Australian Housing
Data Analytics Platform

WHAT IF? PLANNING SUPPORT SYSTEM: USER MANUAL - VERSION 1.8

Version	Date	Note
1.0	16 May 2022	Creation of the AHDAP - What If? User Manual
1.1	26 May 2022	Complete the draft of all sections
1.2	14 June 2022	Minor revision of content, renumber all the figures and tables, add one section 'Copyright Acknowledgement'
1.3	10 Feb 2023	Update sections 3-6 based on the latest version of Ipswich use case (Year 2021)
1.4	10 March 2023	Formatted into new template, tested with Ipswich data and updated
1.5	11 Apr 2023	Major update of Ipswich use case by taking multiple land use changes and priority area into account
1.6 / 1.7	31 May 2023	Minor update in paragraphs, figures and references
1.8 Beta	13 June 2023	Minor update in case study, factor naming and figures

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1. Introduction

1.1. Planning Support Systems and What If?

The idea of planning support systems (PSS) dates back to the 1970s, when Lee Jr (1973) cast doubt on the construction of large-scale urban models. PSS are defined as geo-information technology-based instruments that are dedicated to supporting those involved in planning the performance of specific tasks (Geertman, 2006). With the assistance of PSS, urban planners and policy makers can simulate the expansion of their cities in a more intuitive and reliable way. On the basis of modelling techniques, PSS can be categorised into four groups: large-scale, rule-based, state-change and cellular automata (CA) based (Klosterman and Pettit, 2005). Since the beginning of the 21st century, the following PSS have gradually been proposed by researchers, with various of practical uses: UrbanSim (Waddell, 2002; Jin and Lee, 2018), What if? (Klosterman, 1999; Pettit et al., 2020) CommunityViz (Kwartler and Bernard, 2001; Walker, 2017) and SLEUTH (Clarke and Gaydos, 1998; Rienow and Goetzke, 2015).

Of all PSSs, What If? has been identified as a transparent, flexible and user-friendly system, with a dedicated allocation procedure for generating holistic land-use planning scenarios. A series of What if? scenario planning case studies have been conducted, especially in Australia, including Hervey Bay (Pettit, 2005) and Ipswich City (Lu et al., 2022) in Queensland, Mitchell Shire in Victoria (Pettit et al., 2008), and Perth-Peel region in Western Australia (Pettit et al., 2015). These case studies have demonstrated the capability of the What If? PSS to produce objective and reliable predictions of land use change and allocation under various circumstances. Consequently, there is a strong connection between the theoretical and practical values at national-scale.

The latest version of What If? has been developed as part of the Australian Housing Data Analytics Platform (AHDAP). It uses existing GIS data to support some of the significant and challenging works of the land use and urban planning process: 1) analysing the suitability of land use transformation for different types, 2) projecting future population and number of employees, as well as the corresponding land use demands, and 3) allocating the projected demands to the most suitable locations under various conditions. The AHDAP-based What If? (AHDAP - What If?) provides a user-friendly interface with clear guidance on each stage of the tasks. These tasks, that would typically take weeks or months in traditional urban planning departments, can be executed in an efficient and precise way with the integrated modules and functions in AHDAP -What If?. Furthermore, the outputs of different stages can be viewed as colourful maps and tables. The customised outputs can address the concerns and preferences of different communities in a more comprehensive and understandable way.

1.2. System Overview

The AHDAP-What If? PSS is operated with a ‘bottom-up’ structure, which begins with land units at parcel-level scale. Public policy choices are applied to these parcel-level units, and information is derived by aggregating the parcels for the selected study region. Just like the previous versions of What If?, the system does not attempt to ‘predict’ future conditions exactly. Instead, it is an explicitly policy-oriented PSS that determines what would happen based on the users’ settings and assumptions. The impact of government policies is considered in different modules of the system, including in the suitability evaluation, the required infrastructure of land use transformation, as well as checking the alternative land use plans before the transformation.

What If? requires a shapefile, the most commonly used format of spatial data, as the input for operation. Shapefiles can be created using GIS software (external to What If?). In general, the shapefile required for a What If? case study includes the information of: 1) Natural conditions (e.g., slopes and soils), 2) existing and proposed infrastructure (e.g., the proximity to major and secondary roads, or the proposed time for accessing public transport), and 3) land use controls (e.g., natural protection areas, zoning districts). These layers are spatially joined with the original land use maps of the study region to produce a shapefile with validated topological relationships.

AHDAP - What If? projects future land use patterns by balancing the supply of and demand for, land suitable for different uses at each location. Alternative visions for an area's future can be explored by defining alternative suitability, demand and allocation scenarios. The final output of the AHDAP - What If? is generated by considering three alternative scenarios providing concrete and understandable expressions of the potential future under policy choices and assumptions. For instance, it is demonstrated by the system that there is insufficient land simultaneously to accommodate a high-speed growth of low-density residential with relatively strict agricultural protection policies. In summary, it is the flexibility and reliability of simulation outcomes that promotes the practical use of AHDAP - What If? in different study regions.

1.3. New features of the AHDAP - What If? System

AHDAP - What If? is an upgraded version of the online What If? (OWI), which was built on the Australian Urban Research Infrastructure Network. In comparison with the previous version, AHDAP - What If? has the features described in *Table 1*.

Table 1. The comparison between OWI and AHDAP – What If?

Online What If? (OWI)	AHDAP - What If?
Four Setups and three scenarios	One Setup and three scenarios with optimised workflow
For suitability scenario, suitability rating (six types) and factor weights (numerical scores) are applied	For suitability evaluation, only factor weights are applied to avoid redundancy
The values of driving factors are recorded in different units	The values of driving factors are normalised to reduce the influence of different units

1.4. Accessing the System

The AHDAP - What if? is a web application, requiring credentials to login into the system. Please note that the AHDAP - What If? system is currently supported by Chrome, Internet Explorer and Safari. The link to the login page is: https://whatif.ahdap.org/. Authentication is done through a Central Single Sign On (SSO) managed by the AHDAP project admin. This SSO is designed so that a single user account is sufficient for use with all the applications across AHDAP. The login screen is shown in *Figure **1***.

To create a user account or obtain details for a temporary demo account please contact AHDAP admin at admin@ahdap.org and login credentials will be emailed to you. If you already have a user account with AHDAP, please contact the administrator to add access to the AHDAP - What If? to your existing account (no need to create another account). In this user manual, the admin user is used to create the Ipswich use case.

Users will need basic GIS skills to prepare the input spatial data required by the AHDAP - What If? system (see section 2).

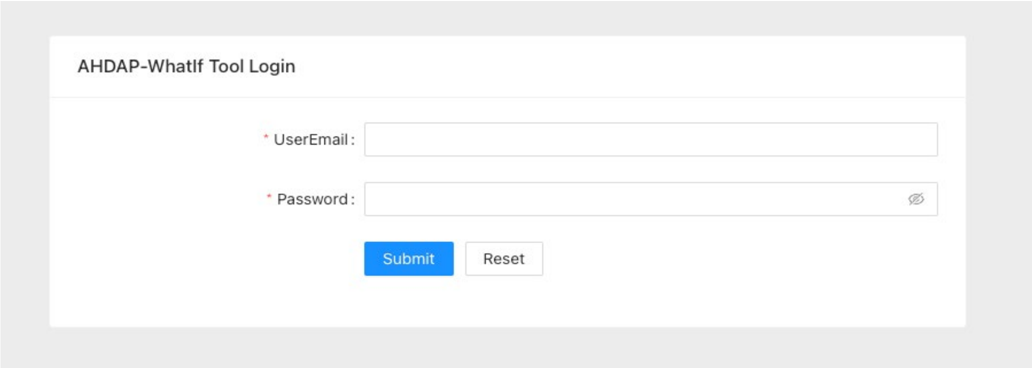


Figure 1. What if Tool Login Screen

2. Data Preparation

2.1. Basic Requirements for Spatial Data

In a typical What If? project, the input shapefile of spatial data should be homogeneous land units or uniform analysis zones (UAZs). The basic requirements for the input spatial data are listed in the following table:

Table 2. Summary of basic requirements for input shapefile

Parameter	Requirement
Data format	Shapefile
Coordinate system	WGS 84 / Pseudo-Mercator (EPSG:3857)
Mandatory fields in the spatial data	**1. Land use type** The purpose to which the land cover is committed. For instance, there are 10 typical land use categories in ABS mesh block census data: Residential, Commercial, Industrial, Parkland, Education, Hospital/Medical, Transport, Primary production, Water, Other.
	2. Parcel size (Unit: km^2) The area of land parcel, which can be measured using GIS software (such as ArcGIS or QGIS).
	3. Suitability factors (normalised) Normalised (range between 0 and 1) suitability factors are applied for the calculation of different land use transformations by taking a land parcel as the basic unit.
	4. Infrastructure control The infrastructure control is conducted at the parcel level and is necessary for land use allocation. For instance, (1) a public transport service infrastructure control has been selected which identifies areas where public transport services will be provided; and (2) it is assumed that new residential and commercial development can only be located in areas with access to public transport services. Namely, the model will allocate the projected residential and commercial demand to parcels with public transport services in a given projection year.
	5. Growth pattern The chosen growth pattern identifies priority areas for transforming candidate parcels, which also affects the results of land use allocation.

2.2. Data Processing

In this user manual, the City of Ipswich, Queensland, Australia is used as the case study, and the data is prepared using QGIS (Version: 3.16). Mesh Blocks are the smallest geographic areas defined by the Australian Bureau of Statistics (ABS), forming the building blocks for larger regions of the Australian Statistical Geography Standard (ASGS). They broadly identify land use such as residential, commercial, primary production, parks and so on. Therefore, obtaining and processing Mesh Blocks as the base homogeneous land units or UAZs is the first step in data processing for the AHDAP - What If? system.

2.2.1. Data Extraction and Reprojection

1. Download the ABS GDA94 “Mesh Blocks – 2021 – Shapefile” zip from the following link (link accessed: 02 Mar 2023) https://www.abs.gov.au/statistics/standards/australian-statistical-geography-standard-asgs-edition-3/jul2021-jun2026/access-and-downloads/digital-boundary-files. Unzip the folder and the file will have the name ‘MB_2021_AUST_SHP_GDA94’.
2. From the same link as above, download the relevant ABS GDA94 area boundary zip file for the same year. In this case as Ipswich is a LGA download “Local Government Areas - 2021 - Shapefile”. Unzip the folder and the file will have the name ‘LGA_2021_AUST_GDA94_SHP’.
3. In QGIS, select the Ipswich polygon within LGA_2021_AUST_GDA94_SHP and use the *Extract by Location* tool with *intersect* and *Selected features only* to extract the Mesh Blocks intersecting your area (i.e. Ipswich) using the spatial extent of its boundary (*Figure 2*). Name the output, e.g. UAZ_Ipswich_2021. If Mesh Blocks outside your area of interest but touching the boundary are exported, you may need to manually select and delete them from the exported layer (*Figure 3*).

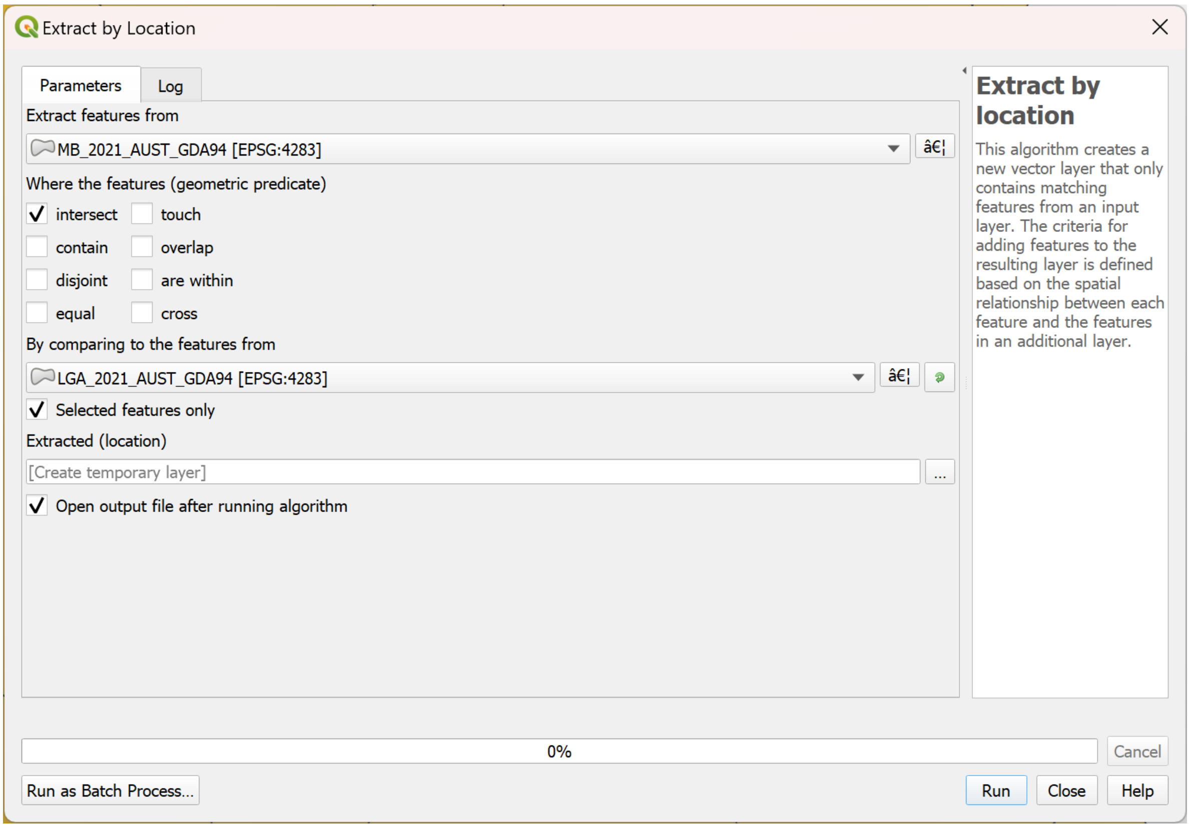


Figure 2. Extract the Mesh Blocks by location.

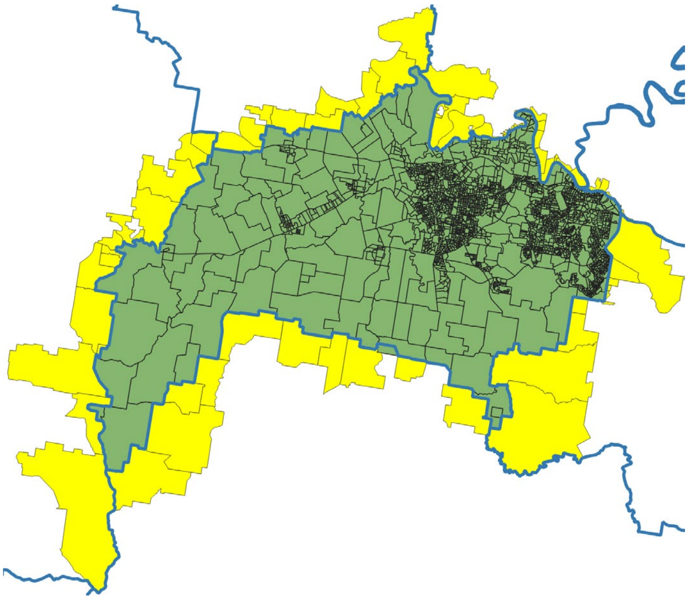


Figure 3. Manually select and delete remaining polygons (i.e. yellow) outside your area of interest

4. As per *Table 2*, WGS 84 / Pseudo-Mercator (EPSG:3857) is the required coordinate system of input data. Therefore, *Reproject* the Mesh Blocks coordinate system from EPSG:4283 to EPSG:3857 as per *Figure 4*. Name the output UAZ_Ipswich_2021_WGS84.

