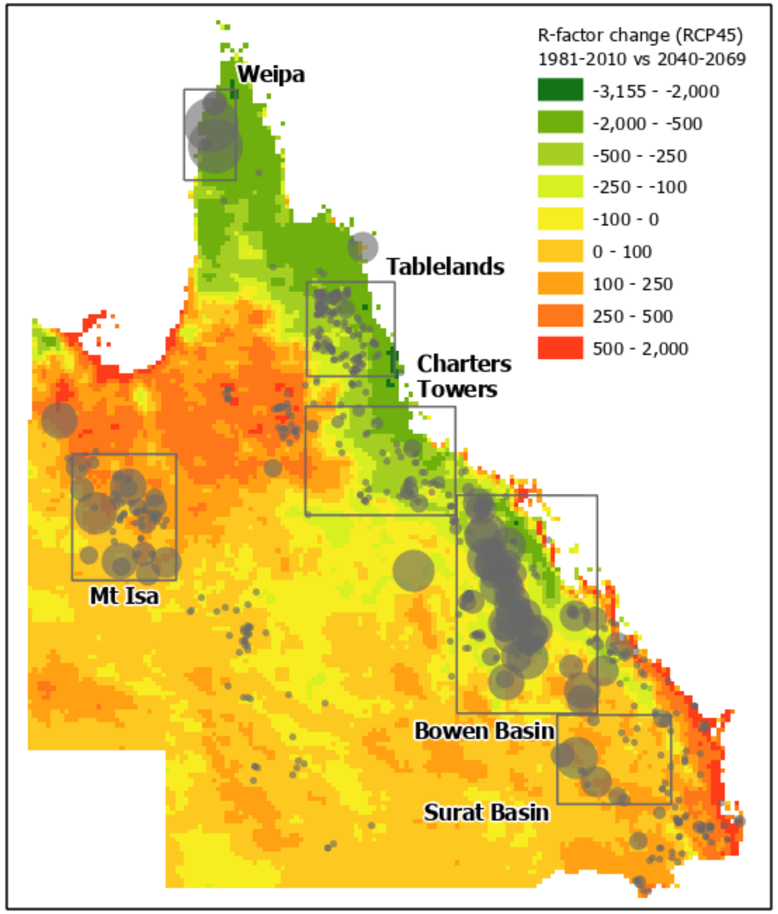


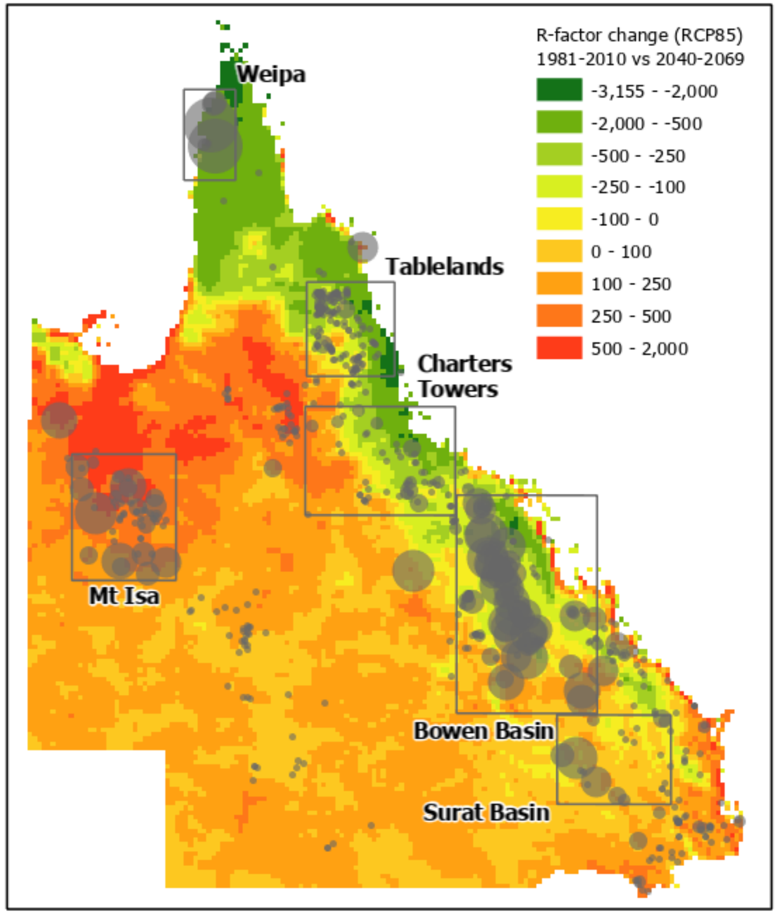


- **WEPP is catchment based and requires detailed delineation of catchments to facilitate comparison with RUSLE**
- **Soil loss volumes from WEPP are commonly lower than RUSLE (about 40%)**



…and what about climate change?





Preliminary R-Factor data based on model data from Queensland Department for Environment and Science, processed by N. Bulovic (SMI)

- **Rainfall data based on RCP45 and RCP85 climate scenarios suggest R-Factor will increase for some of the mining regions in Queensland**
  - Southern Bowen Basin (Coal)
  - Surat Basin (Coal/CSG)
  - Mt Isa (Base metals and critical minerals)
- **This will lead to higher soil erosion volumes in some areas that need to be accounted for in the design of sediment control structures**

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Conclusions

- RUSLE has shown to be most suitable to model soil loss volumes, especially considering the **complex topography** in open-cut mine operations
- Integration of hydrology, erosion modelling and information on operational domains can be used by sites to **design sediment control** structures more **efficiently**
- Further work is required, especially on **validation** of soil loss volumes under real-world conditions (ACARP proposal submitted) and correction of the model results by the sediment delivery ratio (SDR)
- **Training course** for industry professionals is going live in April 2024 covering Erosion and Sediment Control Practices (Module 3 following Module 1 and 2 on Mine water management launched in 2022)

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