Assessment in the Course

ERST606 – Advanced Geographic Information Systems A

# Suitable Areas for Maize (Zea mays L.) Cultivation in New Zealand


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10/06/2025

# Abstract

This study identifies suitable areas for maize (Zea mays L.) cultivation in New Zealand using a GIS-based multi-criteria evaluation (MCE). Four categories—climate, soil, terrain, and land use—were selected based on an in-depth literature review. Each national dataset was reclassified to a common suitability scale, weighted, and combined in ArcGIS Pro. The analysis produced a national raster map (100 m resolution) with four suitability classes. Very suitable areas are mainly located in the North Island, especially around Auckland and Waikato. In contrast, suitable zones in the South Island are more limited. They can be mainly found in Central Canterbury and parts of Southland, where terrain and land use promote maize production. The model focuses on biophysical factors and supports spatial decision-making for policy makers, and farmers aiming to optimise land use for sustainable maize expansion.

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## List of Abbreviations

| | |
|---|---|
| DEM | Digital Elevation Model |
| FAO | Food and Agricultural Organization of the United Nations |
| FAR | Foundation for Arable Research |
| GDD | Growing Degree Days |
| GIS | Geographic Information System |
| MCE | Multi-Criteria Evaluation |

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# 1 Introduction

Identifying land suitable for agricultural production is a key challenge in the context of global food security, environmental sustainability, and economic development. In New Zealand, where agriculture plays a significant role in both the economy and land use, optimising crop placement is particularly important. Maize (Zea mays L.) is grown in New Zealand as a forage and grain crop, supporting both the dairy and livestock sectors. In 2021, the area under maize cultivation was approximately 74,000 ha, which corresponds to 215,000 tonnes of corn and 1,165,640 tonnes of silage (FAR, 2021). However, its successful cultivation depends on a combination of climatic, edaphic, and topographic conditions, which vary significantly across the country's diverse landscapes.

Given the spatial variability of environmental factors across New Zealand, Geographic Information Systems (GIS) offer an efficient means to integrate and analyse these data at national scale. Previous studies have demonstrated the use of GIS for maize suitability modelling, e.g. in South Africa (Moeletsi & Walker, 2013), India (Ramamurthy et al., 2020), Indonesia (Habibie et al., 2021) and Cameroon (Kenzong et al., 2022). What they all have in common is that a number of factors are weighted and calculated as a raster analysis. The factors are always related to climate, soil and landscape, but the exact selection and weighting varies. In the South Island of New Zealand, Wilson et al. (1994) explored climatic limitations to maize production, while more recent advancements in spatial data availability have enabled more detailed, raster-based analyses.

The objective of this study is to identify and map areas across New Zealand that are suitable for maize cultivation. The results are intended to support farmers, agricultural advisors and policy makers in making informed decisions about crop placement and land management. To achieve this, a spatially explicit land suitability analysis is conducted using *ArcGIS Pro*. The approach integrates multiple environmental and soil dataset into a weighted Multi-Criteria Evaluation (MCE) framework. Each factor is reclassified and standardised to a common suitability scale, and the results are combined using raster-based overlay techniques to generate a nationwide 100 m resolution suitability map for maize production in New Zealand.

# 2 Methodology

## 2.1 Study Area

This study focuses on the entire land area of New Zealand (see Figure 1), comprising approximately 268,000 km² across both the North and South Islands (FAO 2022b). A national-scale approach was selected to enable a comprehensive evaluation of spatial suitability for maize cultivation, a crop of increasing agronomic and economic relevance in New Zealand's arable farming systems. National datasets of high spatial resolution are available to support this analysis, mainly by the data portals by Manaaki Whenua Landcare Research (2025) and the Ministry for the Environment (2025).


*Figure 1: Study Area*

## 2.2 Criteria Selection and Weighting

The essential basis of the analysis is the selection of meaningful criteria, their weighting and suitability. The concept is to give values between 0 and 10 for each individual criterion and to summarise them by using percentual weights. This results in a total suitability score between 0 and 10, which is then classified.

The selection of criteria is based on comprehensive literature research. As can be seen in Figure 2, four categories weigh equal for the overall assessment. Climate and soil are focussing on the growth requirements of maize, while terrain and land are related to management.

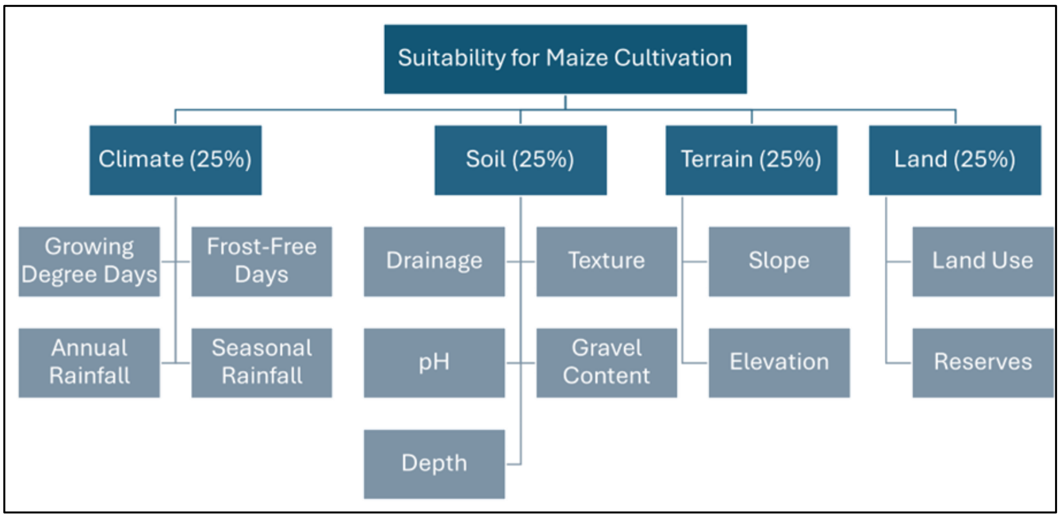


*Figure 2: Criteria to Assess Suitability for Maize Cultivation*

*Table 1: Criteria for Suitable Maize Areas (Part 1)*

| | Criterion | Range / Class | Suitability | Weight | Data Source | Reference / Justification |
|---|---|---|---|---|---|---|
| **Climate (25%)** | **Growing Degree Days (GDD, base 10°C)** | <1000 | 0 | 35% | https://data.mfe.govt.nz/layer/115379-growing-degree-days-state-1972-2022/ | (Food and Agricultural Organization of the United Nations, 2022a; Moeletsi & Walker, 2013; Wilson et al., 1994) |
| | | 1000 - 1200 | 3 | | | |
| | | 1200 - 1400 | 6 | | | |
| | | 1400 - 1700 | 8 | | | |
| | | 1700 - 2200 | 10 | | | |
| | | >2200 | 9 | | | |
| | **Annual Rainfall (mm)** | <500 | 0 | 15% | https://data.mfe.govt.nz/layer/89421-average-annual-rainfall-19722016/ | (Food and Agricultural Organization of the United Nations, 2025) |
| | | 500 - 700 | 4 | | | |
| | | 700 - 900 | 7 | | | |
| | | 900- 1200 | 9 | | | |
| | | >1200 | 6 | | | |
| | **Seasonal Rainfall (mm)** | <300 | 0 | 30% | Spring: https://data.mfe.govt.nz/layer/89417-seasonal-rainfall-spring-19812010/<br><br>Summer: https://data.mfe.govt.nz/layer/89414-seasonal-rainfall-summer-19812010/ | Food and Agricultural Organization of the United Nations (2025) |
| | | 300 - 400 | 4 | | | |
| | | 400 - 550 | 7 | | | |
| | | 550 - 700 | 10 | | | |
| | | >700 | 6 | | | |
| | **Frost-Free Days** | <90 | 0 | 20% | https://data.mfe.govt.nz/layer/115371-frost-days-state1972-2022/ | (Eagles, 1979; Food and Agricultural Organization of the United Nations, 2022a, 2025) |
| | | 90 - 120 | 3 | | | |
| | | 120 - 140 | 6 | | | |
| | | 140 - 170 | 8 | | | |
| | | >170 | 10 | | | |

