The AGIE methodology instructions

Introduction

Here we present a description of the AGIE methodology in the form of instructions, with the aims of helping to interpret the Plymouth analysis presented in the main report and enabling the methodology to be repeated for other areas. This will require familiarity with spreadsheets and GIS (geographic information system) software. We have used ArcGIS Pro and Microsoft Excel, and refer to tools, commands, formulae and so on for that software.

The AGIE score can be calculated for urban areas of England; results are presented at the LSOA (neighbourhood) scale within a larger administrative area, e.g. a Local Planning Authority or Unitary Authority. The score ranges from 0 to 100, with higher scores indicating greater priority, i.e. poorer green infrastructure equity, within the area of interest.

Before repeating the methodology for your own area, you should check that there is data coverage for your area of interest by using the map search facility on the Tree Equity Score website (Tree Equity Score data, a cornerstone of the AGIE score, has been produced for urban areas only).

AGIE is a composite indicator, meaning that the final score is made up of a number of separate components. There are nine component metrics covering green infrastructure provision and environmental and demographic priority factors (Table 2 in main report). The metrics are normalised and added together, unweighted, to create the final score for each LSOA.

The AGIE score is then used to place LSOAs into four equally sized categories, i.e. quartiles, from least need (low priority; lowest 25% of AGIE scores) to greatest need (highest priority; highest 25% of AGIE scores).

Below we describe how the nine metrics were extracted from the different datasets and used to calculate the final AGIE score.

Following the methodology will result in:

- An ArcGIS Pro project that includes layers with which you can visualise green infrastructure equity in your area of interest
- A workbook that contains all the calculations required to generate the AGIE score

We do not include:

- Detailed instructions for presenting the data using ArcGIS Pro.

Questions or comments on this methodology should be addressed to martha.crockatt@ouce.ox.ac.uk.

Conventions, abbreviations and acronyms

AGS: Accessible Greenspace; also referred to as Accessible Green Infrastructure, AGI
Area of interest: the area to which you are applying the methodology
GBI: Green and Blue Infrastructure
NE GI: Natural England Green Infrastructure
NT: National Trust
Sheet: a tab or sheet in an Excel workbook
Workbook: an Excel workbook
WT: Wildlife Trusts
X: your area of interest, e.g. a layer in ArcGIS Pro called 'Social Statistics_X' is the social statistics layer with data only for your area of interest

Your project: your ArcGIS Pro project

1. Downloading the data

Data sources are presented in the accompanying workbook Example AGIE score calcs.xlsx in the tab Data Sources. All data sources are publicly available at no cost.

1.1. Download the data described in the Data Sources tab. Note the instructions for filtering the boundaries data so that you download only those for your area of interest in the Notes column.

2. Setting up your calculation workbook

The example workbook includes the data for Plymouth City Council in its final format, i.e. this is how your workbook will look when you have completed the methodology. The workbook AGIE score template.xlsx contains the required tabs, example headings and formulae so that the AGIE score is automatically calculated when your data is pasted in. For transparency, we include brief descriptions of the formulae.

Note: We recommend using the example workbook in a downloaded rather than online version.

2.1. Create a copy of the AGIE score template.xlsx workbook, renamed to include the name of your area of interest.

When copy and pasting data into the AGIE score template check that you are pasting into the correct location; some tabs include example data in the first row below the headings. Cells with formulae have been protected to avoid accidental deletion; no password is required, but you cannot simply type into them. Should you need to edit these cells follow instructions in the READ ME tab of the AGIE score template workbook.

3. Boundaries

3.1. Download boundaries for local authority and LSOAs for your area of interest using the links and instructions in the Data Sources sheet of the template workbook. You may also download ward boundaries. These are not used within the following analysis, but can be helpful in communicating findings as they are more commonly understood / referred to than LSOAs. If you do not need to use wards in your analysis you can ignore all references to wards within this methodology.

We used 2021 boundaries to align with 2021 census data; we used full resolution boundaries clipped to the mean high-water mark[1]. Local authority and LSOA boundaries are used for data manipulation in ArcGIS Pro for some of the component metrics, and ward boundaries are used for visualising the AGIE score.

3.2. Upload these boundaries to a new ArcGIS Pro project (hereafter 'your project') and add them to a new group layer named 'Boundaries' in the Contents pane. Check that the boundaries are correct before continuing.

3.3. Create a reference list of LSOAs within your area of interest from the LSOA boundary layer in ArcGIS Pro by selecting all rows of the relevant attribute table and copy and pasting them into the LSOA_list tab of your workbook.

3.4. Only the columns LSOA21CD (unique code for each LSOA) and LSOA21NM (unique name for each LSOA) need be retained. Delete the other columns which have been pasted.

The columns for LSOA code, name (and ward, if using) are added to the AGIE calcs sheet as follows.

3.5. Copy and paste the LSOA21CD and LSOA21NM columns from the LSOA_list sheet into the first two columns of the AGIE calcs sheet.

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[1] Boundaries with different spatial resolutions are available to download (for source see the data sources sheet in Example AGIE score calcs.xlsx), e.g. full resolution boundaries that extend to the low or high water mark, or boundaries generalised to 20 or 200 m. An explanation of these datasets is available at: https://geoportal.statistics.gov.uk/

3.6. If you are using wards: Download the 'LSOA ward to lookup' CSV file. Filter by local authority district, column LAD25NM, to select the data for your area of interest.

3.6.1. Copy and paste these rows into the LSOA-Ward lookup sheet of the AGIE Calcs workbook.

3.6.2. Use the Vlookup formula in column C, Ward, to populate this column with the name of the ward in which each LSOA sits.

4. All green infrastructure

Natural England's GI dataset includes a layer of all green and blue infrastructure. Including this in your project / mapped outputs provides valuable context for consideration of accessible green infrastructure.