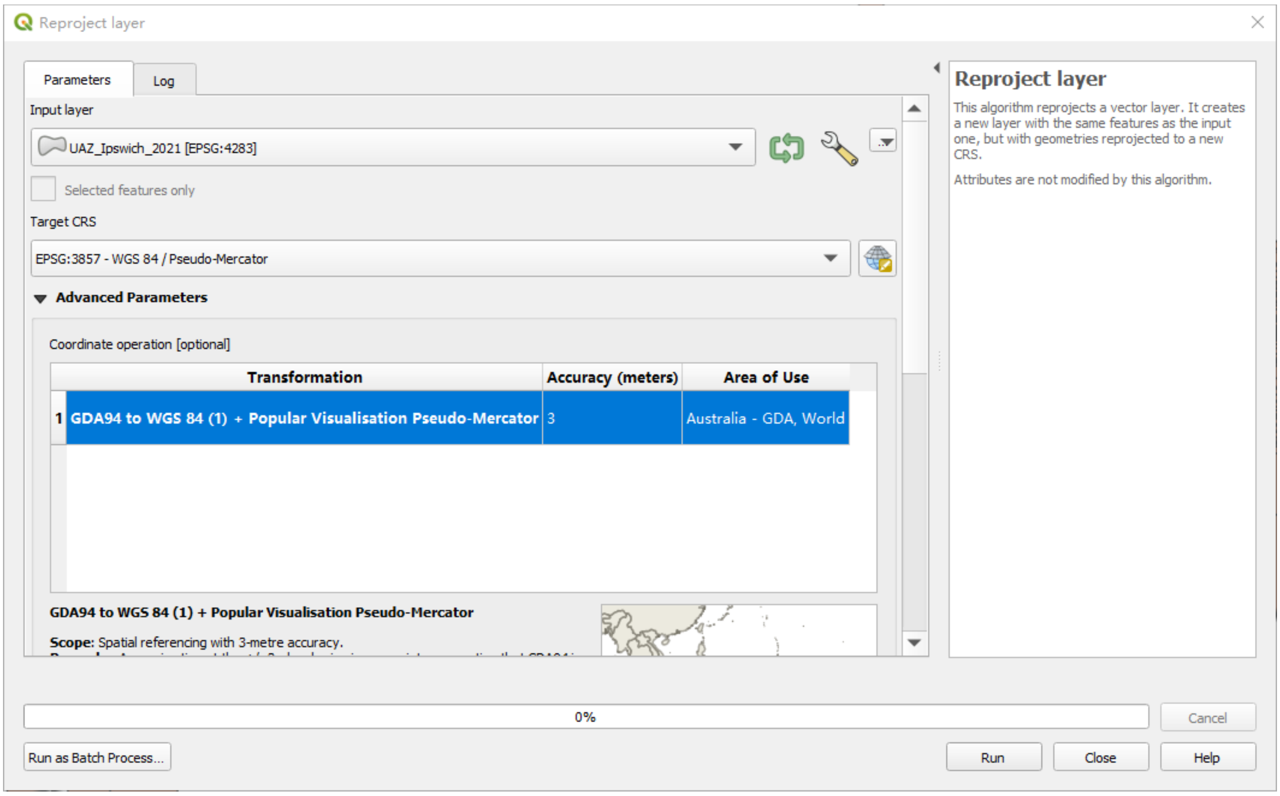
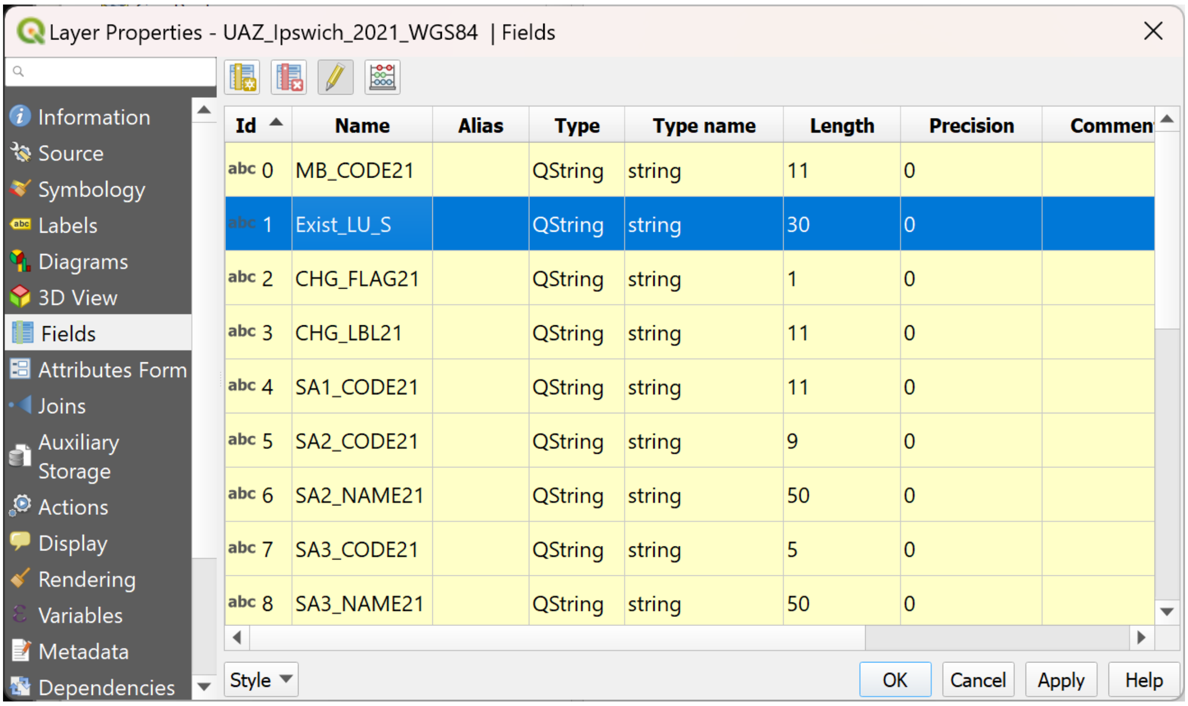


Figure 4. Reproject the coordinate system of spatial layer

2.2.2. Fields: Land Use Type and Parcel Size

1. *Optional Step: Toggle Editing* for the reprojected layer and in *Layer Properties* > *Fields* rename the original field 'MB_CAT21' field to 'Category' (so the field name is more recognisable), which corresponds to the first mandatory field **Land use type**.



2. Add a field 'Area' of the parcel size in m² using the *Field Calculator* (via the attribute table) as per *Figure 5*.

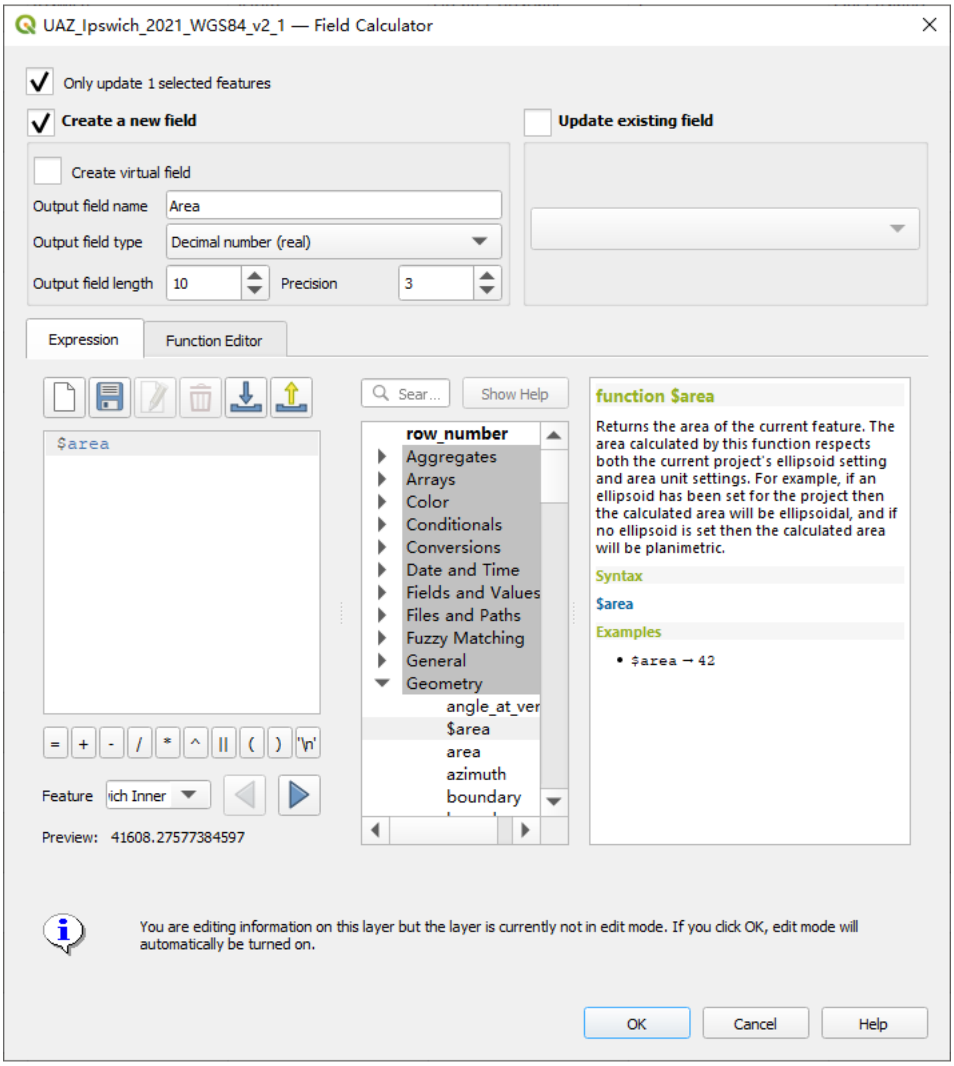


Figure 5. Calculate the field Area for parcel sizes

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3. To keep the dataset neat, all other unrelated fields can be deleted via the *Layer Properties*. *Toggle Editing* off and save changes.

2.2.3. Fields: Driving Factors

Eight driving factors are applied for evaluating the suitability of residential land use transformation, based on: activity centres, primary schools, residential land, railway stations, shopping centres, main roads, protected areas and fire hazard zones. A vector shapefile in point, line or polygon format is required, representing each of these factors. All driving factor data should be in the same coordinate system (WGS 84 / Pseudo-Mercator, EPSG:3857) as the Mesh Block data. Driving factors distances will be joined to the Mesh Block data and normalised distance to each of these driving factors will then be calculated and stored in the Mesh Block data using the Normalised Factor Full Names from *Table 3* as the field names.

Table 3. Driving factors and data sources of the Ipswich case study

Factor name	Definition	Normalised Factor Full Name	Data source
F_Act	Distance to activity centre	Normalised_distance_to_activity_centre	OpenStreetMap
F_PriSch	Distance to primary school	Normalised_distance_to_primary_school	Queensland Spatial Catalogue (QSpatial)
F_Resi	Distance to existing residential land	Normalised_distance_to_existing_residential_land	Australian Bureau of Statistics (ABS)
F_Rail	Distance to railway station	Normalised_distance_to_railway_station	Geoscience Australia (GA)
F_Shop	Distance to shopping centre	Normalised_distance_to_shopping_centre	OpenStreetMap
F_Road	Distance to main roads	Normalised_distance_to_main_road	Geoscience Australia (GA)
F_Pro	Distance to protected area	Normalised_distance_to_protected_area	Queensland Spatial Catalogue (QSpatial)
F_Fire	Distance to fire hazard zone	Normalised_distance_to_fire_hazard_zone	Queensland Spatial Catalogue (QSpatial)
F_Flood	Distance to flood extent	Normalised_distance_to_flood_extent	Queensland Spatial Catalogue (QSpatial)

1. Add the driving factors vector data in WGS 84 / Pseudo-Mercator, EPSG:3857 to QGIS.
2. To calculate the distances, the plugin QGIS NNJoin can be utilised as per *Figure 6*. The 'Input vector layer' is the processed Mesh Blocks base data (i.e. UAZ_Ipswich_2021_WGS84), and eight layers of driving factors will be used as the 'Join vector layer', one at a time. Use the *Neighbour distance field* to name each field 'F_xxx' as per the Factor name filed in *Table 3* e.g. "F_Act" for activity centre. The distances between parcels and driving factors will be recorded in each new field in the updated Mesh Blocks base data.

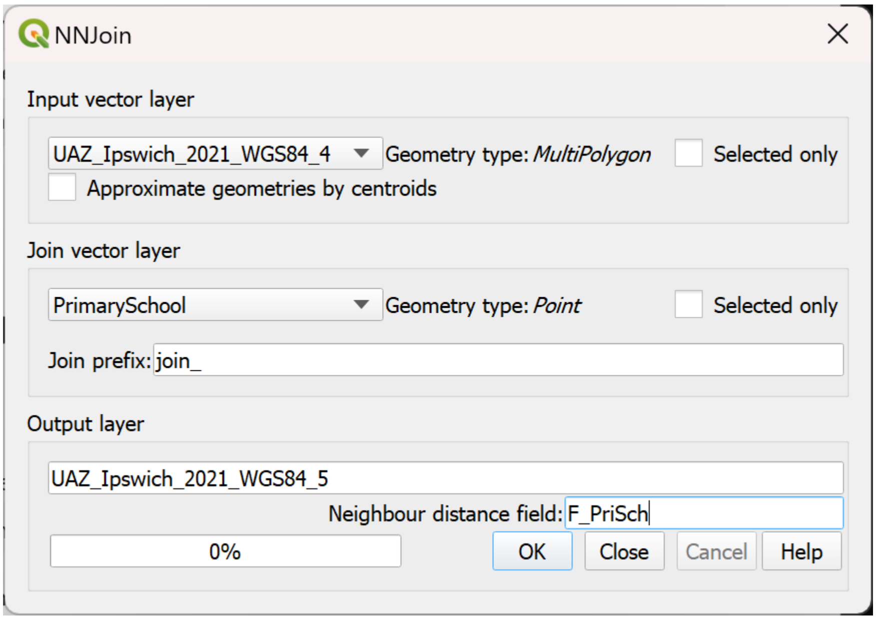

Figure 6. Join driving factors to the Mesh Blocks base data

3. To keep the dataset neat, *Toggle Editing* on and delete all fields with the prefix "join_" via the *Layer Properties*. *Toggle Editing* off and save changes.
4. Next use the *Field Calculator* (*Figure 7* left) to normalise each field of driving factors values for **activity centres, primary schools, existing residential land, railway stations, shopping centres, main roads** to values between 0 and 1 using the following equation:

$$V_{Ni} = 1 - \frac{V_{Oi} - V_{min}}{V_{max} - V_{min}}$$

where V_{Oi} and V_{Ni} refer to the original and normalised distances between parcel i and the selected driving factor, V_{max} and V_{min} are the maximum and minimum distances among all parcels and the same driving factor.

5. For **protected areas** and **fire hazard zones** use the *Field Calculator* (*Figure 7* right) to normalise each field of driving factors values to values between 0 and 1 using the following equation to select potential mesh blocks that are far away from fire hazard zones and protected areas:

$$V_{Ni} = \frac{V_{Oi} - V_{min}}{V_{max} - V_{min}}$$

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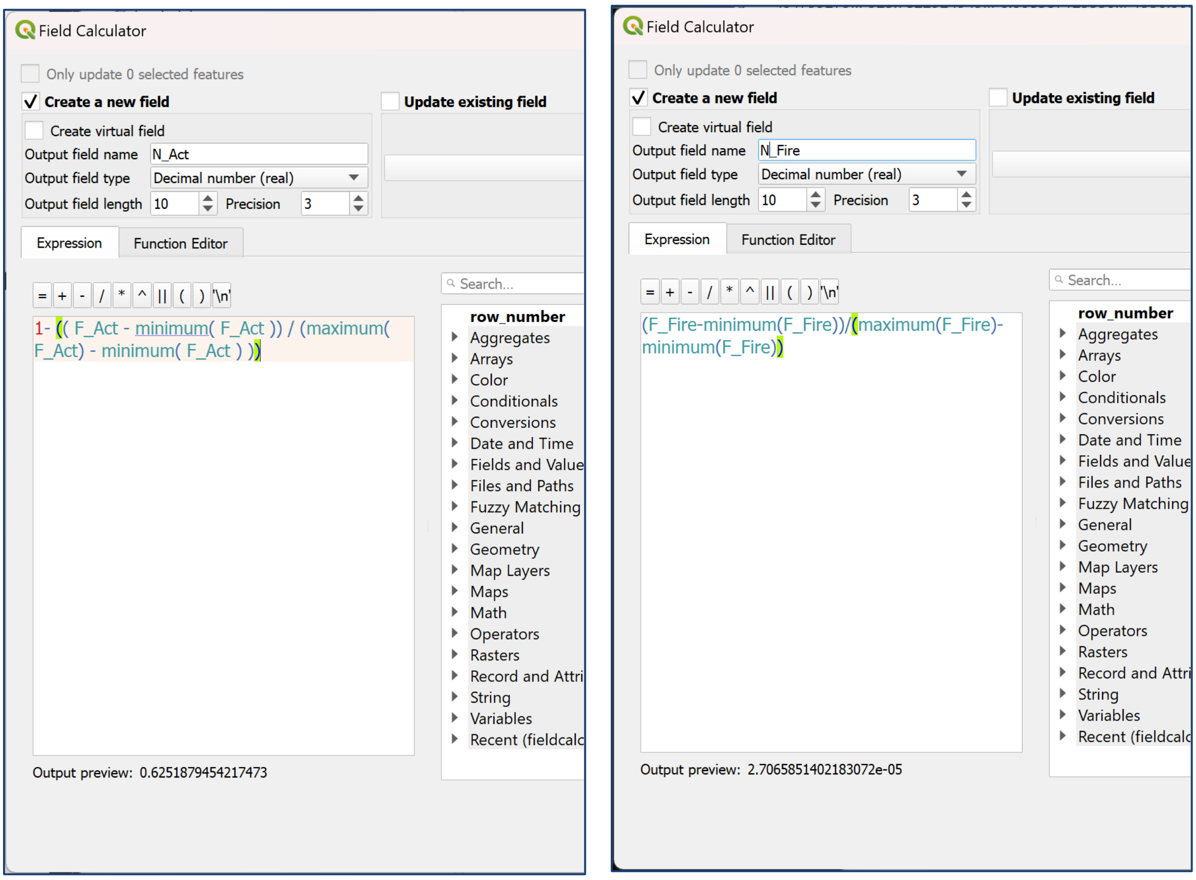

Figure 7. Normalisation calculation

2.2.4. Fields: Infrastructure Control and Growth Pattern

The infrastructure control field is enforced during the allocation stage of What If?. The infrastructure control field name can be chosen by the user. The values in the field should be integer numbers, which indicate the year in which infrastructure construction is expected to be completed. For instance, '2026' means the infrastructure construction will be completed by the year 2026, and corresponding parcels are not permitted to be allocated before 2026 regardless of their overall suitability. For specific parcels, if the required infrastructure already exists at the beginning of the simulation period, the values can be set as '0'.