*Table 2: Criteria for Suitable Maize Areas (Part 2)*

| | Criterion | Range / Class | Suitability | Weight | Data Source | Reference / Justification |
|---|---|---|---|---|---|---|
| **Soil (25%)** | **Soil Drainage** | Very Poorly Drained (1) | 1 | 30% | https://lris.scinfo.org.nz/layer/48085-lenz-soil-drainage/ | (Van Es et al., 2005) |
| | | Poorly Drained | 3 | | | |
| | | Imperfectly Drained | 6 | | | |
| | | Moderately Well Drained | 8 | | | |
| | | Well Drained (5) | 10 | | | |
| | **Soil Texture** | Clayey (C) | 5 | 25% | https://lris.scinfo.org.nz/layer/48082-lenz-soil-particle-size/ | (Meng et al., 2022) |
| | | Loamy (L) | 9 | | | |
| | | Sandy (S) | 3 | | | |
| | | Silty (Z) | 7 | | | |
| | **Soil pH** | <5 | 0 | 15% | https://lris.scinfo.org.nz/layer/120518-s-map-predicted-ph-august-2020/ | (Longhurst et al., 2018) |
| | | 5 - 5.5 | 8 | | | |
| | | 5.5 - 6.5 | 10 | | | |
| | | 6.5 - 7.5 | 7 | | | |
| | | >7.5 | 0 | | | |
| | **Gravel Content** | <5 % | 10 | 10% | https://lris.scinfo.org.nz/layer/48109-fsl-topsoil-gravel-content/ | (Vine et al., 1981) |
| | | 5 - 15% | 9 | | | |
| | | 15 - 30% | 6 | | | |
| | | 30 - 50% | 2 | | | |
| | | >50% | 0 | | | |
| | **Soil Depth (cm)** | Very Shallow (<20 cm) | 0 | 20% | https://lris.scinfo.org.nz/layer/119593-s-map-soil-depth-aug-2024/ | (Kenzong et al., 2022) |
| | | Shallow (20 - 45 cm) | 4 | | | |
| | | Moderately (45 - 100 cm) | 8 | | | |
| | | Deep (>100 cm) | 10 | | | |

*Table 3: Criteria for Suitable Maize Areas (Part 3)*

<table>
<tr><th></th><th>Criterion</th><th>Range / Class</th><th>Suitability</th><th>Weight</th><th>Data Source</th><th>Reference / Justification</th></tr>
<tr><td rowspan="12">Terrain (25%)</td><td rowspan="6">Slope (%)</td><td><2%</td><td>10</td><td rowspan="6">60%</td><td rowspan="12">https://data.linz.govt.nz/layer/51768-nz-8m-digital-elevation-model-2012/</td><td rowspan="6">(Kenzong et al., 2022)</td></tr>
<tr><td>2 - 5%</td><td>8</td></tr>
<tr><td>5 - 8%</td><td>6</td></tr>
<tr><td>8 - 16%</td><td>4</td></tr>
<tr><td>16 - 25%</td><td>2</td></tr>
<tr><td>>25%</td><td>0</td></tr>
<tr><td rowspan="6">Elevation (m)</td><td><1100</td><td>10</td><td rowspan="6">40%</td><td rowspan="6">(Kenzong et al., 2022)</td></tr>
<tr><td>1100 - 1150</td><td>8</td></tr>
<tr><td>1150 - 1200</td><td>6</td></tr>
<tr><td>1200 - 1250</td><td>4</td></tr>
<tr><td>1250 - 1300</td><td>2</td></tr>
<tr><td>>1300</td><td>0</td></tr>
<tr><td rowspan="14">Land (25%)</td><td rowspan="12">Land Use</td><td>Natural forest</td><td>0</td><td rowspan="12">100%</td><td rowspan="12">https://data.mfe.govt.nz/layer/117733-lucas-nz-land-use-map-2020-v003/</td><td rowspan="12">(Journeaux et al., 2017)</td></tr>
<tr><td>Pre-1990 planted forest</td><td>0</td></tr>
<tr><td>Post-1989 forest</td><td>2</td></tr>
<tr><td>Grassland - woody biomass</td><td>3</td></tr>
<tr><td>Grassland – low producing</td><td>4</td></tr>
<tr><td>Grassland – high producing</td><td>8</td></tr>
<tr><td>Cropland – perennial</td><td>6</td></tr>
<tr><td>Cropland - annual</td><td>10</td></tr>
<tr><td>Wetland - open water</td><td>0</td></tr>
<tr><td>Wetland – vegetated n. forest</td><td>0</td></tr>
<tr><td>Settlements</td><td>0</td></tr>
<tr><td>Other</td><td>0</td></tr>
<tr><td rowspan="2">Reserves</td><td>Is reserve</td><td>0</td><td rowspan="2">100%</td><td rowspan="2">https://data.linz.govt.nz/layer/53564-protected-areas/</td><td rowspan="2">n.a.</td></tr>
<tr><td>Is not reserve</td><td>1</td></tr>
</table>

### 2.2.1 Climate

Climate conditions (see Table 1) influence maize growth, development, and yield. Growing Degree Days (GDD) quantify heat accumulation essential for maize to complete its life cycle. Adequate annual and seasonal rainfall ensures sufficient soil moisture during key growth stages, especially in spring and summer, while avoiding both drought stress and waterlogging. A high number of frost-free days is also vital, as maize is sensitive to frost, particularly during germination and flowering stages. Together, these climatic factors determine whether the environment supports maize cultivation.

### 2.2.2 Soil

Soil characteristics (see Table 2) determine root development, water retention and nutrient availability. Well-drained soils prevent root rot and ensure oxygen availability, while loamy textures offer the ideal balance of moisture and aeration. Optimal soil pH promotes nutrient uptake, while extreme pH levels can hinder maize growth. Low gravel content enhances root penetration and water retention. Finally, deeper soils support better root expansion and nutrient storage, enabling plants to withstand environmental stresses. Thus, soil quality is foundational to maize suitability.

### 2.2.3 Terrain

Terrain factors (see Table 3) such as slope and elevation directly affect land workability, erosion risk, and temperature. Flat to gently sloping land is ideal for mechanised farming and minimises erosion, promoting stable plant establishment. Elevation affects climate. Higher altitudes often bring lower temperatures and shorter growing seasons, which can limit maize development. Therefore, evaluating the terrain helps determine whether the landscape can physically and climatically support successful maize cultivation.

### 2.2.4 Land

Land use and conservation status (see Table 3) determine the availability of an area for maize cultivation. Land currently under intensive agricultural use offers existing infrastructure and fewer ecological barriers. Conversely, natural forests, wetlands, and reserves are unsuitable due to legal restrictions or environmental conservation. Identifying appropriate land use types ensures that maize is grown on land that is both legally accessible and ecologically appropriate.

## 2.3 Analysis in ArcGIS Pro

The spatial analysis was conducted as a raster analysis with a cell size of 100 x 100 m (1 ha). This cell size was chosen to match the resolution of most of the input datasets as well as providing a good resolution for the national scale analysis.

The analysis workflow (see flow charts in Appendix A) relies on three core geoprocessing tools: *Feature to Raster*, *Reclassify*, and *Raster Calculator*. The *Feature to Raster* tool is used to convert vector-based datasets into raster format. This step ensures that all datasets are in a compatible format for subsequent raster calculations. The *Reclassify* tool is applied to classify each input layer based on the defined suitability criteria. Finally, the *Raster Calculator* is used to combine all reclassified layers into a composite suitability index. This involves applying weights to each factor, as defined in the MCE framework, and calculating a weighted sum that reflects the overall suitability for maize cultivation.

Not shown in the flowchart is the preparation of the terrain Digital Elevation Model (DEM). It was prepared using *Mosaic to Raster* as the data is provided as raster fragments. In addition, *Extract by Mask* is used to visualise the individual regions. The result layer is extracted into the individual regions using the region boundaries.

