Literature Review Instructions

Rafli Ramdani
Master of Business Analytics

Azham Hassan Venghat
Master of Business Analytics

Report for
ETC5543

21 August 2025

MONASH
BUSINESS
SCHOOL

**Department of
Econometrics &
Business Statistics**

📞 (03) 9905 2478
✉ BusEco-Econometrics@monash.edu

ABN: 12 377 614 012

1   Objective

To support the development of a flexible, high-resolution modelling framework by conducting a structured literature review of:

1. The **existing Tasmanian Enterprise Suitability Maps (TESMs)** – their inputs, methods, and limitations (extensive, around 4500 words)

2. Comparable **crop suitability models** from other regions

3. **Emerging, high-value, or climate-resilient crops** suitable for Tasmania's cool temperate climate

Your review will guide improvements to TESMs and the inclusion of specialty crops (e.g. truffles).

---

2   Part 1: Review of the Existing Tasmanian Enterprise Suitability Maps (TESMs)

2.1   Current model features

Enterprise Suitability Maps are a map that combine high-resolution digital soil mapping, climate modelling, crop suitability rules. These rate climate, landscape, and soil variables to the requirements of a range of crops. The purpose of this map is to assist farmers, industry, or investors to identify areas where crops or enterprises could potentially be introduced, intensified, or diversified, guiding more detailed investigations at the farm or paddock-scale. possible risks or impediments to growing the crops and mitigation to improve suitability.

Tasmania's Department of Natural Resources and Environment Tasmania alongside Tasmania Institute of Agriculture develop, review, evaluate, and improve the map. Tasmania Enterprise Suitability Maps (TESM) is built from digital soil and climate modelling through on-farm soil sampling and climate sensing (refer to the Digital Soil Mapping and Climate Mapping sections below for further information on these topics).

The current mapping assumes water for crop irrigation is available and therefore not a limiting factor to production. This assumption is made in order to enable an assessment of land potential based on soil and climate attributes, independent of current water limitations, and to support planning and investment decisions that align with the scope of new irrigation infrastructure projects in Tasmania, particularly those driven by initiatives such as the "Water for Profit" program, which has expanded

irrigation capacity and underpinned decision support for Tasmanian agriculture. The program operates through co-investment models where government funds subsidize infrastructure and development costs, but farmers and enterprises contribute financially for access and ongoing usage, so water is not provided free of charge (Kidd et al, 2015).

Table 1: *List of All Current Crops in TESM*

Type	Crops
cereals	barley, linseed, wheat
perennial horticulture	blueberriesNHB, blueberriesSHB, cherries, hazelnuts, olives, raspberries, sparklingwg, str
vegetables	carrots, carrotseed, onions, potatoes
pharmaceuticals	hemp, poppies, pyrethrum
pastures	cocksfootcontinental, cocksfootmediterranean, lucerne, phalaris, redclover, ryegrass, stra
forestry	E_globulus_tree, E_nitens_tree, P_radiata_tree

The range of agricultural commodities covered in this map includes vegetables, cereals, pharmaceuticals, perennial horticulture, pastures, and forestry, with a detailed description of the crop–commodity type pairs provided in Table 1.

- Identify spatial inputs (e.g. rainfall, soil type, temperature, slope)

The Tasmanian Enterprise Suitability Maps (TESMs) draw upon a wide array of spatial inputs grouped into soil, climate, and topographic attributes. These inputs are derived from digital soil mapping (DSM) and climate modelling, which generate spatially continuous raster grids of functional attributes across the state. Soil properties such as pH, electrical conductivity, clay percentage, exchangeable calcium and magnesium, stone content, effective rooting depth, and depth to sodic layers form the foundation of the database.

Soil drainage class is a particularly critical input, as it strongly influences whether irrigated enterprises can establish successfully; Kidd et al. (2014) demonstrated that integrating expert-based drainage estimates with DSM techniques produced predictive drainage surfaces with robust validation metrics

Climate inputs include frost risk, chill hours, growing degree days, extreme heat risk, and rainfall, all derived from extensive temperature sensor networks combined with terrain covariates

Topographic variables such as slope, elevation, and aspect are incorporated to capture effects on water movement, microclimates, and erosion potential. Together, these inputs are resampled into a

consistent gridded format (typically 30–80 m resolution), enabling the creation of suitability surfaces that represent the continuous spatial variability of Tasmanian landscapes.

Variable	Class
Air temperature	climate
Chill hours	climate
Daily maximum temperature	climate
Depth to sodic layer	soil
Duplex soil	soil
Electrical conductivity	soil
Elevation	topography
Exchangeable calcium	soil
Exchangeable magnesium	soil
Extreme heat risk	climate
Frost risk	climate
Growing Degree Days	climate
Growing Season Temperature	climate
Heat stress	climate
Hot weather during summer	climate
Rainfall	climate
Slope	topography
Soil Depth	soil
Soil depth	soil
Soil drainage	soil
Soil texture	soil
Stone abundance	soil
pH	other

- Describe modelling approach (deterministic rules, scoring thresholds)

Current Tasmania Enterprise Suitability Maps modelled using . . . approach, specifically using . . . in the . . . part of the mapping, and . . . . in the . . . . .