The growth pattern field also influences the land use allocation process. The growth pattern field name can be chosen by the user. Different growth patterns identify areas where candidate parcels have priority to be selected for transformation. There are no universal rules on setting of growth patterns at this stage, users can set any integer number to indicate the priority of different regions within their own case studies.

2.3. Data Validation

Data validation is essential before importing data into What If?, as a tiny error in the dataset could lead to the decline of modelling accuracy in the future. Therefore, data validation is implemented using the *Check validity* tool in QGIS as per *Figure 8*. The geometries of the shapefile will be checked and then classified into three separate layers: valid, invalid and error. If there are any invalid or error results, these must be fixed before the data can be imported into What If?.

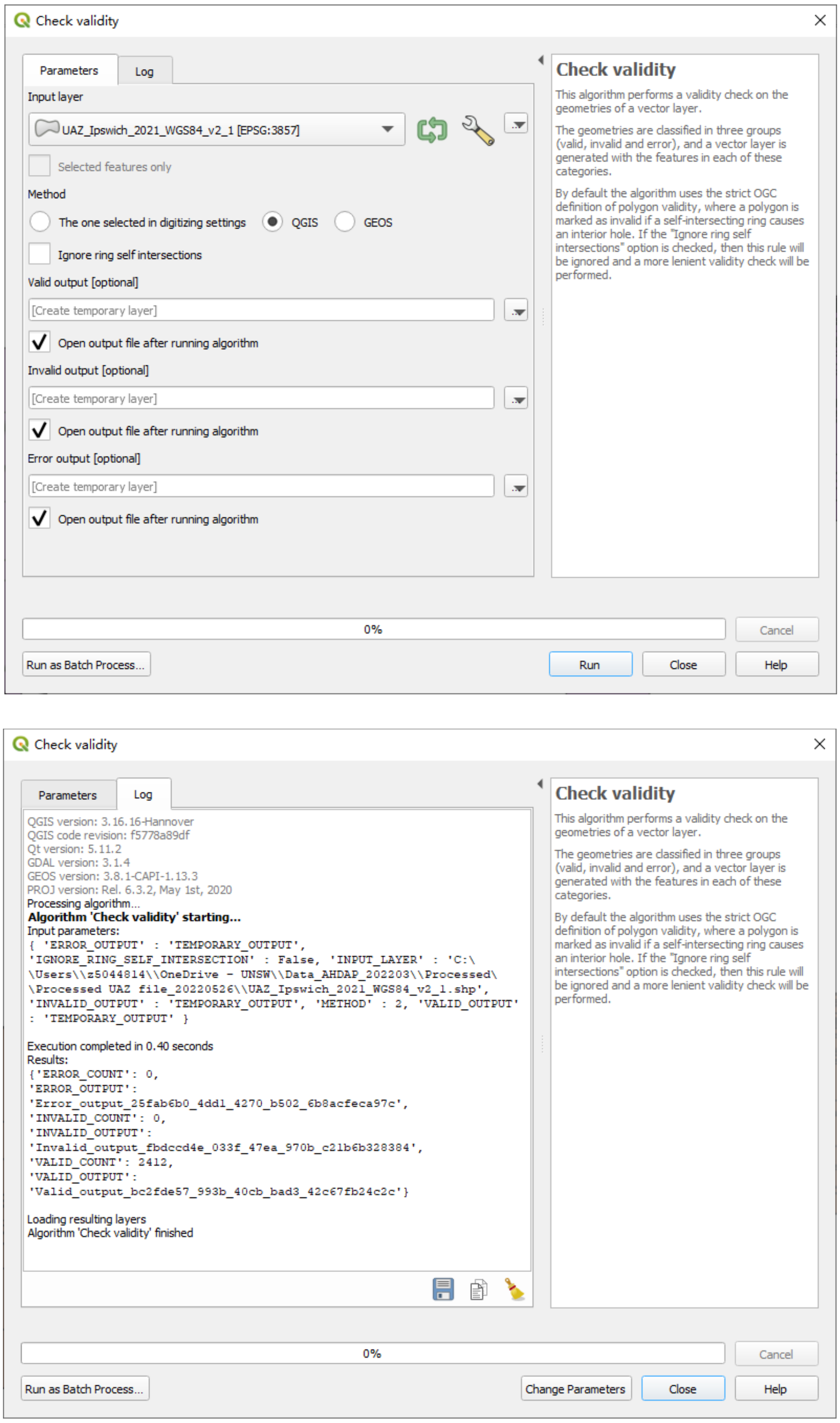

Figure 8. Data validation in QGIS

2.4. Data Zip

Please also compress the prepared shapefile as a single zip file (.zip) before uploading to What If?. The acceptable zip file size by the What If? system is limited to 10MB.

3. Project Module

The Project module is the most essential component of the AHDAP – What If? tool. After login, the Projects List screen will appear as per *Figure 9*. The Ipswich test dataset (a Local Government Area (LGA) in South-Eastern of Queensland, Australia) is already populated in the system database. Any new projects the user creates will be shown in the user's Project List and can be accessed anytime with that user's login credentials.

The AHDAP – What If? system provides two ways to access each module screen: (1) by clicking the module in the menu on the left-hand side of the application; (2) by clicking the module button in the **Actions** column of the **Projects List** screen which shows the project's specific scenarios.

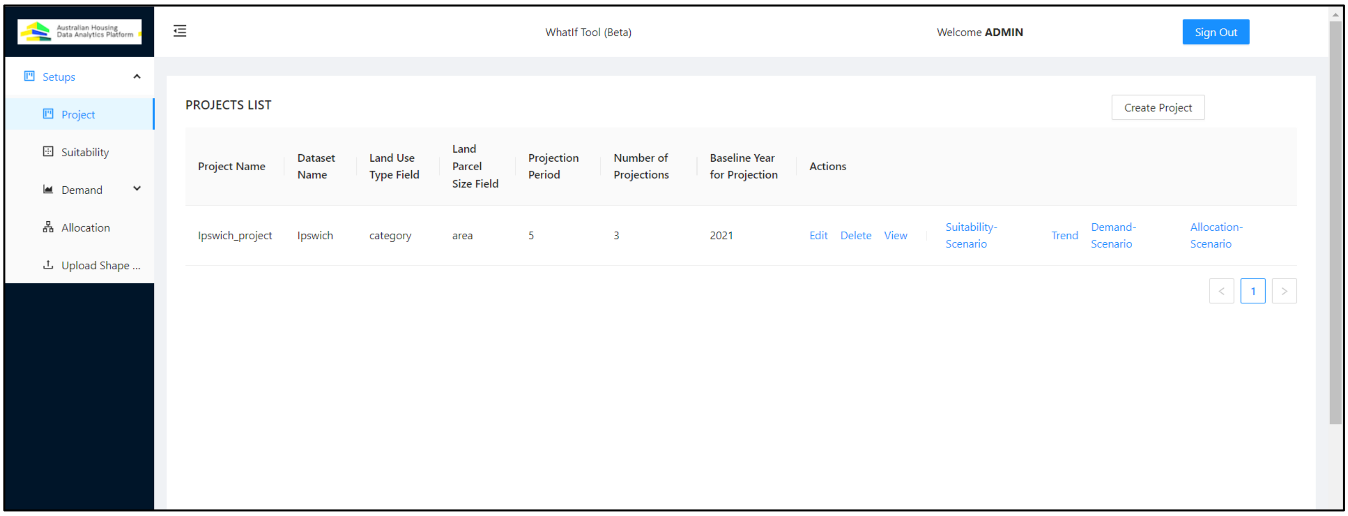

Figure 9. AHDAP – What If? Project List screen

The Project module provides the following functionalities via the **Project List** screen (*Figure 9*):

1. Upload Shapefile (left-hand menu)
2. Create the Project Setup
3. Edit the Project Setup Parameters
4. Delete the Project Setup
5. View the Project Setup Parameters

3.1. Upload Shapefile

1. If using your own data (rather than the Ipswich case study) Click the Upload Shape…(File) option in the left-hand menu which displays the Uploading Shape File (zip) function (Figure 10).
2. Specify the dataset name. Please avoid using '.' in the Dataset Name field.
3. Select the file path of the zipped shapefile (processed in the Data Preparation section) to be uploaded or drag and drop the zip file into the upload area.
4. Click 'Submit', and the selected shapefile will be uploaded and stored in the database of AHDAP-What If?.

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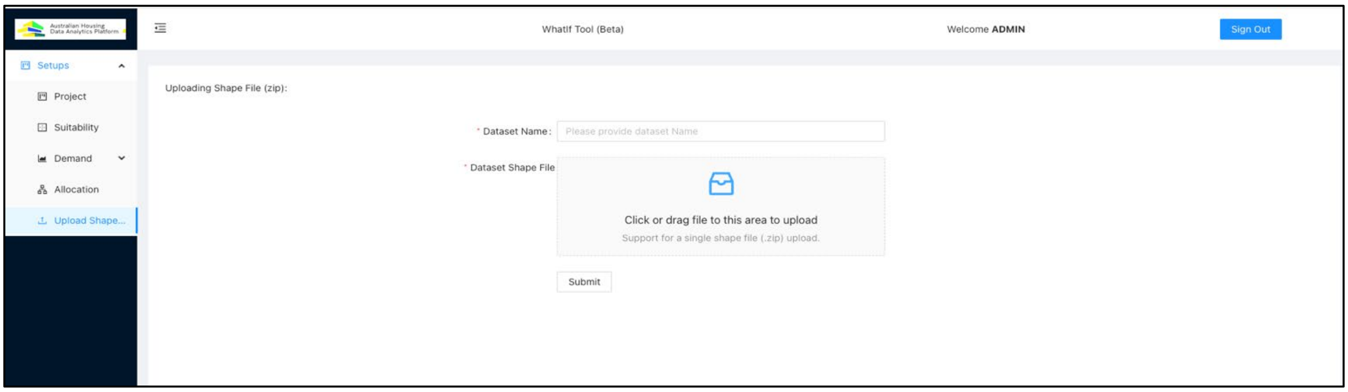

Figure 10. AHDAP – What If? Upload Shapefile

3.2. Create Project Setup

Click on **Create Project** at the top of the **Projects List** screen. This will display the **Project Setup** screen shown in *Figure 11* below. The following steps are required (described in below sections in detail) to create a new What If? project:

1. Setup Project
2. Provide More Info
3. Review/Confirm

3.2.1. Setup Project

This user manual provides a step-by-step guide for the user to go through the Ipswich test data. As mentioned, the Ipswich dataset has already been imported to the system database. However, users can create upload and select their own dataset, similar to as below for Ipswich:

1. Enter the **Project Name**, such as 'Ipswich_project'.
2. Choose the corresponding dataset, uploaded in the previous step from the drop-down list.
3. Click on **Next Step.**

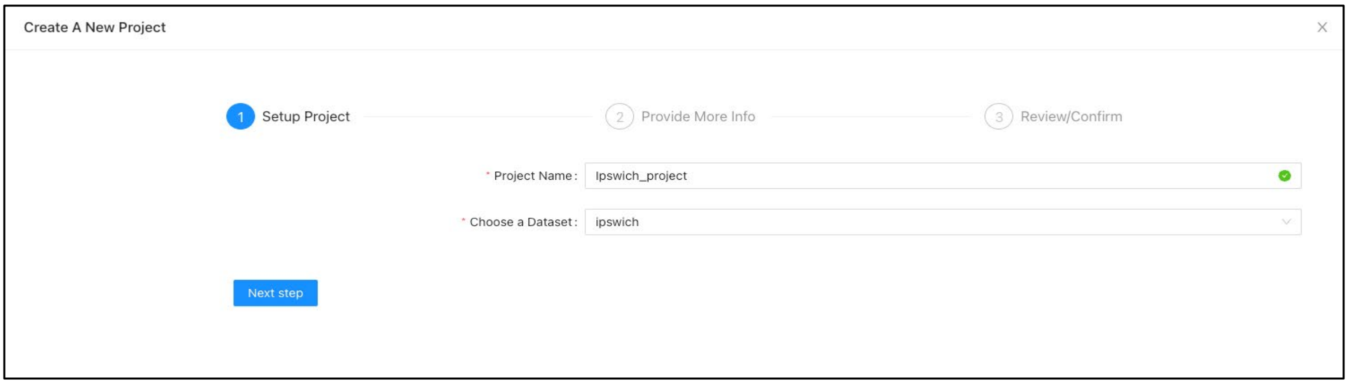

Figure 11. Project Setup Screen

3.2.2. Provide More Info

Next, provide more info as per *Figure 12*:

1. Select the 'Category' field from the **Choose a Land Use Type** dropdown list.
2. Select 'area' from **Choose a Geographical Unit**
3. Select '5' from the **Projection Period (years)** (how many years each projection will cover)
4. Select '3' from the **Number of Projections** (how many projections to do of each projection period size)

5. Select ‘2021’ from the **Baseline Year for Projection** (or the baseline year to begin projections from)
6. Click on **Next Step**

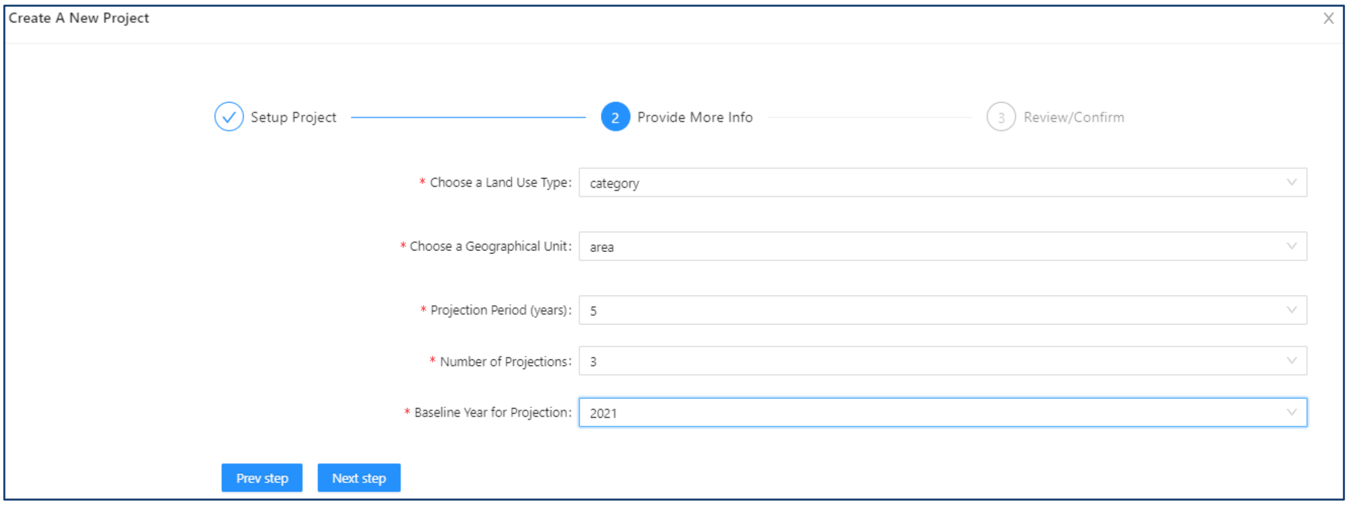

Figure 12. Project Other Parameters Screen

3.2.3. Review/Confirm

Check the parameters selected in the Review/Confirm screen to finalise the Project Setup. Click on **Submit** to create the Project as per *Figure 13*.

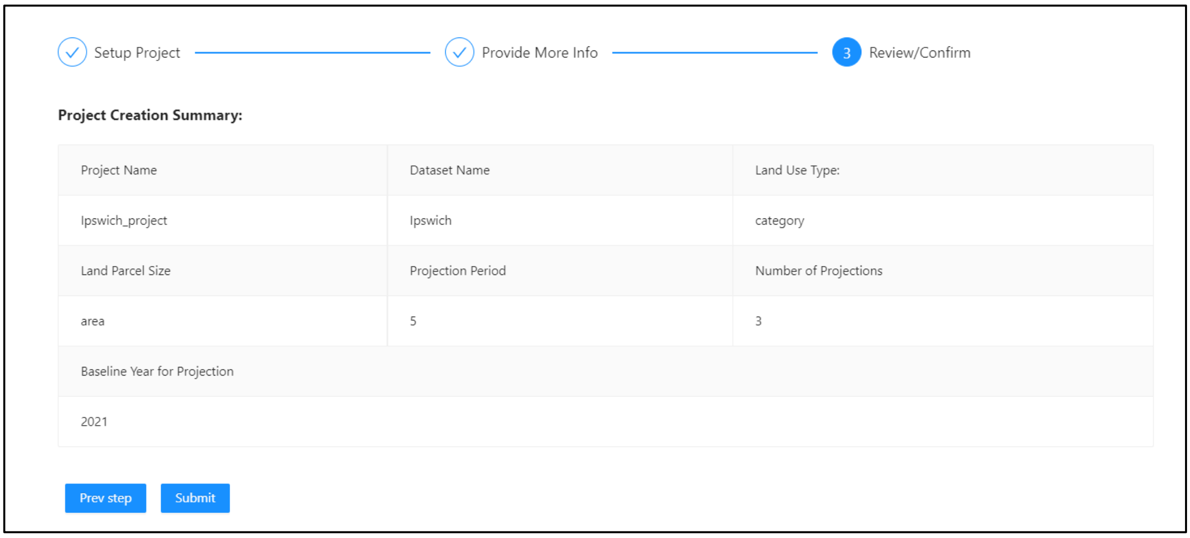

Figure 13. Finalising Project Setup Screen

3.3. Edit/Delete/View the Project Setup

To edit parameters in an existing project, click on **Edit** in the **Actions** column of the **Projects List** screen. The edit functionality will go through the same steps as **Create Project** allowing the values previously entered to be changed. To delete the project click **Delete** in the **Actions** column of the **Projects List** screen and confirm the deletion. To view the project summary click **View** in the **Actions** column of the **Projects List** screen**.**

4. Suitability Module

A Project must be setup (section 3) before creating a Suitability Scenario. To access the **Suitability Scenario** either click **Suitability** in the menu on the left-hand side of the application or click the **Suitability-Scenario** button in the **Actions** column of the **Projects List** screen as shown in *Figure 14*.