# 3 Results

The suitability for maize cultivation was mapped across New Zealand at a 100 m resolution (see Figure 3). The results are classified into four categories: very suitable, suitable, little suitable, and not suitable. Table 4 shows the classification and the land area in each class. The highly suitable area of just under 5 million hectares is significantly higher than the maize area of around 74,000 hectares in 2021. There is therefore clear potential for increasing the area under maize cultivation.

Very suitable areas are mostly located in the North Island. High suitability is especially concentrated in the northern regions, including the greater Auckland area, Waikato and Taranaki. These regions offer favourable conditions in terms of climate, soil, and topography for maize production.

In contrast, the South Island shows more constrained suitability. Suitable areas are primarily found in the Canterbury Plains near Christchurch and in Southland. Flat terrain and agricultural land use support potential maize cultivation here. However, large portions of the South Island, particularly the West Coast and Southern Alps, are classified as not suitable or only marginally suitable. These limitations are likely due to unfavourable factors such as steep terrain, lower temperatures, and higher precipitation levels.

With regard to the objectives of this project, Figure 3 is particularly helpful for policy makers, for example, if the entire potential of maize cultivation is to be evaluated. For farmers and agricultural advisors, however, this scaling is only of limited use. In order to provide decision support for this target group, the results are presented in individual maps for each region of New Zealand in Appendix B. Even though the same resolution is used, the higher scale allows for better information gathering.

*Table 4: Suitability Classes and Areas*

| Class | Suitability Score | Area (ha) | Area (%) |
|---|---|---|---|
| not suitable | 0 – 2.5 | 525,554 | 2% |
| little suitable | 2.5 – 5 | 9,470,056 | 36% |
| suitable | 5 – 7.5 | 11,637,305 | 44% |
| very suitable | 7.5 – 10 | 4,912,854 | 19% |

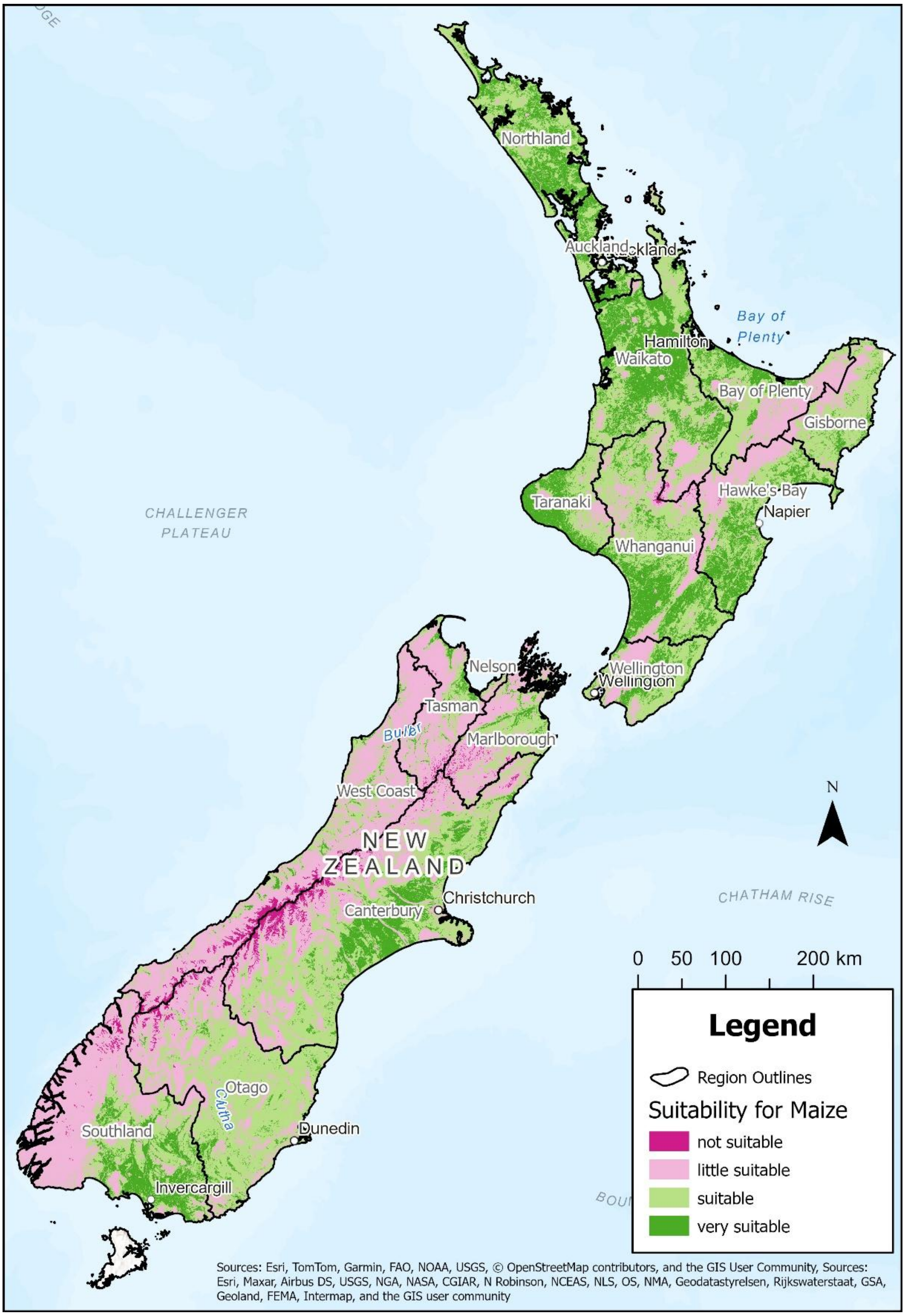


*Figure 3: Map of Maize Suitability in New Zealand*

# 4 Discussion

While this study provides a structured approach to land suitability analysis, several limitations must be acknowledged. A primary concern is the quality and resolution of national datasets. Although most layers used have relatively high spatial resolution, their accuracy varies regionally. For instance, soil and land use layers may be based on extrapolations from limited field data, which introduces uncertainty, especially in under-surveyed areas.

The analysis also assumes homogeneous conditions within each raster cell, ignoring within-cell variability and microclimatic influences such as local wind exposure, shading, or topographic cold air drainage. These can affect maize growth but are difficult to capture at the national scale.

Moreover, many of the datasets (e.g. frost days, GDD) are based on interpolated climate or model predictions, which may not reflect recent variability or future changes due to climate change. Using long-term averages limits the temporal relevance of the results, especially in terms of increasing climate extremes.

The weighting scheme, while informed by literature, also contains subjectivity. Assigning relative importance to criteria reflects assumptions about maize ecology and management priorities, which may not be universally applicable across different production systems.

An additional limitation is the limited availability of maize varieties in New Zealand. The model assumes generic crop requirements, but different maize hybrids vary in their growing requirements. Most available varieties are bred for North Island conditions and may perform poorly in marginal areas of the South Island, even if biophysically suitable. This restricts how much of the theoretically suitable land can actually be used for maize production.

Lastly, the model omits economic, infrastructural, and socio-political factors, which are critical for actual land-use decisions. As such, the suitability map should be interpreted as a biophysical potential, not as a prescriptive recommendation.

All in all, the model probably tends to overestimate the potential area, but still gives clear tendencies towards usability for maize. The limitations must be taken into account, especially for very localised decisions.

# 5 Conclusion

This study developed a national-scale suitability map for maize cultivation in New Zealand using an MCE approach in ArcGIS Pro. By integrating climate, soil, terrain, and land-use data, areas were classified from very suitable to not suitable for maize production.

The key message is that New Zealand holds strong potential for expanding maize cultivation, especially in the North Island. The results provide a useful decision-support tool for land managers, policy advisors, and farmers. They highlight regions where maize cultivation could be expanded or introduced. Future work should aim to include dynamic climate projections and socio-economic factors to further improve the model's relevance and applicability for sustainable agricultural planning.

To increase the model's reliability, future work should assess the spatial accuracy of input data, especially the distribution of weather stations used for climate layers. In addition, integrating dynamic climate projections and socio-economic factors would improve long-term relevance. An online, interactive version of the tool could further support farmers and decision makers. It would allow users to explore suitability at the local scale and assist in practical land management decisions.