The TESMs employ a deterministic, rule-based modelling framework underpinned by digital soil assessment (DSA). Each enterprise has a rule-set derived from agronomic literature, expert workshops,

and industry consultation, specifying threshold ranges for soil, climate, and terrain parameters. For example, blueberries require well-to-moderately well-drained soils, with imperfect drainage considered only marginally suitable. These thresholds are applied to the input rasters to generate binary or categorical scores (e.g., well-suited, suitable, marginal, unsuitable), following the FAO-style "most limiting factor" principle where the lowest-rated parameter governs the final suitability class. The rule-based approach ensures transparency and interpretability: stakeholders can query maps to identify specific limiting factors (e.g., frost risk or shallow soil depth) and consider mitigation strategies.

The modelling relies heavily on digital soil mapping outputs, which are produced using machine-learning and geostatistical methods such as regression trees, random forests, and regression-kriging. These methods allow predictions of soil attributes from field observations and environmental covariates, while also quantifying uncertainty in the estimates.

In short, TESMs are built by applying expert-defined suitability rules to high-resolution soil and climate grids, combining deterministic thresholds with DSM-derived spatial predictions. The result is a transparent, operational tool for land-use planning, with all of its drawbacks.

2.2   Critically assess limitations

- Missing inputs (e.g. chill hours, pH, drainage, frost exposure) adding new proposed parameters that may help making our map perform better in accuracy.

According to the each crop rules dataset, extracted from the website, each crops has different combination of crucial climate variable(s) and topography to consider. This claim supported by this data from Tasmanian Goverment. This makes modelling an accurate and reliable model for all crops challenging. Missing data happen in all variables.

Adding on, by investigating the crops rules dataset *(see Appendix Table A1)*, there are limitations of the lack of common/standardize variables. This makes the mapping harder, since the lack of common variables means the map is less-reliable.

- Lack of uncertainty estimation or validation (modelling limitation, compare this with smap and gaez)

Another limitation is in the suitability framework, the integration of these attributes remains deterministic rather than probabilistic. Uncertainty estimates are not considered through into the final TESMs. This makes the maps practical and user-friendly, but at the cost of underrepresenting the variability and confidence levels inherent in the underlying data. with limited flexibility and no formal propagation of uncertainty.

- Inflexibility for adding niche or specialty crops

Although LISTmap provides an option to add external layers through formats such as WMS or KML and others *(see Appendix Figure A1)*, the main limitation lies in the availability of suitable data rather than the platform itself. High-resolution spatial datasets for niche or specialty crops are rarely produced because they require costly ground truthing, sensor calibration, and long-term monitoring. Even when data are available from sources such as New Zealand's S-map or FAO's GAEZ, the absence of locally collected, large-scale field data in Tasmania prevents the development of reliable crop maps for underrepresented commodities (Zhong et al., 2019; Zhang et al., 2024). This scarcity means that specialty crops cannot be mapped with the same spatial detail as mainstream commodities like cereals or fruit. Furthermore, integrating new data into LISTmap is not straightforward. Users must first prepare and host the datasets in platforms such as ArcGIS, then import them manually into LISTmap. Even then, integration may not function seamlessly, and formal inclusion of a new crop layer still requires request to the custodians of Tasmania's agricultural spatial data at the Department of Natural Resources and Environment.

Equally important is the lack of locally validated crop-specific suitability rules, which are essential for converting soil, climate, and topographic data into meaningful classifications of land potential. Suitability assessments rely on agronomic thresholds such as acceptable ranges for pH, rainfall, or frost tolerance, yet these thresholds are largely absent for specialty crops in Tasmania. As emphasised by Magliocca et al. (2020) and Pramanik et al. (2023), the introduction of new crops is limited not only by the scarcity of environmental datasets but also by uncertainty in defining where and under what conditions they can be successfully cultivated. Together, these gaps in spatial data and suitability rules explain the current inflexibility in extending Tasmania's Enterprise Suitability Maps to niche or specialty crops.

- Over generalization (ignoring micro climates, management practices)

Despite the robustness of the spatial inputs and the transparency of the rule-based modelling approach, several limitations emerge when moving from data layers to practical suitability maps. The deterministic framework treats thresholds as fixed, without accounting for uncertainty in soil and climate predictions or variability in management practices. Moreover, while the rules capture key agronomic requirements, they may oversimplify interactions between factors such as soil drainage, temperature extremes, and crop management. As a result, the TESMs provide a valuable first-pass planning tool, but their outputs must be interpreted with caution, particularly when extending to niche crops, areas with complex microclimates, or situations where farmers employ adaptive management strategies.