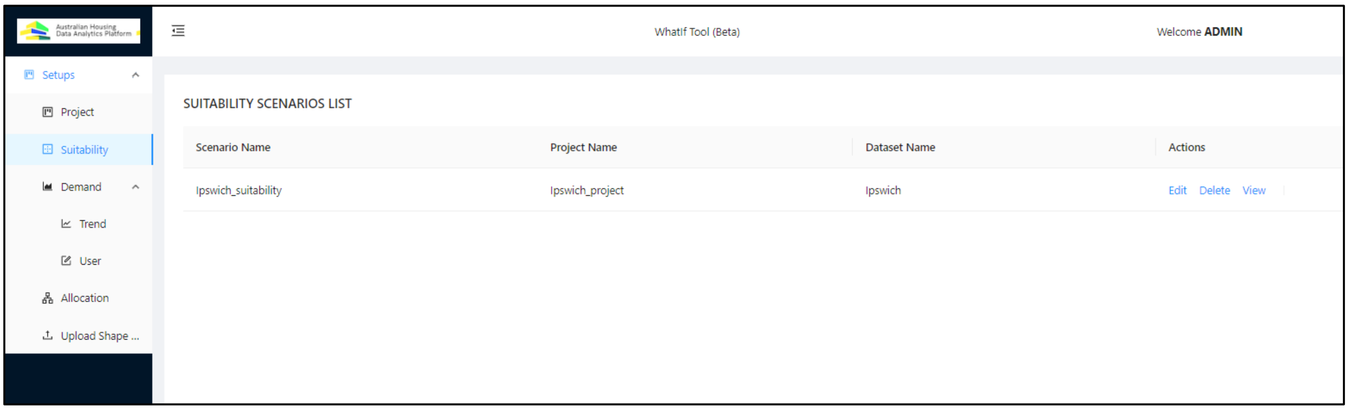

Figure 14. Suitability Scenarios List Screen

The Suitability module assesses the relative suitability of parcels for different land uses. The scenario-based suitability analysis implemented in AHDAP - What If? uses Multi-Criteria Evaluation (MCE) techniques to calculate a ***Suitability Score***, or a numeric value, indicating a location's overall suitability for a given land use when all the suitability factors are considered. Multiple suitability scenarios can be created for a project.

The Suitability module provides the following functionalities via the Suitability Scenarios List (*Figure 14*):

1. Create the Suitability Scenario Setup
2. Edit the Suitability Scenario Setup Parameters
3. Delete the Suitability Scenario
4. View the Suitability Map

4.1. Create Suitability Scenario Setup

Click on the **Create Suitability Scenario** option at the top of the **Suitability Scenarios List**. The following steps (described in below sections in detail) are required to create a new Suitability Scenario:

1. Setup Suitability Scenario
2. Provide Conversion Rules
3. Add Suitability Factor Weights
4. Review/Confirm

4.1.1. Setup Suitability Scenario

To define the new suitability scenario setup (*Figure 15*):

1. Enter the **Suitability Scenario Name**, such as 'Ipswich_suitability'. Please do not use '.' in the suitability scenario name.
2. **Choose a Project** from the drop-down selection, such as 'Ipswich_project'.
3. Provide the **Suitability Land Use Names** by clicking the **Add Suitability Land Use Name** button and typing any name in the text box. Users can add up to four Suitability Land Use Names which represent the potential land use types for the suitability scenario. For Ipswich, two suitability land use names are used: 'High_density_residential' and 'Low_density_residential'.
4. Click on **Done**.
5. Click on **Next Step**.

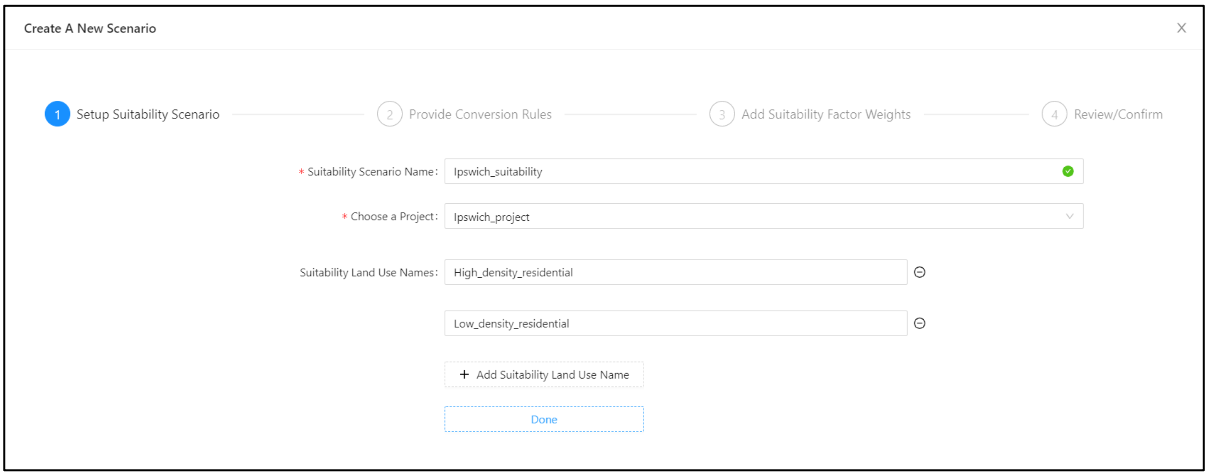

Figure 15. Suitability Land Uses Setup Screen

4.1.2. Provide Conversion Rules

This step is to specify the permitted land use conversions, namely the land uses that may be converted from their current use (e.g., Grazing Native Vegetation) to another use (e.g., Residential) during the land use allocation process. The table provides the existing land uses from the "mb_cat21" field in the *Current Land Use* column and the other column headings are the Suitability Land Use Names provided in the previous step. **Tick** the boxes to define the conversion rules. For instance, for the Ipswich use case tick 'Industrial', 'Other' and 'Primary Production' to be converted to both low and high density 'Residential' as shown in the *Figure 16*. Click **Next Step**.

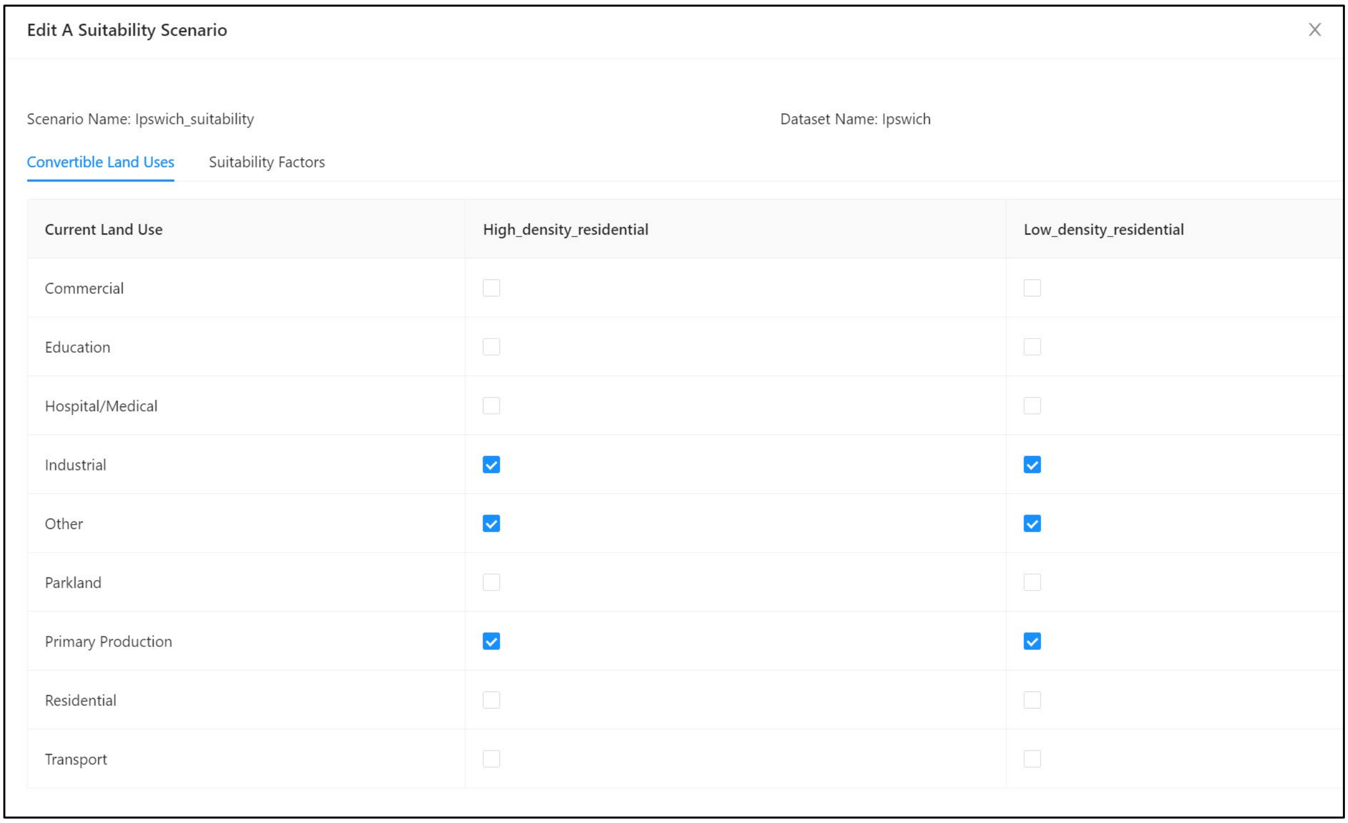

Figure 16. Suitability Conversion Rules Screen

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4.1.3. Add Suitability Factor Weights

Suitability factors are the characteristics of the land that will be considered in determining the relative suitability of different locations for each potential land use. The suitability factors to be considered are specified by the user, including natural conditions, social and economic factors, as well as ecological environmental protection factors.

To define these suitability factors:

1. Select the normalised driving factors from the **Add factor field** drop down list.
2. Choose the weights of each driving factor for each Suitability Land Use Name using the slider the bars as per Figure 17. For exact Ipswich weights see *Table 4*.

Table 4 Ipswich Suitability Factor Weights

Normalised Factor Full Name	High_density_residential	Low_density_residential
Distance_to_activity_centre	80	60
Distance_to_primary_school	36	25
Distance_to_railway_station	70	50
Distance_to_existing_residential_land	20	10
Distance_to_shopping_centre	45	35
Distance_to_main_road	20	50
Distance_to_protected_area	30	35
Distance_to_fire_hazard_zone	35	35
Distance_to_flood_zone	25	25

3. Click **Next Step**.

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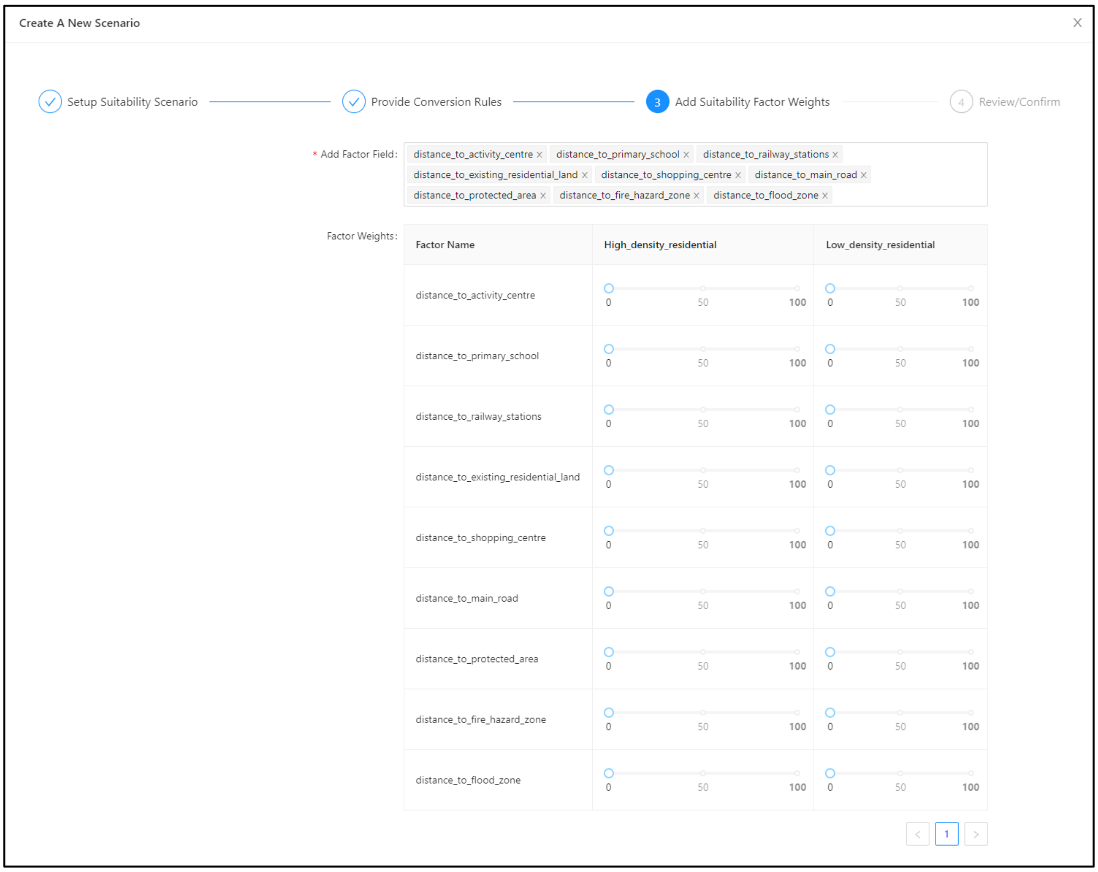
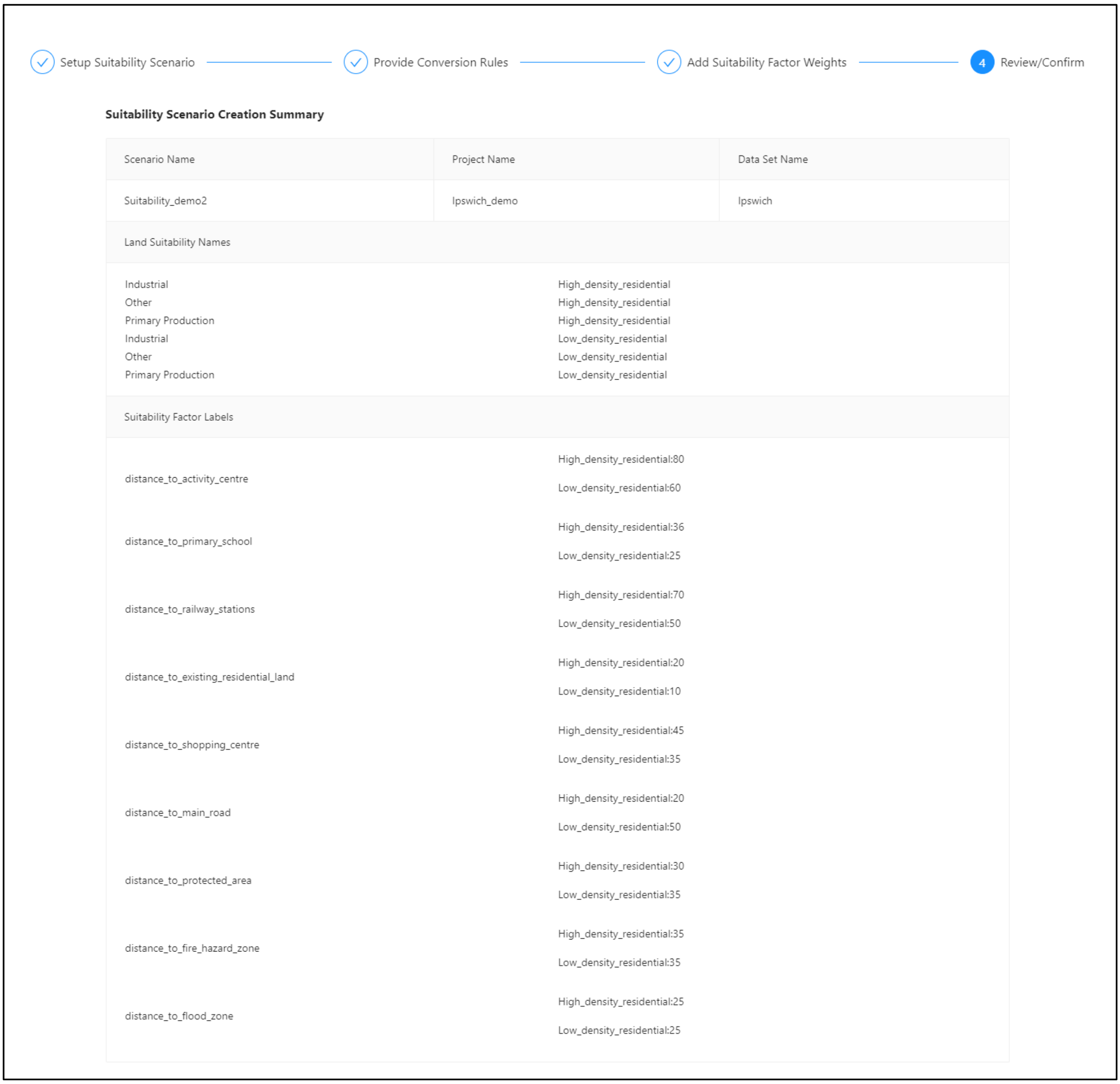


Figure 17. Suitability factor weights screen

4.1.4. Review/Confirm

Review/Confirm the parameters set to finalise the Suitability Scenario Setup. Click on **Submit** to create the Suitability Scenario as per *Figure 18*. Use the X in the top right corner to close the screen.