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# Appendix

## A. Flow Charts

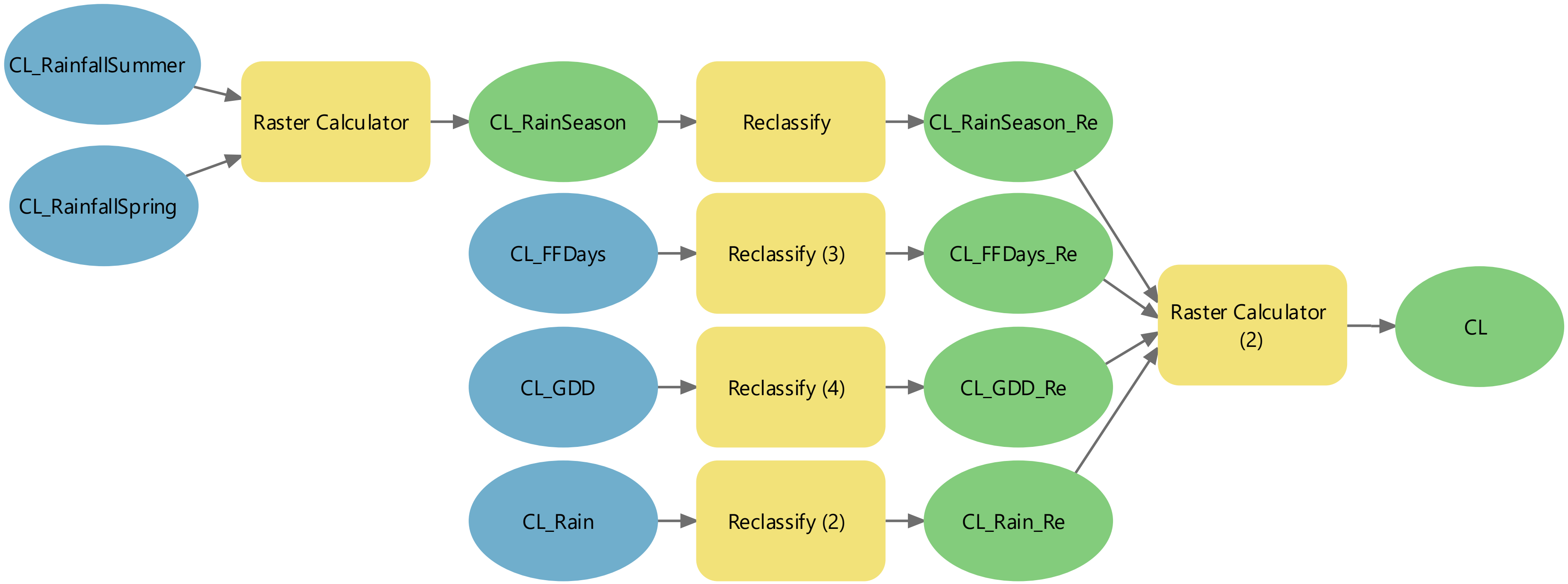



*Figure 4: Flow Chart Climate*

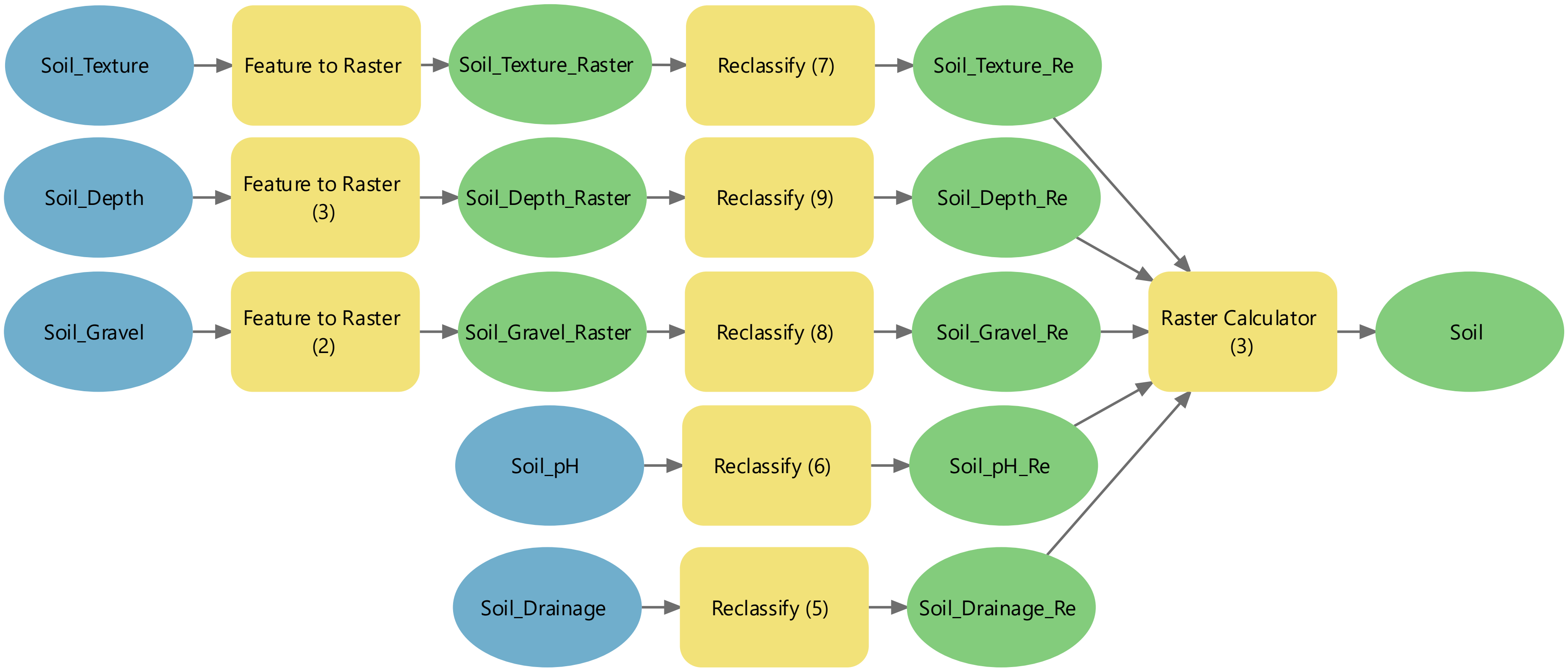



*Figure 5: Flow Chart Soil*