In addition to microclimatic variability, the maps also overlook differences in management practices

that strongly influence crop outcomes. Access to water is a clear example: while rainfall and groundwater availability are well mapped, the actual feasibility of irrigation depends on proximity to dams, rivers, or irrigation infrastructure, which is not captured in the current models. Similarly, the effectiveness of pest and disease management can substantially alter yields on land that appears equally suitable in biophysical terms. Crop rotations and seasonal timing also affect soil resilience and productivity in ways that deterministic rules cannot reflect. By standardising these factors, TESMs risk portraying land units as uniform when, in reality, farmers' practices create significant variation in outcomes. This underscores the importance of integrating management-related variables such as irrigation access and pest or disease pressure into future suitability frameworks, making them more reflective of real-world agricultural conditions.

2.3   Suggested Comparator Models

Briefly describe **2–3** of the following alternative suitability frameworks, focusing on inputs, methods, uncertainty, extensibility:

- **New Zealand S-map & Crop Suitability Layers** (Manaaki Whenua – Landcare Research)

    - Includes truffles and other specialty crops

    - Integrates soil, climate & management

    - Modular and extensible design

- Victorian Horticulture Crop Suitability Framework

- Queensland Land Suitability Guidelines (DES)

- FAO EcoCrop / GAEZ

In modern suitability frameworks (e.g., New Zealand's S-map + crop suitability layers, or FAO's GAEZ), probabilistic modelling and climate scenarios are often incorporated. This adds reliability because it expresses the range of possible outcomes, not just a single binary threshold. TESMs fall short here.

- USDA Crop Suitability Tools

- CSIRO land evaluation frameworks

---

3 Part 2: Literature Review on Emerging & Climate-Resilient Crops

3.1 Selection Criteria

Identify crops that are:

- **Not** in TESMs

- High-value or specialty (e.g. truffles, saffron, hops)

  - Ginseng (currently under trial or limited local production).

- Climate-resilient (drought/frost/salinity tolerance)

  - Quinoa (drought, salinity, and frost tolerant)

- Suitable for regenerative, small-scale systems in Tasmania

- Under trial or limited local production (bonus)

3.2 Crop Summary Requirements

For each candidate crop, capture at minimum the details required as input to the existing TESM, and any others indentified from your literature review, e.g:

- **Climatic**: temperature range, rainfall, chill hours, frost/heat tolerance

- **Soil**: texture, drainage, pH, organic matter

- **Topography**: slope, elevation suitability

- **Water**: irrigation needs or dryland tolerance

- **Management**: pest/disease issues, growing season, pollination

- **Markets**: value, demand trends, Tasmanian viability

- **Model Inputs**: spatial variables you could add to TESMs

---

4 Deliverables

1. **Narrative Report** (4–6 pages)

   - Executive summary

   - TESMs overview & limitations

   - Comparator model insights

   - 5–10 recommended crops (with focus on truffles)

   - Recommendations for new inputs & uncertainty handling

2. **Reference List**

   Please only use Peer-reviewed journals, government & industry reports. Use reference formating according to Monash unit guidelines.

5 Resources

- **TESMs**: https://dpipwe.tas.gov.au/agriculture/land-resources/land-capability-and-suitability/enterprise-suitability

- **NZ S-map**: https://smap.landcareresearch.co.nz/

- **FAO EcoCrop**: https://ecocrop.fao.org/

- CSIRO, AgriFutures, DPIPWE, AgVic, QLD DES publications

- Google Scholar, Scopus, Web of Science, Trove

6 Appendix

Table 2: *Table A1. All Rules Inputs for TESM*

```
# A tibble: 5 x 82
  Crop_Type `Crop Type` Rating                 `Soil depth` `Depth to sodic layer`
  <chr>     <chr>       <chr>                  <chr>        <chr>
1 barley    barley      "1.0 Well suited"      >40cm        >30cm
2 barley    barley      "1.1 Well suited (w~   >40cm        >30cm
3 barley    barley      "2.0 Suitable"         >40cm        20 – 30cm
4 barley    barley      "2.1 Suitable (with~   >40cm        20 – 30cm
5 barley    barley      "3.0\r\nModerately ~   >40cm        <20cm
# i 77 more variables: `pH\r\n(top 15cm)` <chr>,
#   `Electrical conductivity (ECse)\r\ndS/m` <chr>,
#   `Soil texture (top 15cm – % clay)` <chr>, `Soil drainage` <chr>,
#   `Stone abundance (>200mm\r\ndiameter,\r\ntop 15cm)` <chr>,
#   `Slope\r\n(of land, % rise)` <chr>,
#   `Frost risk\r\nThe chance of having at least 1 day where\r\nTmin <0oC during flowerin
#   `Stone abundance (>200mm diameter, top 15cm)` <chr>, ...
```