Setup Suitability Scenario — Provide Conversion Rules — Add Suitability Factor Weights — 4 Review/Confirm

Suitability Scenario Creation Summary

Scenario Name	Project Name	Data Set Name
Suitability_demo2	Ipswich_demo	Ipswich

Land Suitability Names	
Industrial	High_density_residential
Other	High_density_residential
Primary Production	High_density_residential
Industrial	Low_density_residential
Other	Low_density_residential
Primary Production	Low_density_residential

Suitability Factor Labels	
distance_to_activity_centre	High_density_residential:80 Low_density_residential:60
distance_to_primary_school	High_density_residential:36 Low_density_residential:25
distance_to_railway_stations	High_density_residential:70 Low_density_residential:50
distance_to_existing_residential_land	High_density_residential:20 Low_density_residential:10
distance_to_shopping_centre	High_density_residential:45 Low_density_residential:35
distance_to_main_road	High_density_residential:20 Low_density_residential:50
distance_to_protected_area	High_density_residential:30 Low_density_residential:35
distance_to_fire_hazard_zone	High_density_residential:35 Low_density_residential:35
distance_to_flood_zone	High_density_residential:25 Low_density_residential:25

Figure 18. Finalising Suitability Scenario Setup Screen

4.2. View Suitability Scenario Map Summary

View the mapping of suitable lands by clicking the **View** button in the **Actions** column of the **Suitability Scenarios List** screen. A map will show the suitability layers (*Figure 19*). Use the Layers radio buttons on the left-hand side of the page to select the land use to display in the suitability map. The Ipswich Suitability Scenario use case has two land uses defined, however up to four land uses can be defined as part of the Suitability Scenario creation. *Figure 19* shows areas that are not suitable for the selected land use in red through to areas that the most suitable in dark green.

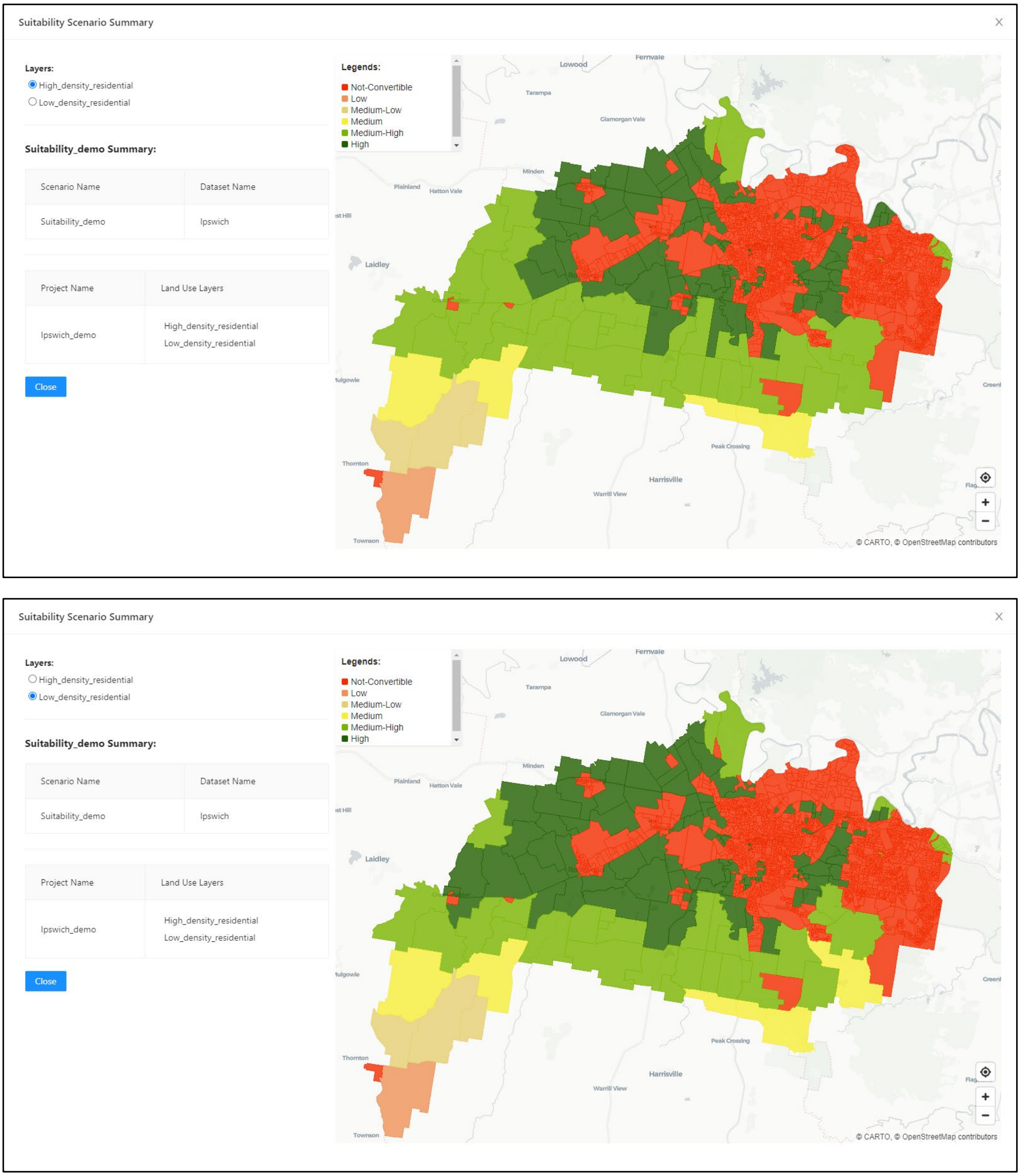


Figure 19. Suitability Scenario Summary for High_denisty_residential (top) and Low_density_residential (bottom)

4.3. Edit/Delete Suitability Scenario Parameters

The edit functionality within the Suitability Scenario only allows edit of **Conversion Rules** and **Factor Weights**. The parameters can be edited by clicking the **Edit** button in the **Actions** column of the **Suitability Scenario List** screen. After clicking **Edit**, the pop-up screen shown has two tabs, one for **Convertible Land Uses** and one for **Suitability Factors**. Edit values and then click **Submit** to persist the changes as shown in *Figure 20* and *Figure 21*.

To delete the Suitability Scenario click **Delete** in the **Actions** column of the **Suitability Scenario List** screen and confirm the deletion.

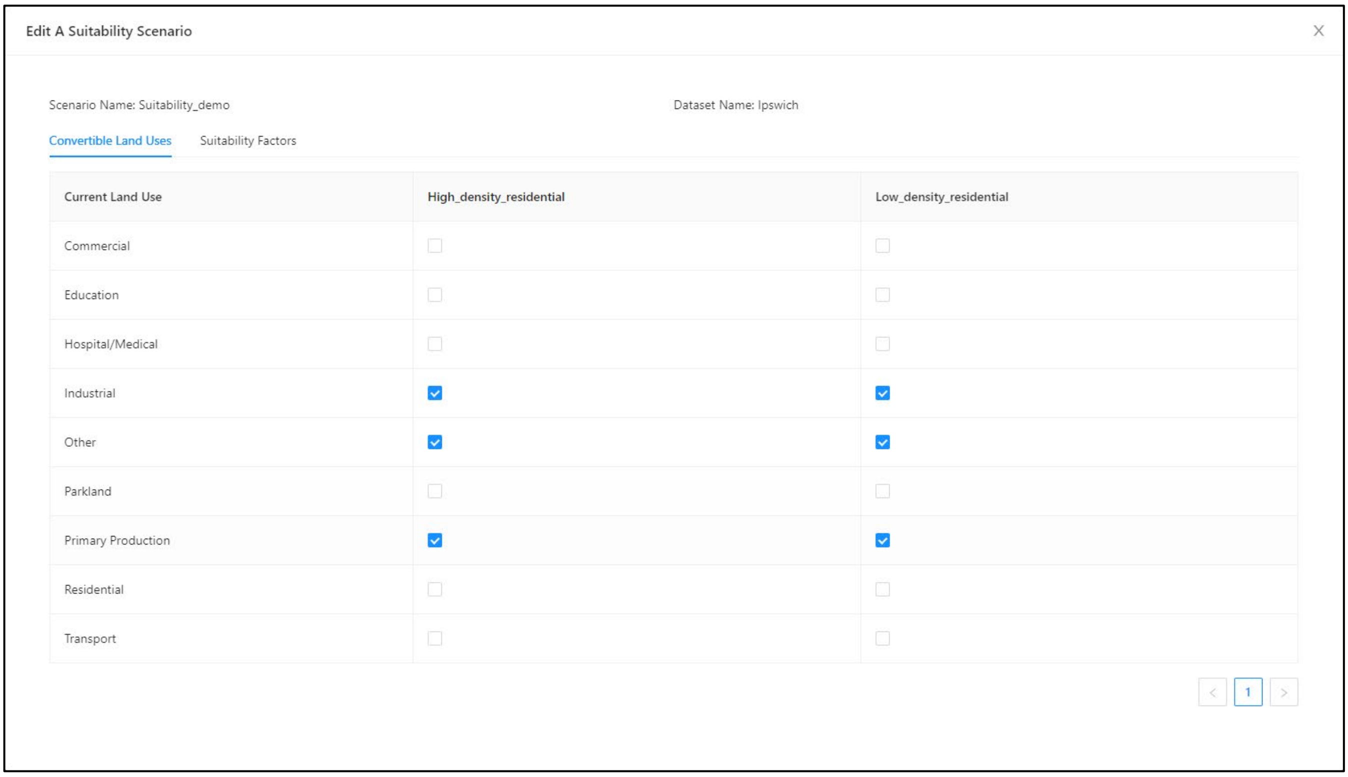


Figure 20. Suitability Scenario Edit Screen - Conversion Rules

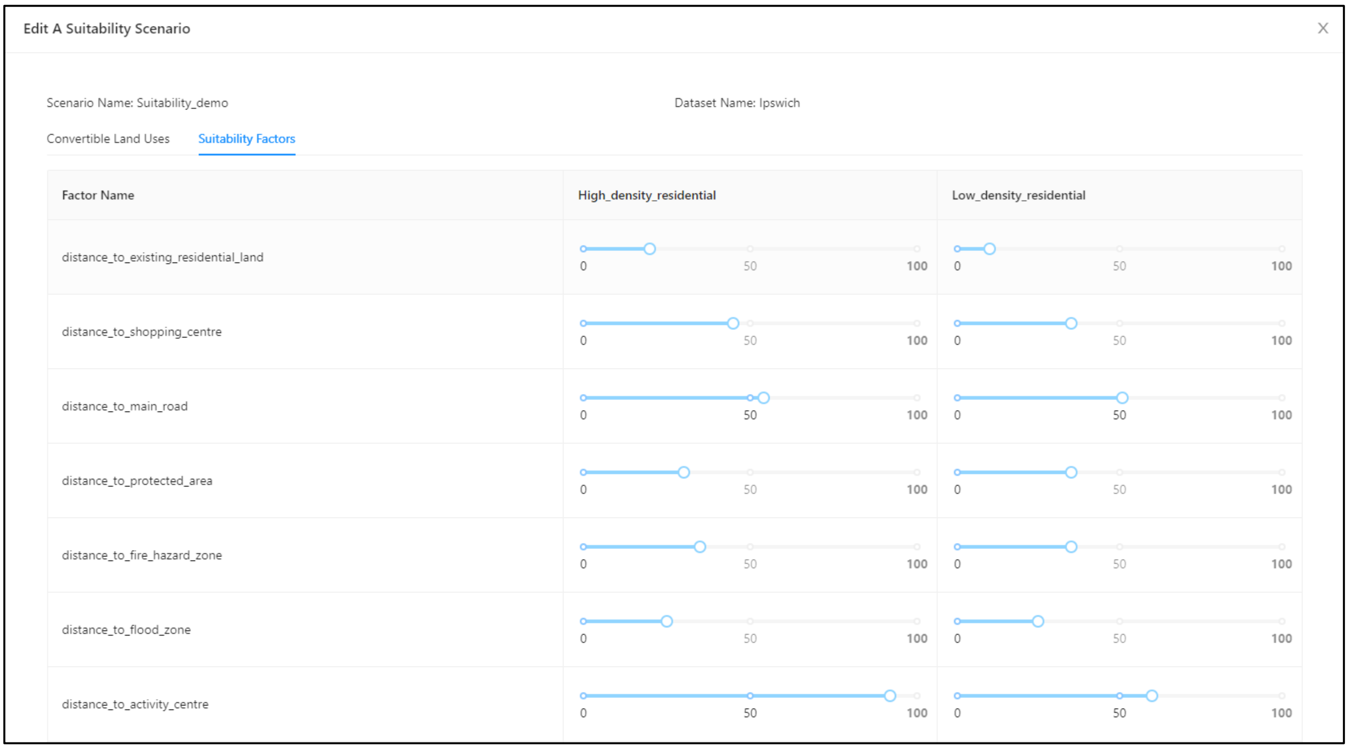


Figure 21. Suitability Scenario Edit Screen - Factor Weights Values

5. Demand Module Including Trend

This module can estimate future land-use demand for residential purposes only. To do this, data on past and current population, and housing – by sector – is required for the study area. This information can be obtained from the Australian Bureau of Statistics (ABS - https://www.abs.gov.au/statistics/people/population). In addition to the current population and employment data, the demand projection model uses two previous years of data to determine the trend.

AHDAP - What If? provides an approach for projecting the residential population and employment values that determine the future demand for different land uses, and these trend calculations are then used in the demand component. There are two approaches for calculating the future demand for different land uses: 1) extrapolating from the Population Growth Trend (ABS data) as is done in the **Trend Module**, 2) manual provision of the estimated future population. AHDAP - What If? currently uses the Growth Trend approach, the AHDAP Trend microservice calculates the future population based on the previous population trend.

5.1. Create the Trend Setup

The Trend setup can currently only be accessed one way - by clicking the **Trend** button in the **Actions** columns of the **Project List** screen as shown in *Figure 22*. Each project has its own trend setup values.

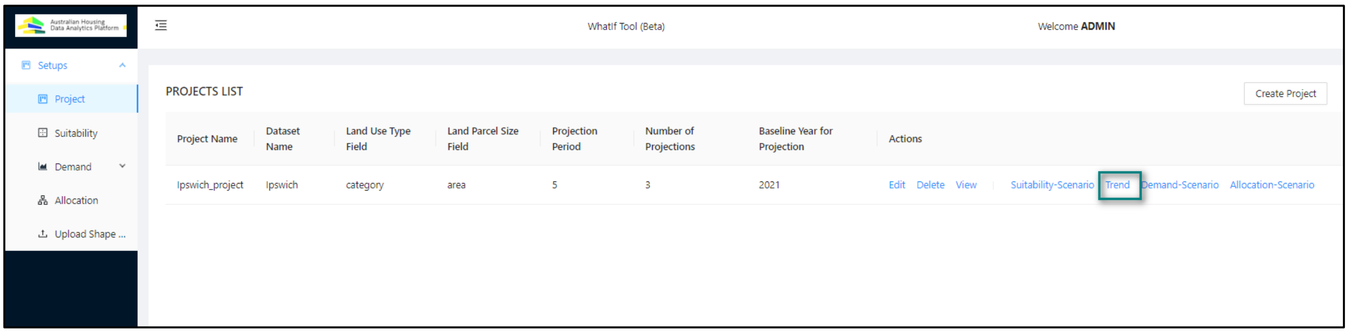


Figure 22. AHDAP - What If? Project List Screen

The Trend Setup creation is a three steps process to input current and past information related to population and employment.

The steps are:

1. Setup Population Trend
2. Setup Employment Trend
3. Review/Confirm

5.1.1 Setup Population Trend

To define the new Population Trend setup (*Figure **23***) first, enter the baseline and two previous years population data for the study area, as per Table 5 for Ipswich.

Table 5. Residential Population Past Trend Data for Ipswich (ABS data based on census years)

Year	Total Population	Household
2021	229208	87287
2016	193733	68674
2011	166904	60935

This data is essential to estimate future land demand for residential use. Trend projections assume that growth rates that are observed in the past will continue. Hence, two previous years of observed/recorded data values for population and households are required as shown in *Figure 23*.