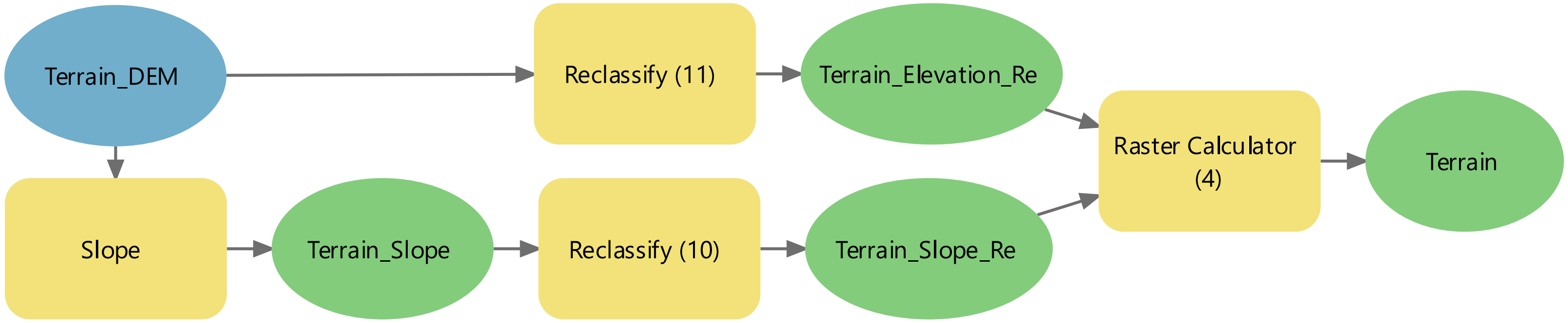



*Figure 6: Flow Chart Terrain*

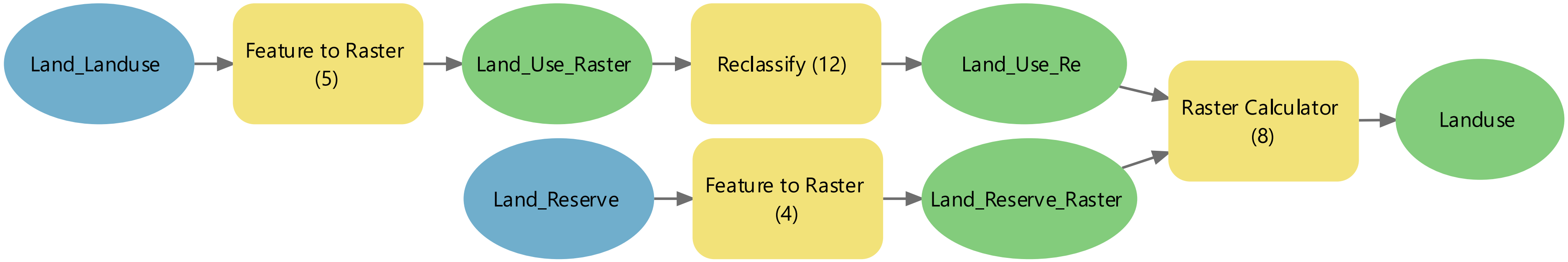



*Figure 7: Flow Chart Land Use*

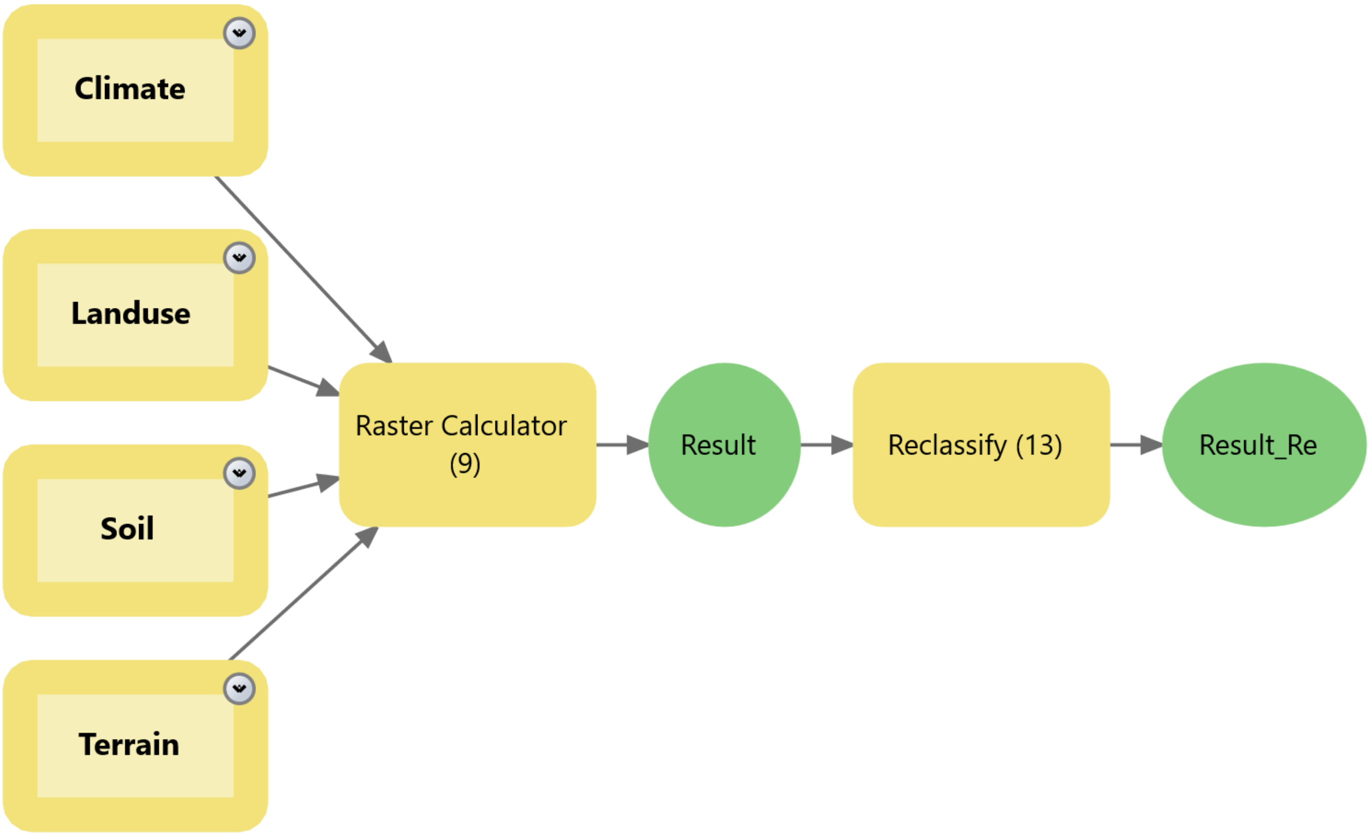
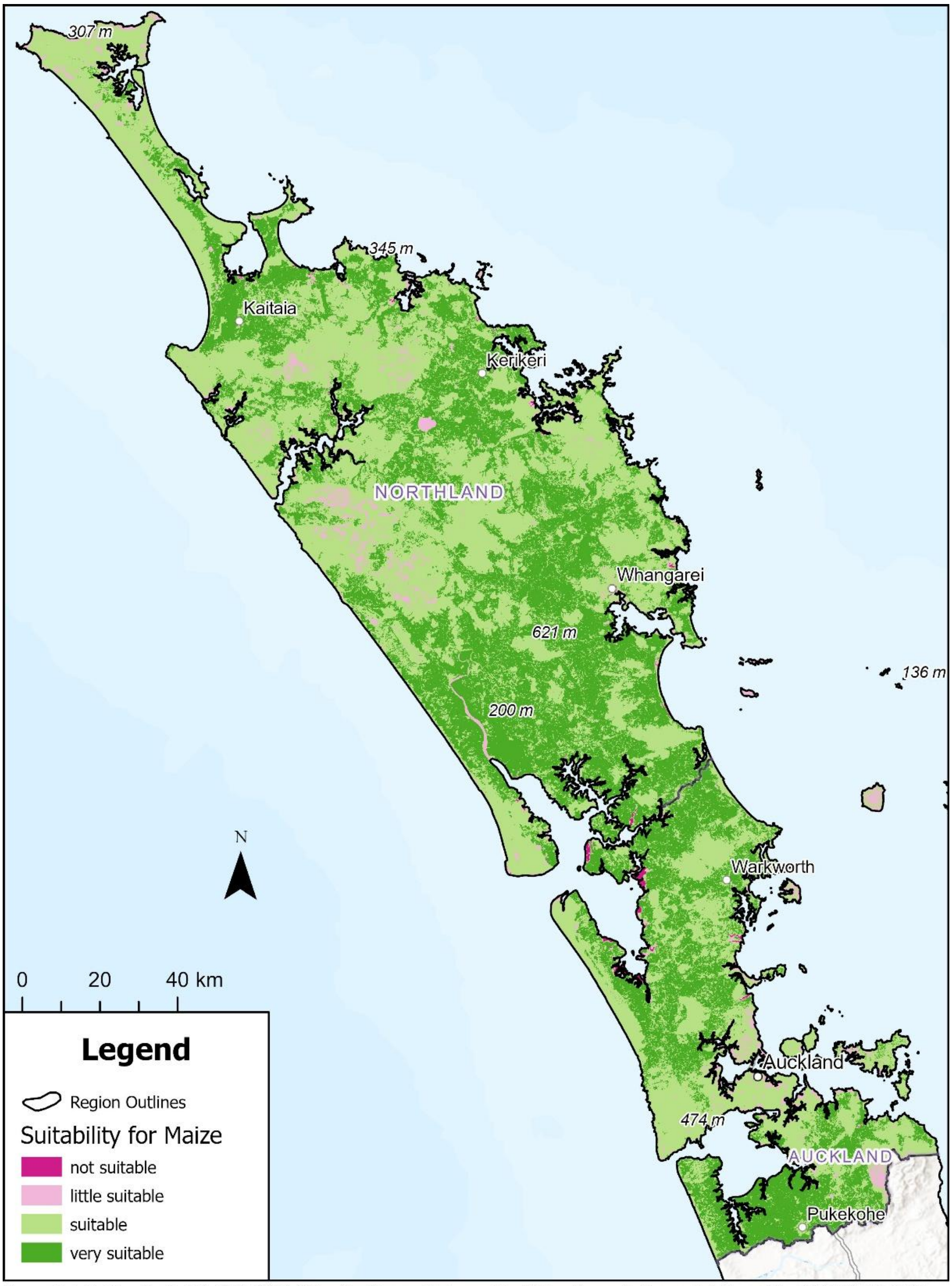