The following data input should be entered through the user interface (for the Ipswich example):

1. Enter **229208** for ***2021* (Baseline) Year Population**
2. Enter **193733** for ***2016* (Previous) Year Population**
3. Enter **166904** for ***2011* (Previous) Year Population**
4. Click on **Next Step.**

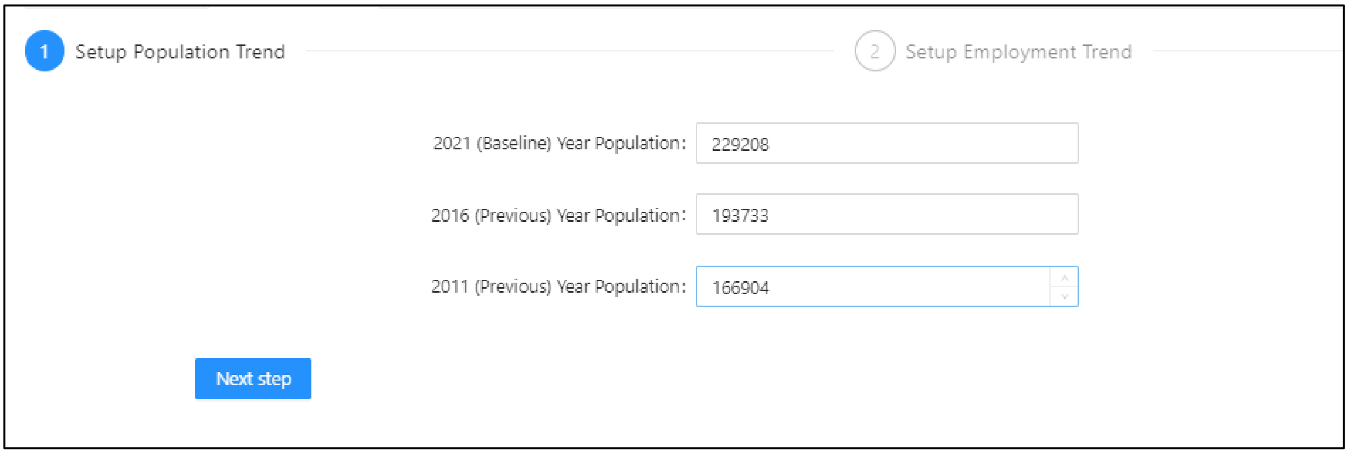


Figure 23. Population Screen

5.1.1. Setup Employment Trend

The current use case for Ipswich is focused on the transformation of residential land. Therefore, the employment demographic trend is set as 0 at present for Ipswich. Nevertheless, the user can still enter the employment values for their own case studies.

1. Enter **0** for ***2021* (Baseline) Year Employment**
2. Enter **0** for ***2016* (Previous) Year Employment**
3. Enter **0** for ***2011* (Previous) Year Employment.**
4. Click on **Next Step**.

5.1.2. Review/Confirm

Review and confirm the values entered then click **Submit**. After submitting the screen shows the **Edit** and **View** tabs for the Trend Setup.

5.2. View/Edit Trend Setup

The Trend parameters can be viewed by clicking the **Trend** button in the **Project List** screen after creating the Trend setup. There are two tabs; one to **View Trend Setup** which displays the calculated Trend values and one to **Edit Trend Setup** to adjust the parameters, as shown in *Figure 24*.

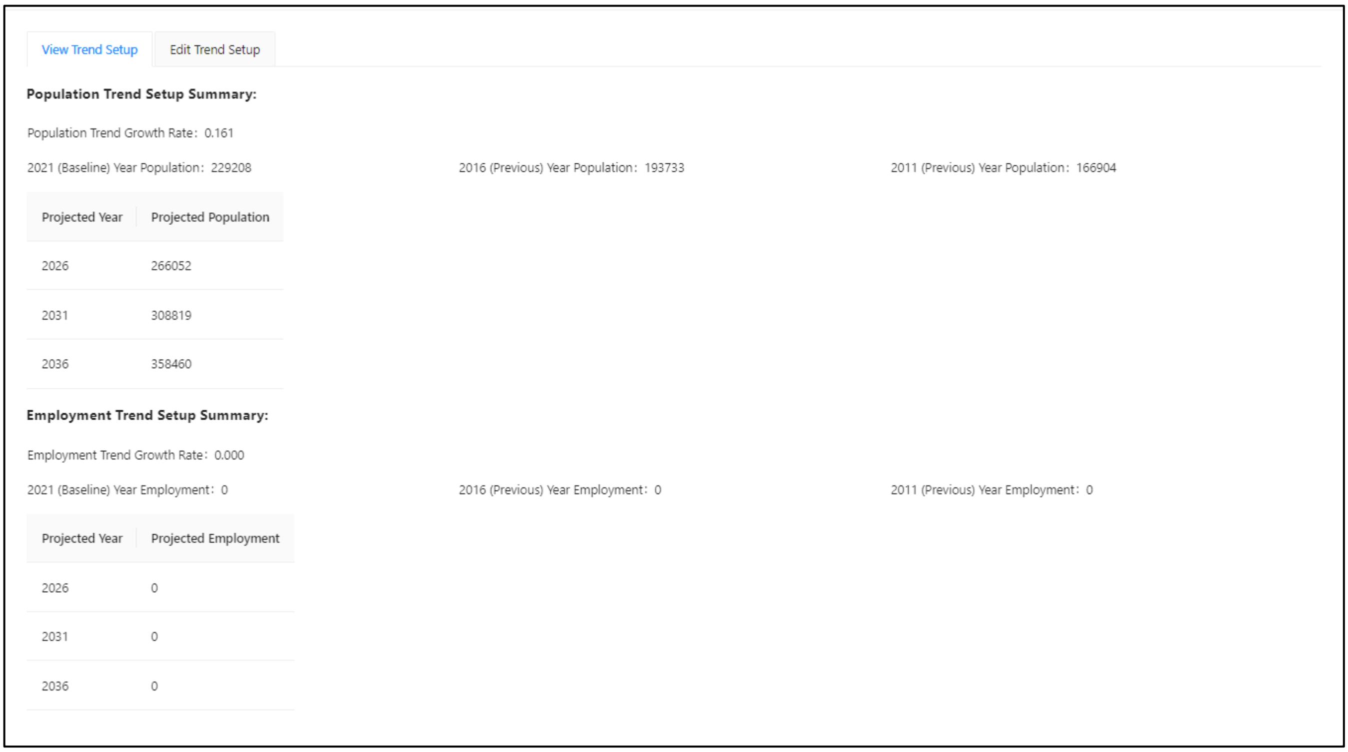


Figure 24. Trend Edit/View Screen

5.3. Create Demand Scenario Setup

To access the **Trend Demand Scenarios List** screen click the **Demand-Scenario** button for the project in the **Actions** column of the **Projects List Screen**, or click the Demand and then Trend buttons on the left hand menu to shows the project's Demand scenarios.

The Demand module is one of the most important modules of AHDAP What-if and enables projection of the future demand for residential land based on assumptions regarding population and employment growth. **Demand Scenario** is a straightforward way to create a projected land demand. It requires manual input of the amount of land required for each housing type per projection year. Any number of demand scenarios can be created per project. The project **Trend setup** must be created before creating a demand scenario for a project. The system will then be able to calculate the future demand for residential land use.

Please note that the **User** button under the **Demand** section in the left-hand menu is not active in the current version of the software. In future the user will be able to provide their own trend information via this button.

The following steps are required to create a new Demand Scenario:

1. Setup Demand
2. Provide Land Use Info, Breakdown
3. Add Low Density Factors
4. Review/Confirm

5.3.1. Setup Demand

AHDAP - What If? creates Demand based on the Population Trend setup in the Trend module. To create a Demand Scenario click **Create Demand Scenario** on the right-hand side of the **Trend Demand Scenarios List** screen.

The data in *Table 6* and *Table 7* is used in the Demand Scenario for the Ipswich case study. Similar data can be obtained for other regions from the ABS website (https://www.abs.gov.au/statistics/people/population). This data is essential to calculate the future land demand for residential use. *Table 7* includes the two main terms Vacancy Rate and Infill Rate. The Vacancy Rate is the proportion of housing that will be vacant and available for sale (i.e., surplus of housing). For the Ipswich use case a vacancy rate of 10% is used so the value entered is 0.1. The Infill Rate is the proportion of new housing units that is assumed to be allocated as "infill" to areas that are already devoted to residential uses. The land use demand for these "infill units" is deducted from the total residential demand in a year.

Table 6. Past Residential Trend for Ipswich

Year	Total Population	Households
2021	229208	87287
2016	193733	68674
2011	166904	60935

Table 7. Housing requirement and land use demand projection for Ipswich

Projected year	Average household size	Vacancy Rate	Infill Rate	Projected number of houses (considering vacancy rate)
2026	2.80	0.1	0.07	$\frac{266052/2.8}{1-0.1} = 105576$
2031	2.81	0.09	0.08	$\frac{308819/2.81}{1-0.09} = 120769$
2036	2.80	0.09	0.08	$\frac{358460/2.8}{1-0.09} = 140682$

Projected year	Projected number of required new houses	Average density* (Houses/km^2)
2026	$(105576 - 87287) \times (1 - 0.07) = 17008$	2150
2031	$(120769 - 87287) \times (1 - 0.08) = 30803$	2300
2036	$(140682 - 87287) \times (1 - 0.08) = 49123$	2350

** The density of housing comes from the "Ipswich City Council - Planning scheme fact sheet No.8"*

To define the new demand scenario setup as per *Figure 25* (values are for the Ipswich use case):

1. Under Setup Demand, **Choose a Project** from the drop-down list. The Project Baseline Year and Baseline Year Population will be displayed.
6. Provide the **Demand Scenario Name,** such as 'Ipswich_demand'. Please do not use '.' in the demand scenario name.
2. Enter ***87287*** in **Number of Baseline Year Dwellings**

3. The **Future Group Quarter Population** is not used for Ipswich but relates to people who temporarily relocate in projection years such as refugees, armed forces, international students, etc. that might affect the future demand. For Ipswich the default 0 values are retained.
4. Edit the **Future Avg Household Size** column cell by double clicking each cell, and provide **2.8** for **2026**, **2.81** for **2031** and **2.81** for **2036** (as per *Table 7*).
5. Edit the **Future Vacancy Rate** column by double clicking each cell, and provide **0.1** for **2026**, **0.09** for **2031**, **0.09** for **2036** (as per *Table 7*).
6. Click on **Done**.
7. Click on **Next Step.**

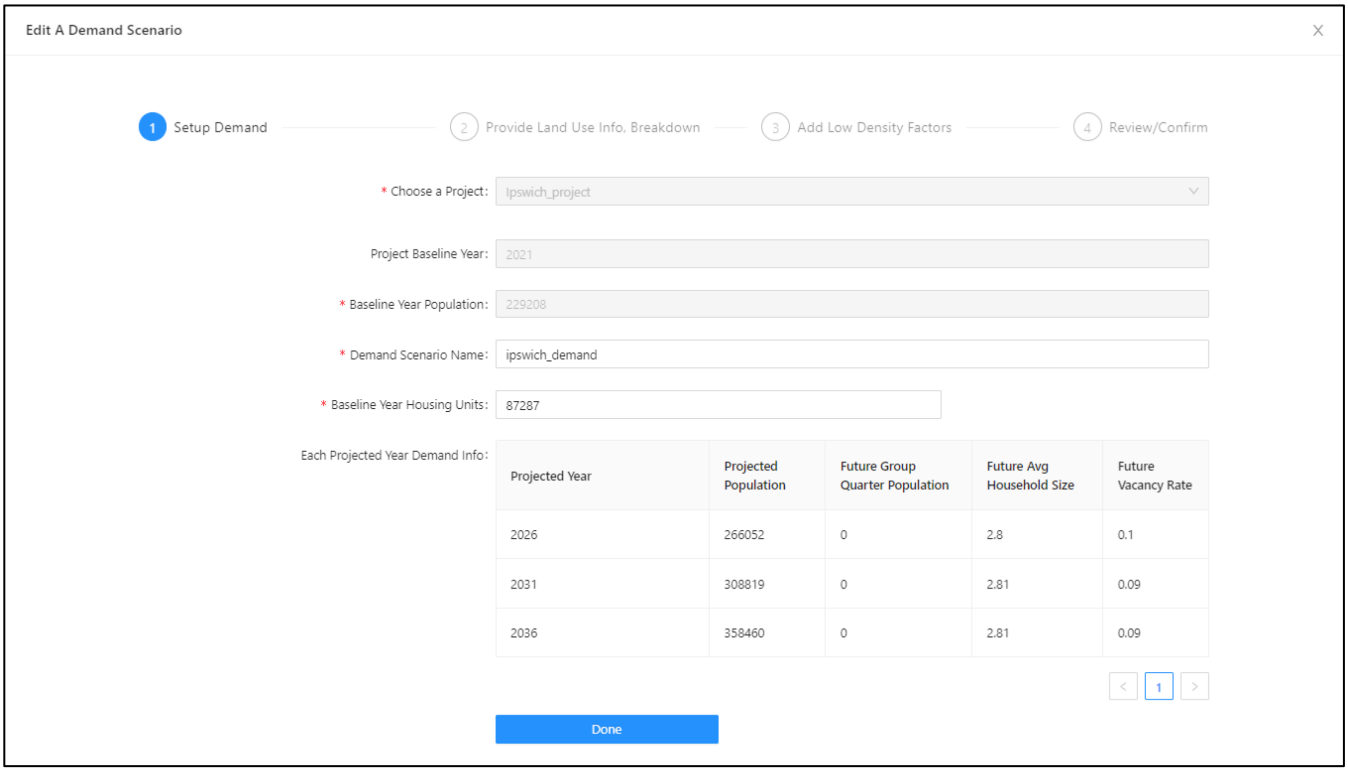


Figure 25. Setup Trend Demand Scenario Screen

5.3.2. Provide Land Use Info, Breakdown

In this step, provide the Land Use Names and their breakdown or future percentage of each type. Any number of unique **Demand Land Use Names** can be added by clicking the **Add Demand Land Use with Breakdown** button. The **Name** and **Breakdown** values are editable by double clicking in each cell. The number in the **Breakdown** column specifies the future percentage breakdown by land use type. Regarding the Ipswich use case, there are two types of residential land: high-density residential and low-density residential (*Figure 26*). The users may consider more than two land use types as long as the *sum of all* **Breakdown** values is equal to 1.0.

Provide names and breakdown values as follows (*Figure 26*):

1. Click on **Add Demand Land Use with Breakdown** to add a new row to the table.
2. Edit the example **Name** by double clicking the cell and enter 'High_density_residential' and 'Low_denisty_residential' and set the **Breakdown** values as '0.6' and '0.4', respectively (*Figure 26*).
3. If using additional residential Land Use types, repeat steps 1 and 2 plus edit the **Breakdown** values by double clicking each cell so they sum to 1.0.
4. Click on **Done with LandUse Name**
5. Click on **Next Step**.

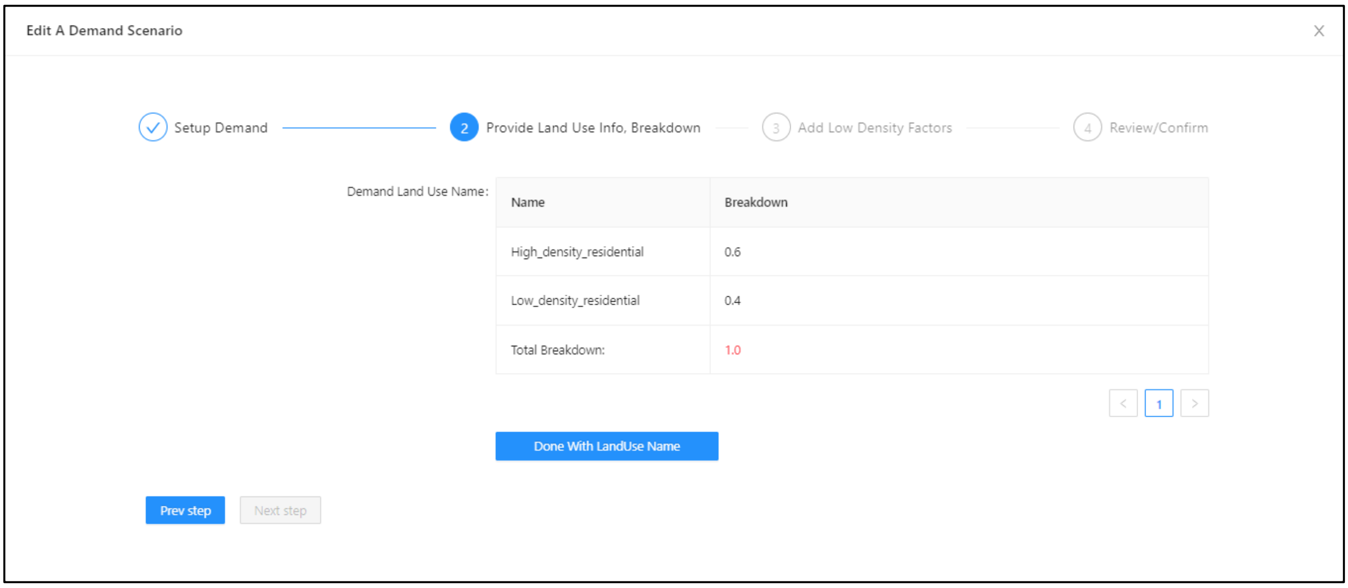


Figure 26. Setup Trend Demand Scenario- Provide Land Use & Breakdown Screen

5.3.3. Add Low-Density Factors

In this step, provide the **Infill Rate** and **Density** of each Land use created for each projected year. For the Ipswich use case there are two residential land uses so there are two nested tables as shown in *Figure 27*.