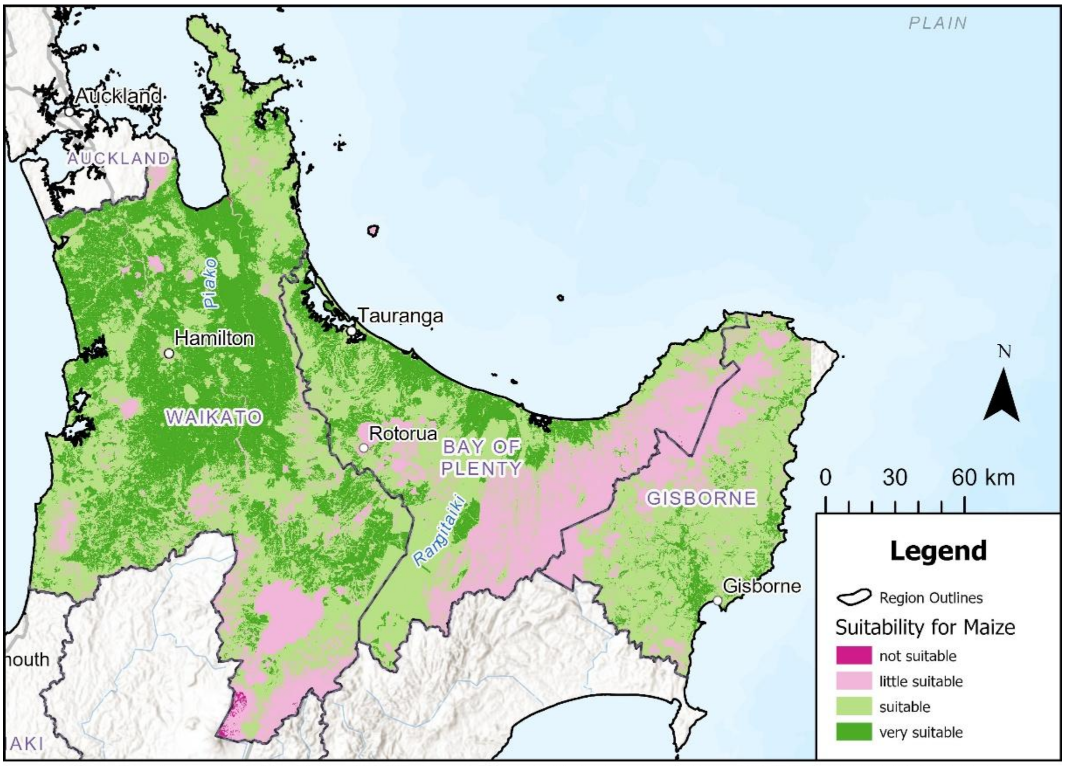

*Figure 8: Flow Chart Result*

# B. Detailed Suitability Maps per Region



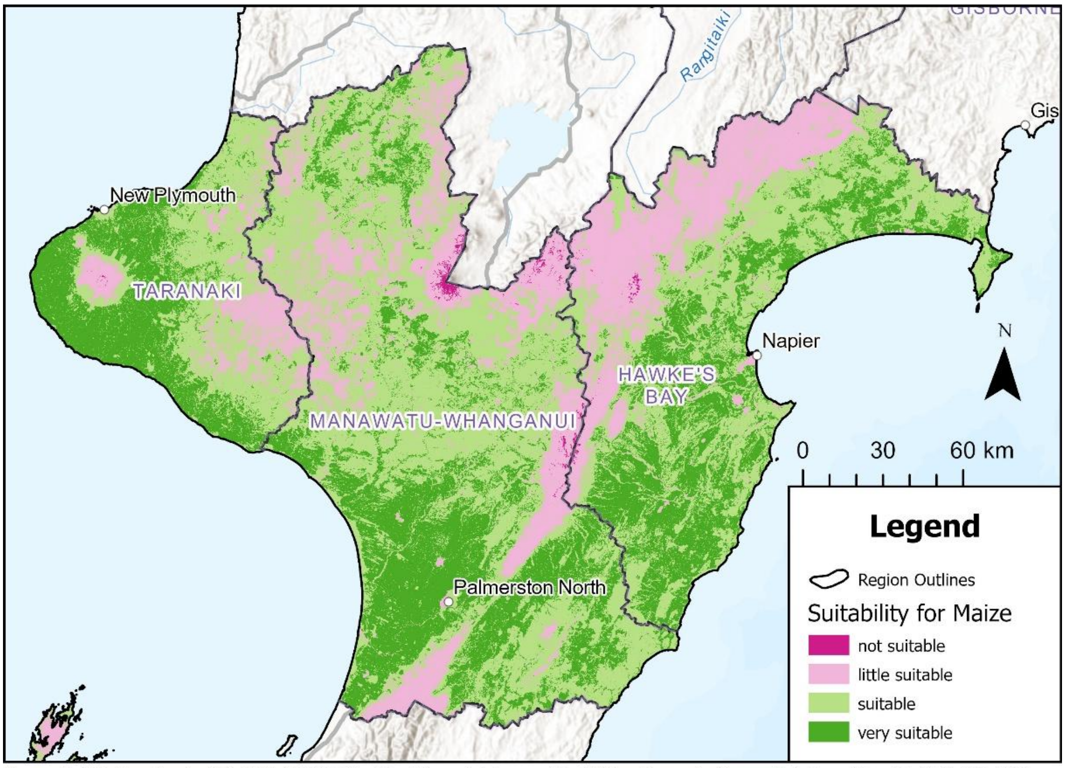

Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, Sources: Esri, Maxar, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap, and the GIS user community

*Figure 9: Suitability Map Northland and Auckland*




Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, Sources: Esri, Maxar, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap, and the GIS user community

*Figure 10: Suitability Map Waikato, Bay of Plenty and Gisborne*




Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, Sources: Esri, Maxar, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap, and the GIS user community