1. Expand the nested table by clicking the + next to the land use name.
2. Edit the **Infill Rate** by double clicking each cell and providing ***0.07*** for **2026**, ***0.08*** for **2031**, ***0.08*** for **2036** (for both 'High_density_residential' and 'Low_denisty_residential' as per *Figure 27*).
3. Edit the **Density** by double clicking the column cell and providing ***3250*** for **2026**, ***3510*** for **2031**, ***3598*** for **2036** (High_density_residential); ***1052*** for **2026**, ***1090*** for **2031**, ***1102*** for **2036** (Low_denisty_residential).
4. Click on **Save for each nested table**.
5. (Optional) Repeat steps 1-4 for other residential land use types as necessary.
6. Click on **Done with Density Factor**
7. Click on **Next Step**

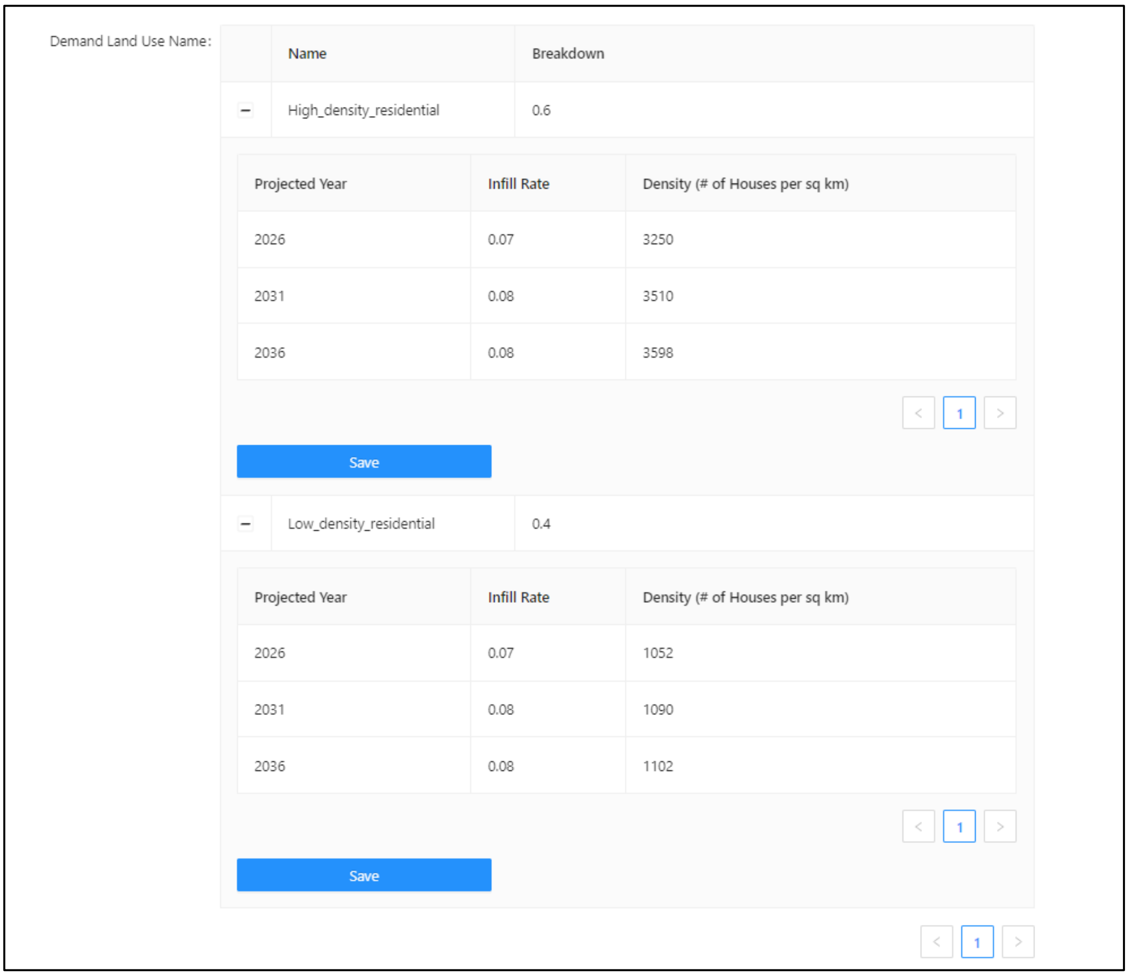


Figure 27. Setup Trend Demand Scenario- Provide Density Factors Screen

5.3.4. Review/Confirm

Finalise the Demand Scenario Setup on the Review/Confirm screen by checking the values. Click on **Submit** to create the Demand Scenario as per *Figure 28*.

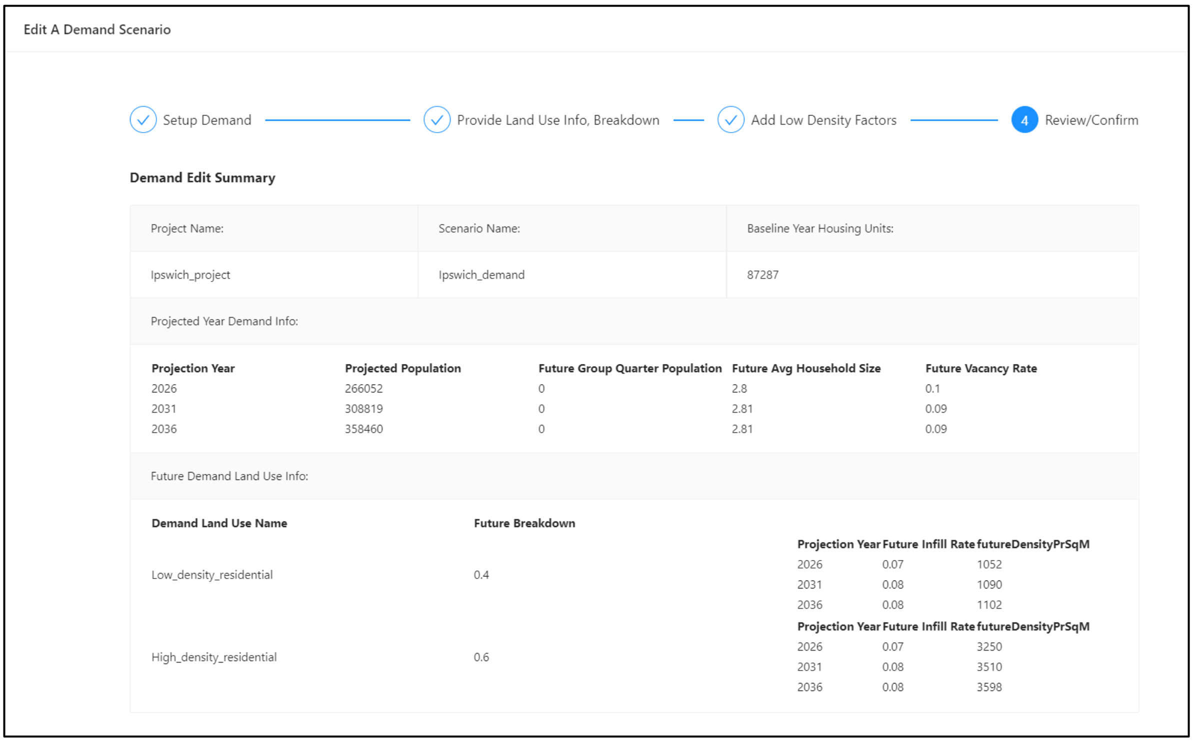


Figure 28. Finalising Demand Scenario Setup Screen

5.4. View Projected Demand Summary

View the summary of projected land use demand (*Figure 29*) by clicking the **View** button in **Actions** column of **Trend Demand Scenario List** screen.

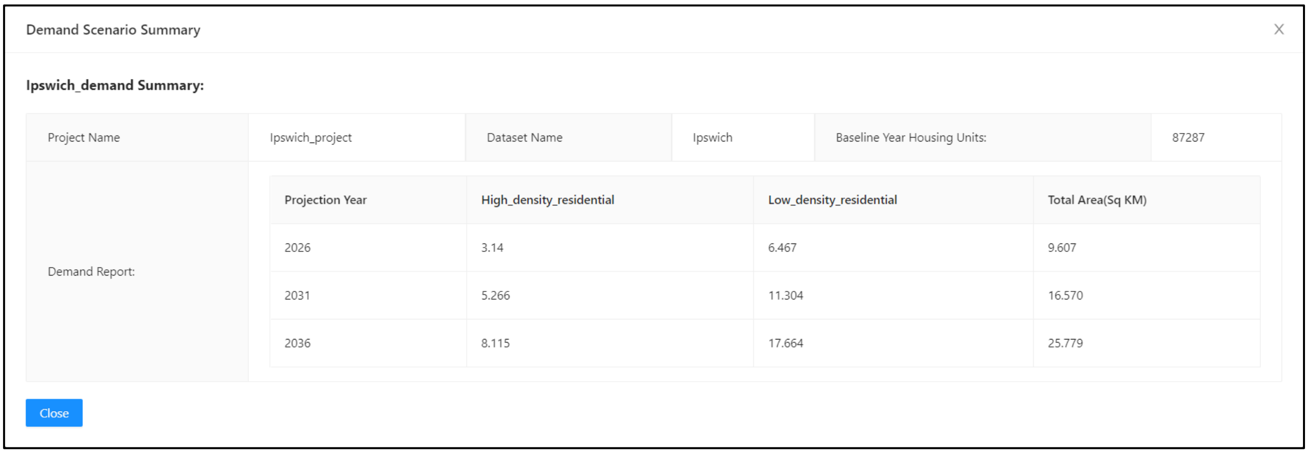


Figure 29. Demand Scenario Summary/View Screen

5.5. Edit/Delete the Demand Scenario

To edit any of the values in an already created Demand Scenario click the **Edit** button in the **Actions** column of the **Trend Demand Scenario List** screen. The edit functionality will go through the same steps as **Create Demand Scenario** displaying the values previously entered by the user. To delete the Demand Scenario click **Delete** in the **Actions** column of the **Trend Demand Scenario List** screen and confirm the deletion.

6. Allocation module

As another key module of AHDAP - What If?, the Allocation module allocates various land use demands to different locations. Specifically, it identifies future land use in each projection year by: (1) allocating the projected land use demands derived from a user-selected Demand Scenario to different locations based on (2) their relative suitability, as defined by the assumptions in the user-selected Suitability Scenario, and (3) the allocation controls setting, namely infrastructure control and growth pattern.

The AHDAP - What If? allocation scenario involves allocating the projected land use demand for each year in succession, starting with the first year and proceeding to subsequent years. If the available land is insufficient to meet the projected demand for a particular land use type, the allocation routine will be terminated. The Allocation module is a straightforward method for determining the future allocation of land. Multiple allocation scenarios can be created for a given project, but they can only be set up after the suitability scenario and demand scenario have been established.

AHDAP - What If? is a tool that projects future land use and population patterns. It does so by allocating projected land use demands, derived from a user-defined demand scenario, to different locations. This allocation is based on the suitability of each location, which is defined by the user-selected suitability scenario, as well as any allocation controls specified in the allocation scenario assumptions. For example, residential land use demand can be assigned to the most suitable sites for residential development first, followed by the second most suitable sites, and so on, until all projected residential demand for each projection year is met. If desired, the demand allocation process can be guided, restricted, or prioritised by a combination of user-selected public policies, such as land use plans, planning schemes, infrastructure control and growth patterns.

6.1. Create Allocation Scenario

To create the **Allocation Scenario** there must already be **Suitability** and **Demand Scenarios** setup. To create an Allocation Scenario click **Allocation-Scenario** for the relevant project in the **Actions** column of the **Project List** screen (or Allocation from the left hand menu), then click **Create Allocation Scenario** on the right-hand side of the **Allocation Scenario List** screen.

The following steps are required to create a new Allocation Scenario:

1. Setup Allocation
2. Provide More Info
3. Set Suitability Land Use Priority (if more than 1 suitable land use)
4. Set Demand Land Use Priority (if more than 1 demand land use)
5. Review/Confirm.

6.1.1. Setup Allocation

To define the new allocation scenario setup (*Figure 30*):

1. Choose a project from the **Choose a Project** drop-down list.
2. Enter an **Allocation Scenario Name** i.e. “Ipswich_allocation”. Please do not use ‘.’ in the allocation scenario name.
3. Choose the suitability scenario from the **Choose a Suitability Scenario** drop-down list.
4. Choose the demand scenario from the **Choose a Demand Scenario** drop-down list.
5. Click on **Next Step**.

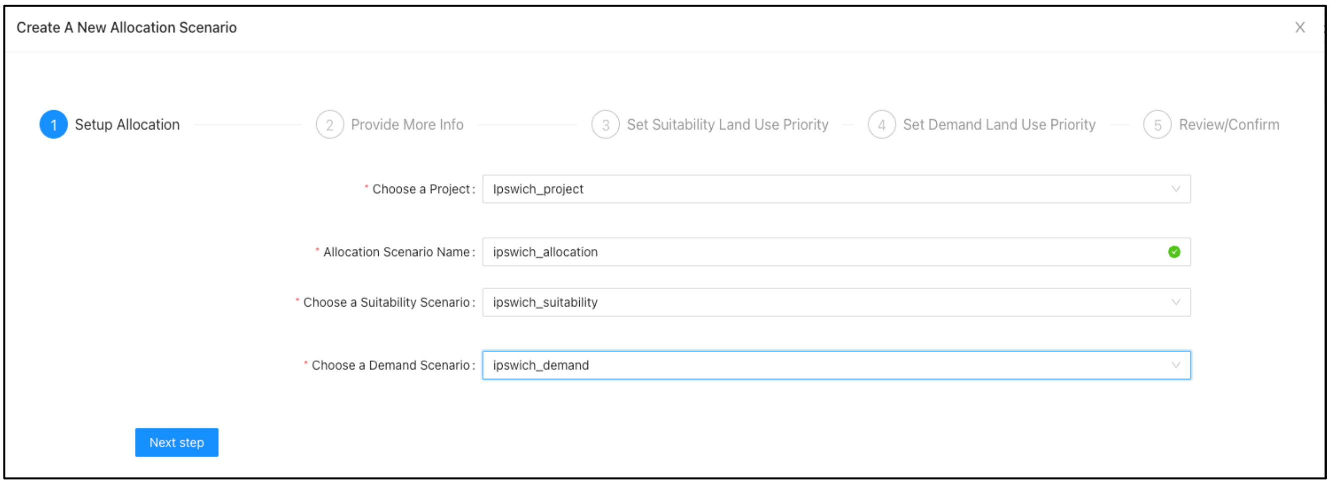


Figure 30. Create Allocation Scenario – Step 1 Screen

6.1.2. Provide More Info

In this step, the allocation process requires consideration of specific fields such as the **Infrastructure Control Field** or **Growth Pattern Field** (refer to section 2.2.4). The **Infrastructure Control Field** outlines the infrastructure plans that will impact the area and identifies the type of limitation that will be provided in a given year. The **Growth Pattern Field** defines the growth pattern and identifies the areas that will be developed in advance. Selecting 'Yes' for either of these fields will require the relevant field in the input dataset to be chosen as shown in *Figure 31*. This additional information is necessary to allocate future land uses to parcels that align with the year in which infrastructure will be available. In the current Ipswich use case, the **Infrastructure Control field and Growth Pattern field** are selected as "within_fire_hazard_zone" and "within_0_to_1600m_of_railway_station", separately. Specifically, candidate parcels located within 1600 meters of railway stations will be given priority for conversion to residential land, and the ones located within fire hazard zone will be excluded from the conversion regardless of their overall suitability.