*Figure 11: Suitability Map Central North Island*

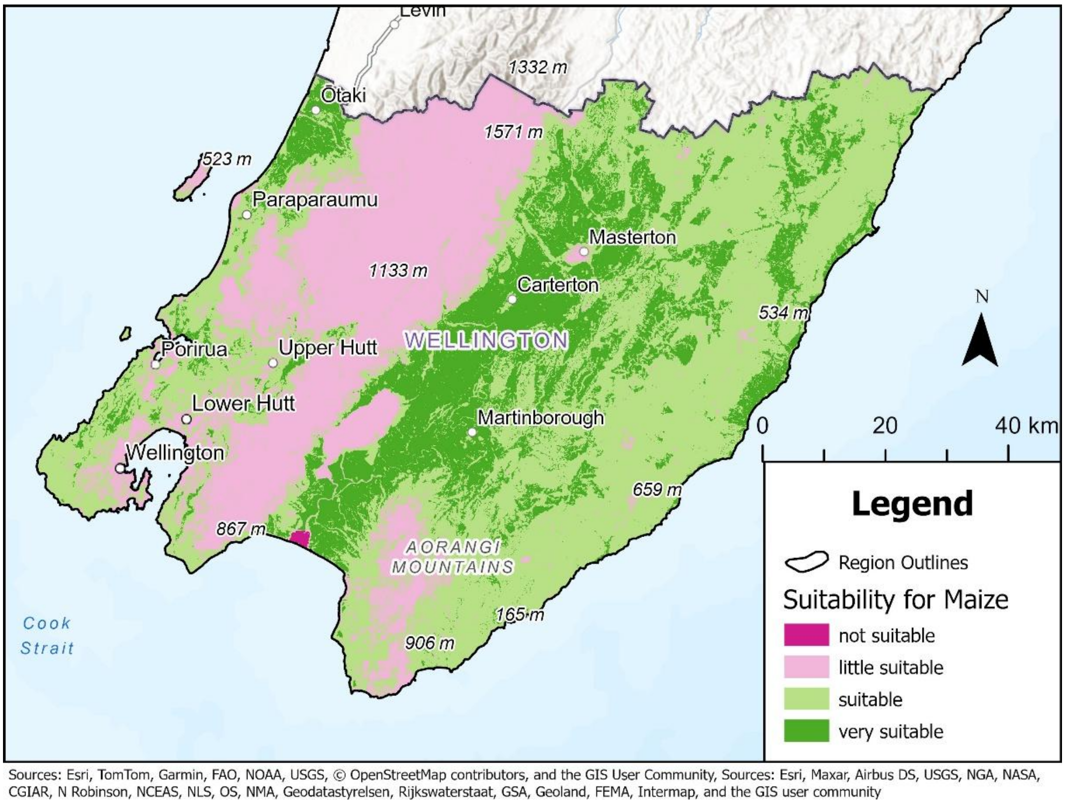



*Figure 12: Suitability Map Wellington*

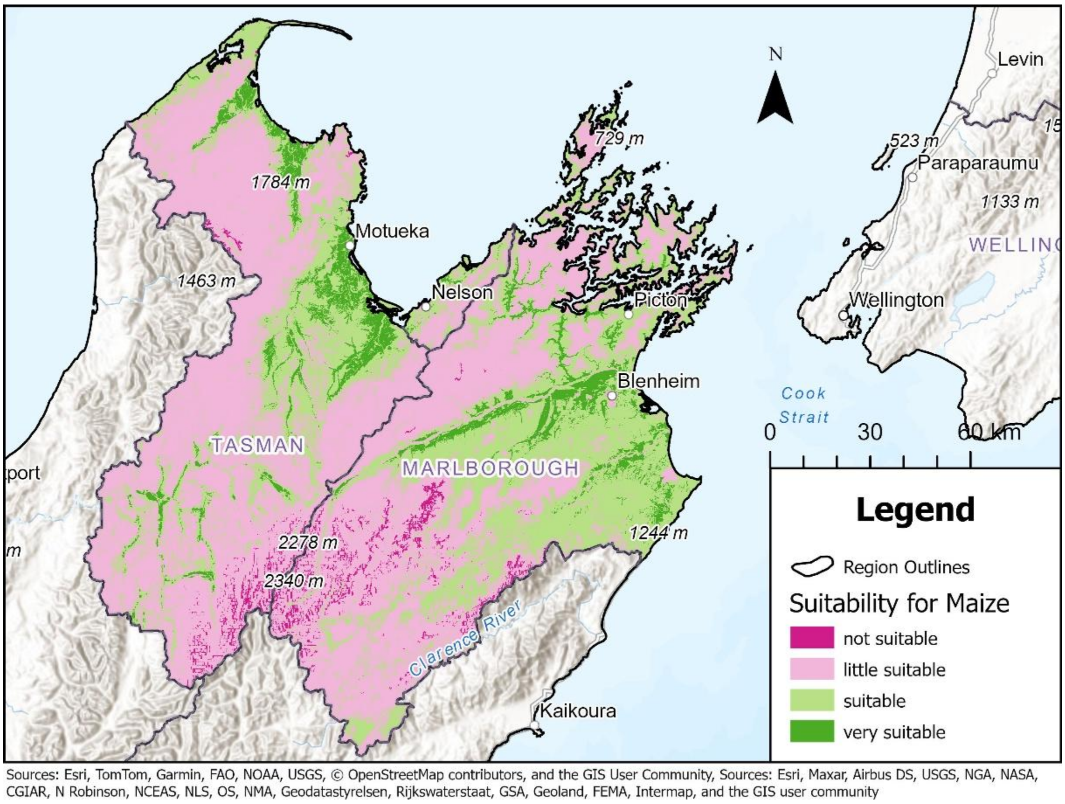
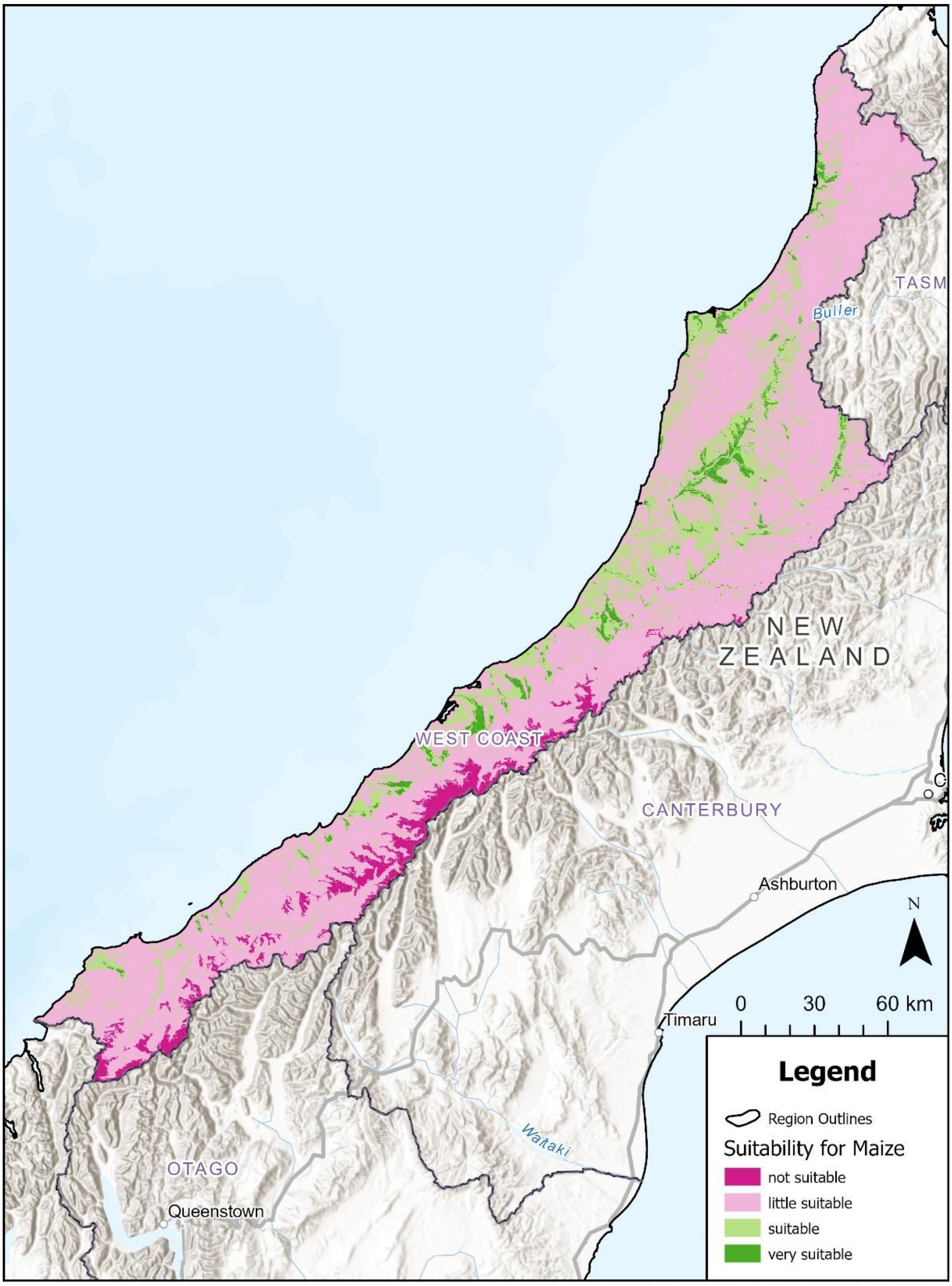
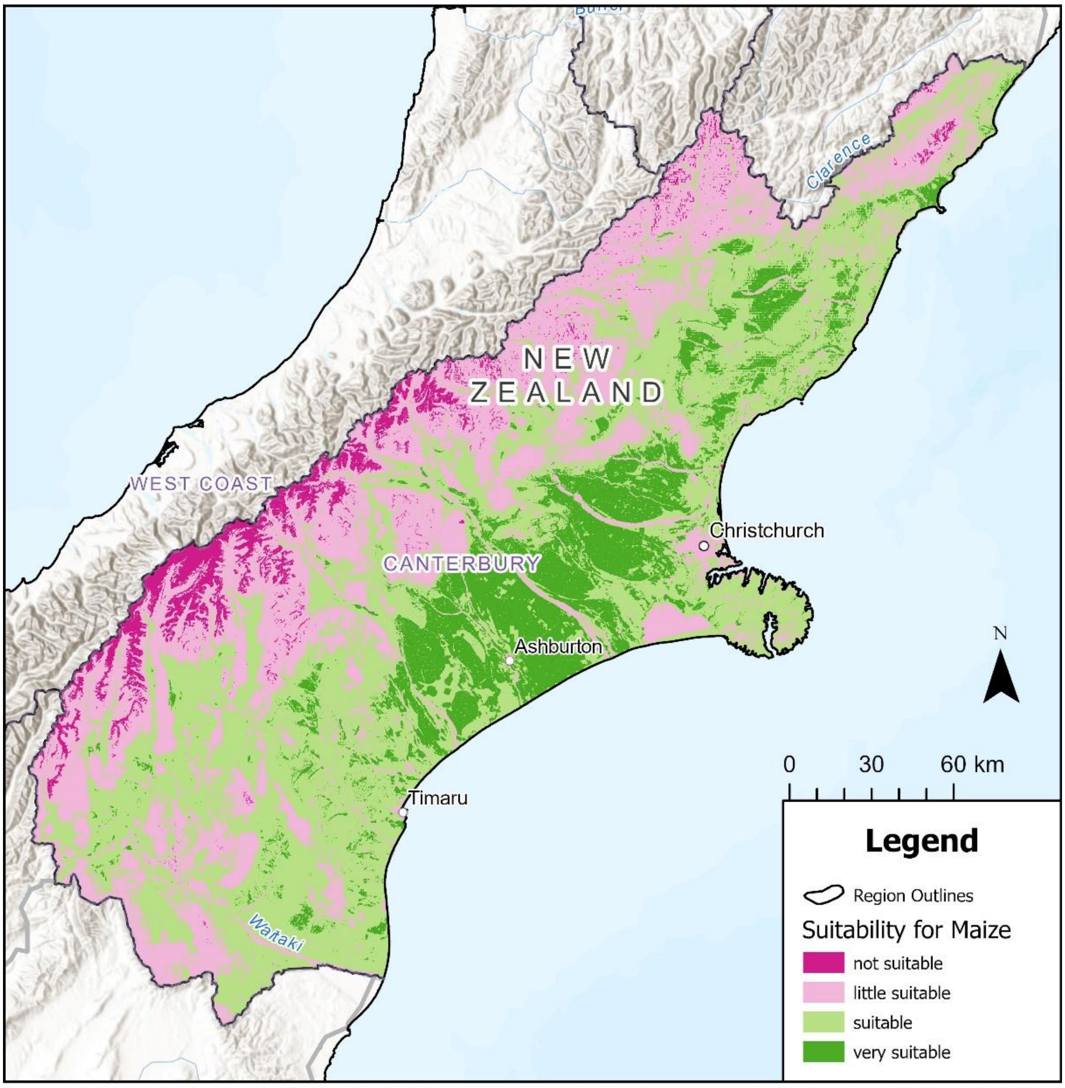



*Figure 13: Suitability Map Tasman, Nelson and Marlborough*




Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, Sources: Esri, Maxar, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap, and the GIS user community

*Figure 14: Suitability Map West Coast*




Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, Sources: Esri, Maxar, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap, and the GIS user community

*Figure 15: Suitability Map Canterbury*

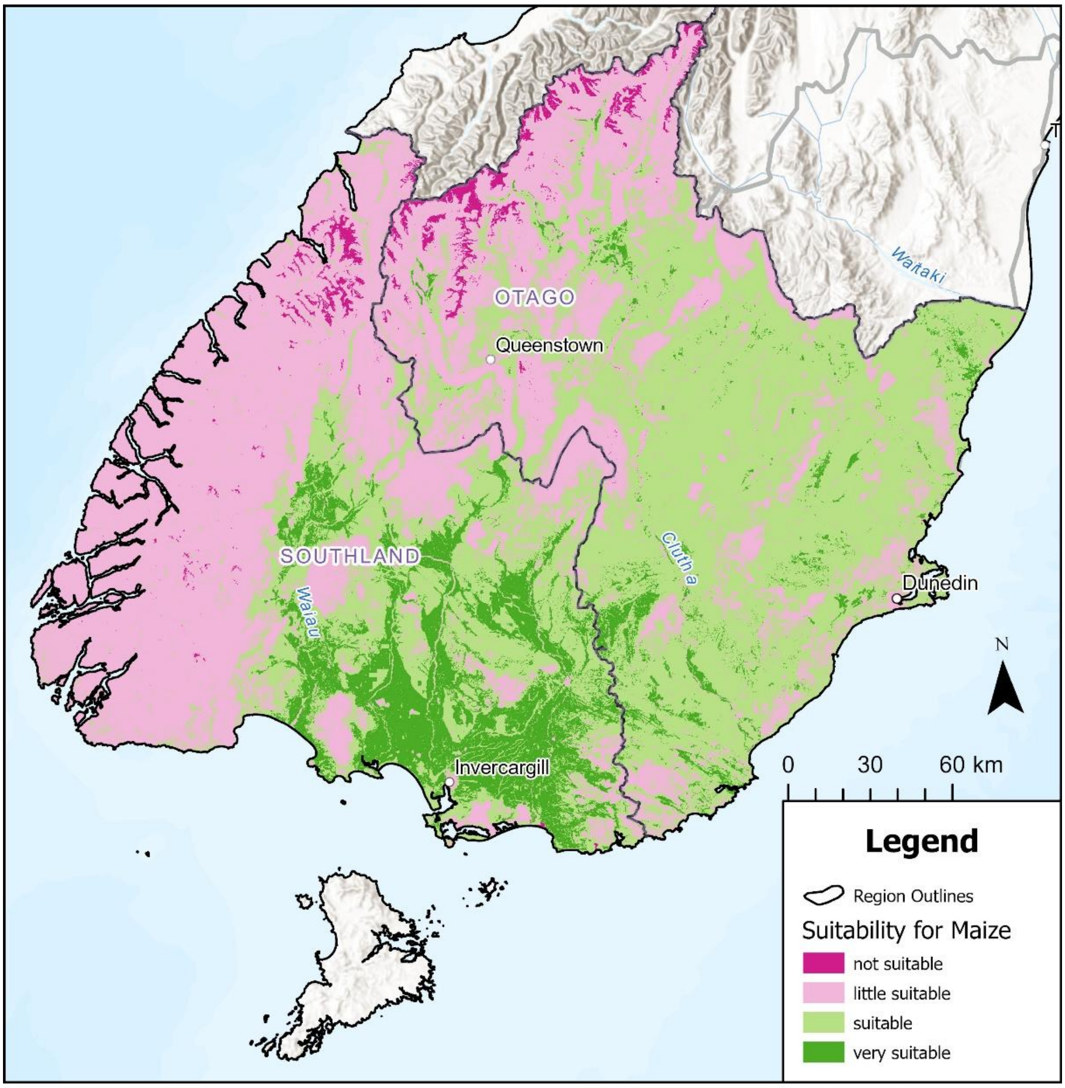



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*Figure 16: Suitability Map Otago and Southland*