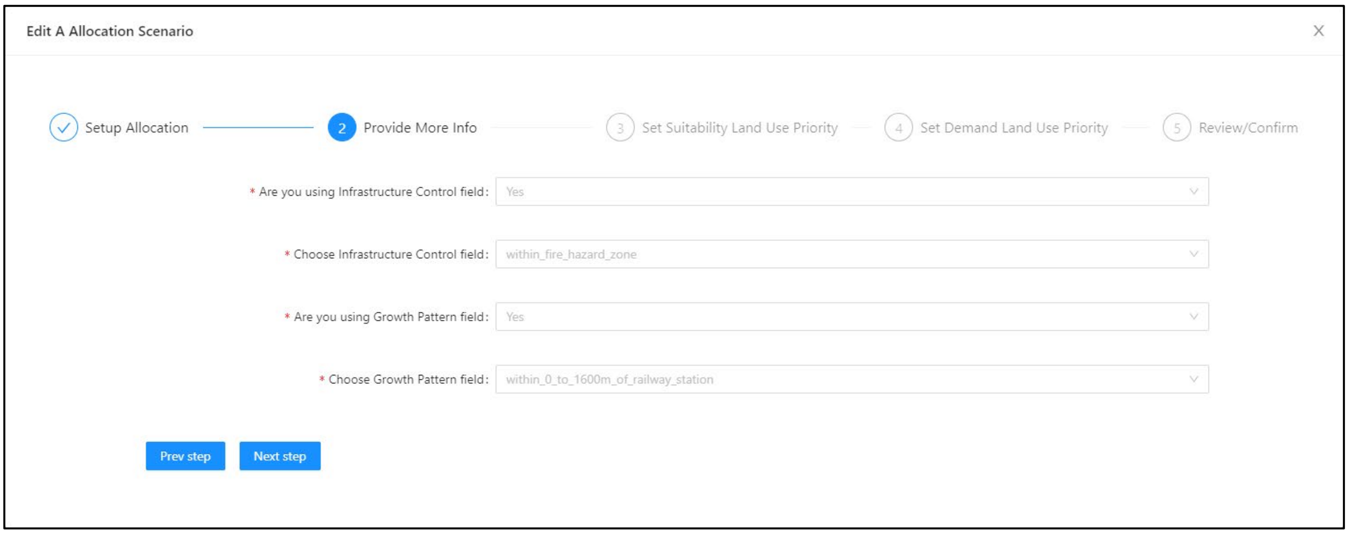


Figure 31. Create Allocation Scenario – With Extra Fields

Figure 32. Create Allocation Scenario – Without Extra Fields

To Provide More Info:

1. Choose **Yes**/*No* (for Ipswich) from the **Are you using Infrastructure Control Field** drop-down list
2. If yes, **Choose Infrastructure Control field** from the dropdown list, i.e. “within_fire_hazard_zone” for the Ipswich case study.
3. Choose **Yes** (for Ipswich)/*No* from the **Are you using Growth Pattern Field** drop-down list
4. If yes, **Choose Growth Pattern field** from the dropdown list, i.e. “within_0_to_1600m_of_railway_station” for the Ipswich case study.
5. Click on **Next step.**

6.1.3. Set Suitability Land Use Priority

This step sets the priority of suitable land use to be considered in the allocation process. In the Ipswich case study, high-density residential is given a higher priority as it is on top (as shown in *Figure 33*). To Set Suitability Land Use Priority:

1. If there is more than one land use, use the three-line symbol (‘☰’) in the Sort column to drag and drop the suitable land use names into priority order, with the highest priority at the top and lowest at the bottom.
2. Click on **Done with Sort Land Use.**
3. Click on **Next step.**

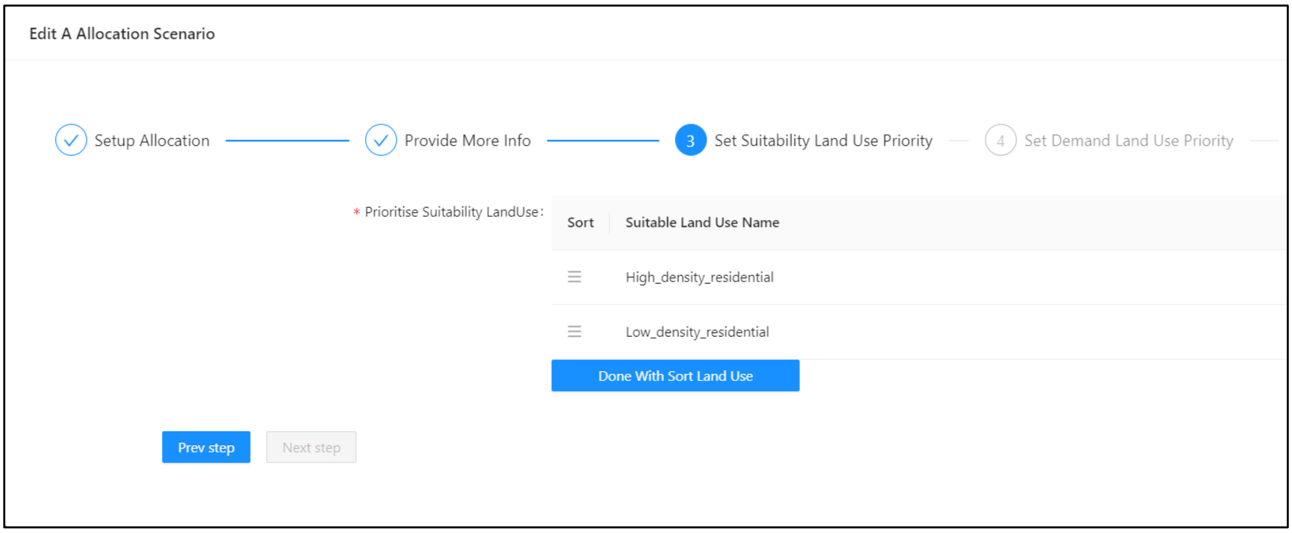


Figure 33. Create Allocation Scenario– Suitability Land Use Priority Screen

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6.1.4. Set Demand Land Use Priority

This step sets the priority of demand land use to be considered in the allocation process. In the Ipswich case study, high-demand residential is given higher priority as it is on top (as shown in *Figure 34*). To Set Demand Land Use Priority:

1. If there is more than one land use, use the three-line symbol ('≡') in the Sort column to drag and drop the demand land use names into priority order, with the highest priority at the top and lowest at the bottom.
2. Click on **Done with Sort Land Use.**
3. Click on **Next step.**

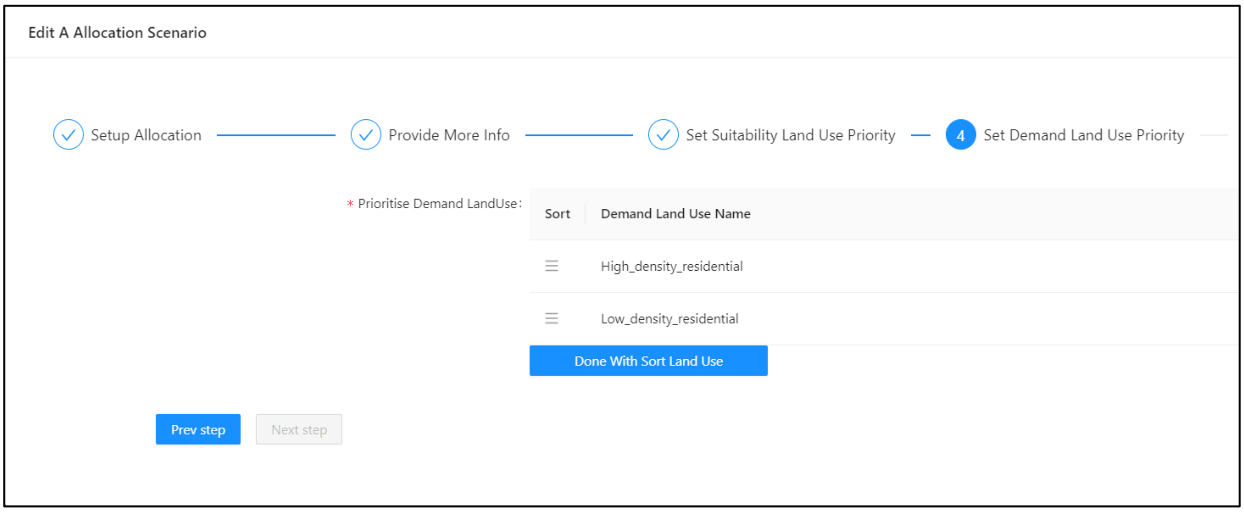

Figure 34. Create Allocation Scenario– Demand Land Use Priority Screen

6.1.5. Review/Confirm

Review the details of the allocation scenario and click on **Submit** to create the **Allocation Scenario setup**, as per *Figure 35*. Close the Review/Confirm screen with the cross at the top right.

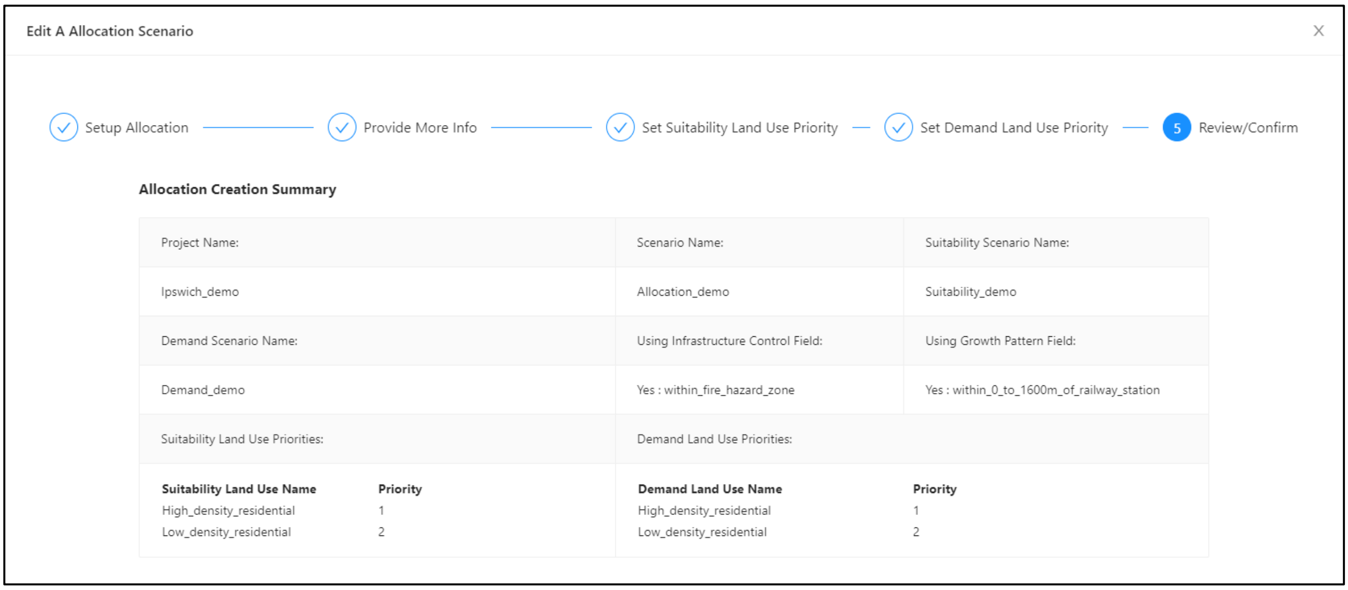

Figure 35. Create Allocation Scenario– Suitability Land Use Priority Screen

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6.2. View/Summary of Allocation Map

View the map of suitable allocated lands for baseline and projected years by clicking the **View** button in the **Actions** column of **Allocation Scenarios List** screen. A popup screen will be shown that displays two tabs; one for the baseline year map allocation (2021) and one for all projected years allocations (2026, 2031,2036). Use the radio buttons on the left-hand side of the Projected Year allocation tab page to select the allocated land use year to be displayed in the allocation map. The allocation results of Ipswich baseline (2021), projected (2026) and projected (2031) years are shown in *Figure 36* , *Figure 37* and *Figure 38*. In the baseline year allocation map, the different colours represent different land use types. For the projected year allocation maps, each colour indicates which land use has been allocated for that year based on each projected demand land use.

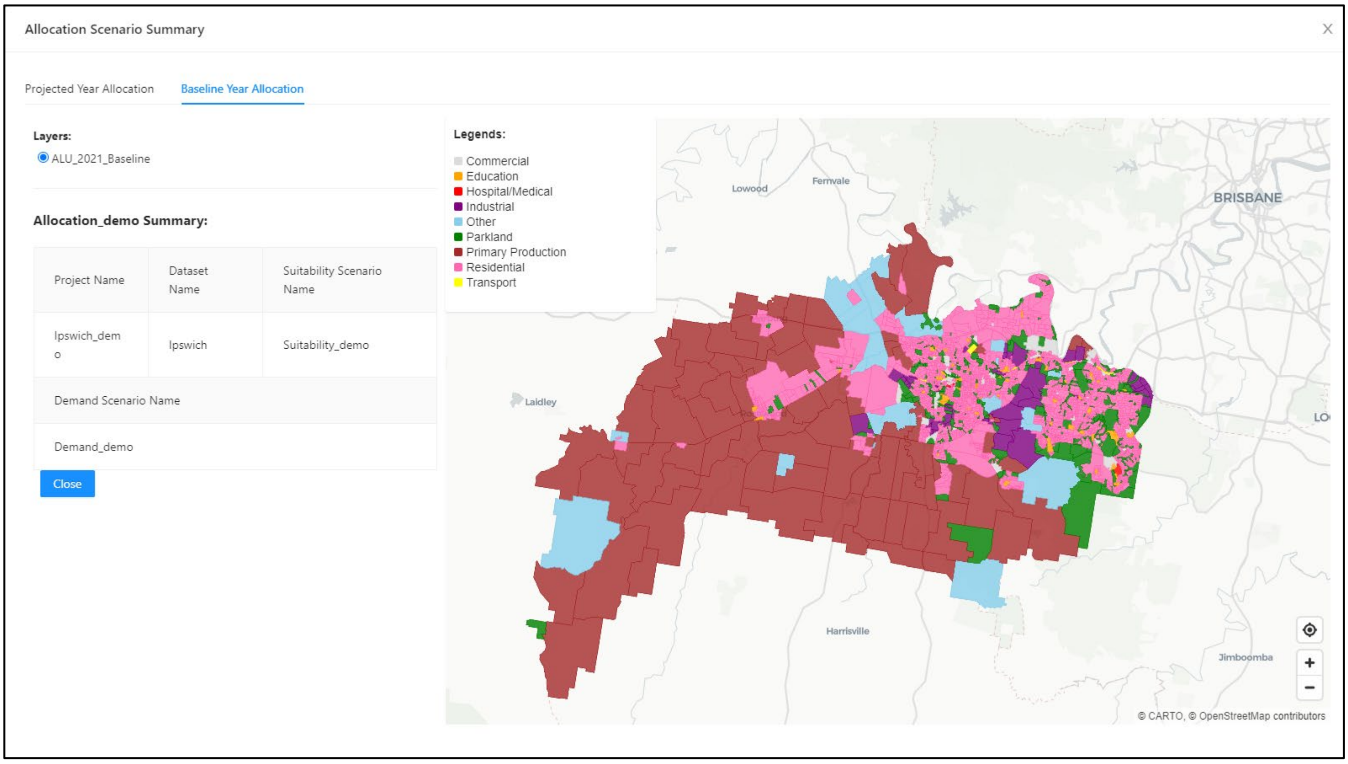

Figure 36. Allocation Scenario Summary – Baseline year (2021)

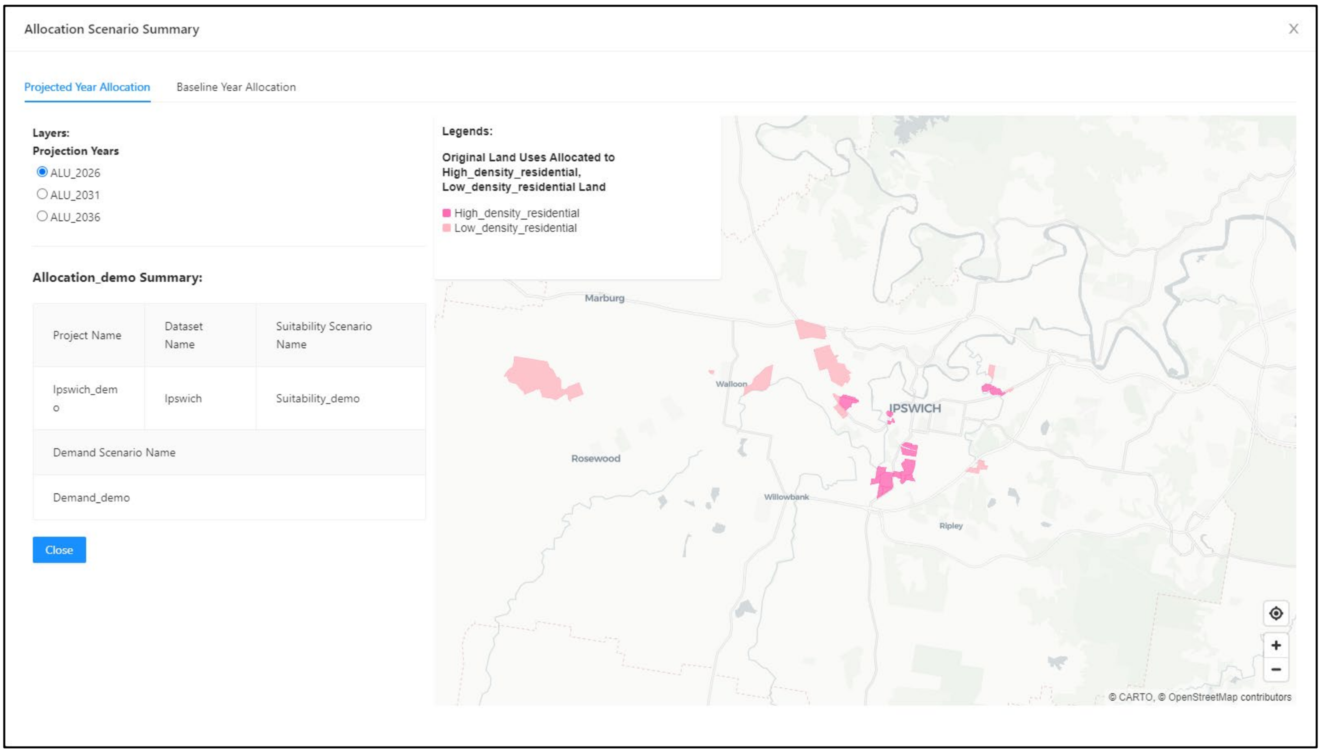

Figure 37. Allocation Scenario Summary – 2026 Projected Year Screen

Figure 38. Allocation Scenario Summary – 2031 Projected Year Screen

6.3. Edit/Delete the Allocation Scenario Setup

To edit any of the values in the created allocation scenario, click the **Edit** button in the **Actions** column of the **Allocation Scenarios List** screen. The edit functionality goes through the same steps as **Create Allocation Scenario** displaying the values previously entered by the user. To delete the Allocation Scenario click **Delete** in the **Actions** column of the **Allocation Scenarios List** screen and confirm the deletion.

Copyright Acknowledgement

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