4.1. Add the dataset to your project:
Green_and_Blue_Infrastructure_NE_FileGDB\DSP_AWS_Published_Outputs_OGL \Modle 1 - GBI Assets Maps\Module1.gdb\All_GI_BI_OGL

4.2. Use the 'Select by Location' tool to select features in this layer that are within your area of interest, using the following parameters:

```
Input Features: Map1_OGL
Relationship: Within a distance
Selecting Features: the boundary layer for your area of interest
Search Distance: 50 m
```

Note: green infrastructure features that are outside the boundary are not included in analyses; the 'Within 50m' option is used to create a buffer so that when maps are presented it is clear that nearby GI has not been missed from mapping.

4.1. Create a new layer from the selected features entitled GBI_50m buffer; remove Map1_OGL from your project.

4.2. Create a New Group Layer in your project entitled Green Infrastructure. Add your newly created layer GBI_50m buffer to the group layer.

4.3. Optional: to quantify the total area of GBI within our area of interest we produced a second GBI layer clipped only to the Plymouth boundary (without the 50m buffer).

Generating the nine individual AGIE metrics

5. Metric 1: Accessible Greenspace (AGS) access

This metric is taken from Defra's partial-combined access scenario, Scenario 7, from their Accessible Greenspace Access dataset. It measures the percentage of households within each LSOA that meet Natural England's Neighbourhood AGS standard and either the Local or the Doorstep standard, i.e.:

> they have an AGS of at least 10 ha within a 15 min walk (1km; neighbourhood standard) and
>
> either an AGS of at least 2 ha within 300 m (5 min walk)
>
> or an AGS of at least 0.5 ha within 200 m (under 5 min walk).

This is measured using active travel distances from unique property references to AGS entry points, based on Natural England's Accessible Greenspace Standards size-proximity criteria.

5.1. Download the Access to green space in England spreadsheet from the Defra website; copy and paste all data from the Scenario 7 sheet into the Scenario7_AGS access sheet in your workbook.

Data are provided for each Output Area (a smaller geography nested within LSOAs), so need to be re-calculated at LSOA level.

5.2. Identify the rows for the LSOAs in your area of interest using the IF formula in column H and the reference list of LSOAs in the LSOA_list sheet.

Note: the Defra data uses LSOA codes (column B, LSOA21 in the Scenario7_AGS access sheet) rather than LSOA names).

5.3. Filter the table so that only data for your area of interest shows; copy and paste this data into the matching columns in the AGS access sheet.

5.4. Copy and Paste Special>Values the LSOA21 column into the LSOA21_calcs column; use the Remove Duplicates tool to leave a list of LSOAs within your area of interest.

The count of total households per OA and the count of households per OA which

meet Scenario 7 are summed for each LSOA in columns J and K, adjacent to your list of LSOAs; these figures are used to calculate the percentage of households per LSOA which meet Scenario 7.

5.5. In the AGIE calcs sheet use the Vlookup formula to populate AGS access, column E, with your calculation of percentage of LSOA with access to AGS in the previous step.

Note: We recommend deleting the data from your Scenario 7 AGS access sheet once you have got to this stage, due to the size of the dataset.

6. Metric 2: AGS provision: amount of AGS in m^2 per person per LSOA

6.1. Create layers showing accessible green infrastructure for your area of interest

6.1.1. Add the accessible green infrastructure data from the Natural England Green Infrastructure database to your ArcGIS project:

Green_and_Blue_Infrastructure_NE_FileGDB\DSP_AWS_Published_Outputs_OGL\Module 1 - GBI Assets Maps\Module1.gdb\Accessible_GI_OGL

This dataset does not include sites with permissive access, so is merged with the NE GI permissive access land layers to provide a more accurate picture of greenspace provision, if there are permissive access sites within your area of interest. These layers include only Wildlife Trust (WT) sites and National Trust (NT) sites that are always open; there may be other permissive access sites in your area owned by other entities that are not included in these layers.

6.1.2. Add the following data sets to your ArcGIS project:

Green_and_Blue_Infrastructure_NE_FileGDB\DSP_AWS_Published_Outputs_OGL\Module 1 - GBI Assets Maps\Module1.gdb\Land_Permissive_Access_NT_OGL AND Land_Permissive_Access_WT_OGL

6.1.3. Visually check if there are National Trust or Wildlife Trust sites within your area of interest by toggling on and off the layers.

If National Trust and/or Wildlife Trust sites appear in your area of interest, they will be merged into one layer in the following steps with the Accessible GI layer.

If no National Trust or Wildlife Trust sites are present in your project area, you can remove these layers from your project at this point.

6.1.4. Use the 'Select by Location' tool to select features in the Accessible GI (and WT and/or NT layers if they have sites in your area) that are within your area of interest, using the following parameters:

```
Input Features: Map3_Accessible_GI (and WT and / or NT layers)
Relationship: Within a distance
Selecting Features: the boundary layer for your area of interest
Distance: 50 m
```

Note: Green infrastructure features and parts of features that are outside the boundary are not included in analyses; the 'Within 50m' option is used to create a buffer so that when maps are presented it is clear that nearby GI has not been missed from mapping.

6.1.5. Create a new layer from the selected features, and remove the layer Map3_Accessible GI (and WT and / or NT layers) from your project.

Note: if there is no NT or WT trust in your area of interest you will have just one layer. If you have WT or NT land there will be a separate layer for each of these datasets, i.e. you will up to three layers in total, if there is both NT and WT in your area of interest.

If there are National Trust and / or Wildlife Trust sites in your area:

6.1.6. Use the 'Merge' tool in the Geoprocessing toolbox to merge the Accessible GI, NT and / or WT layers using the following parameters:

```
Input Datasets: Accessible GI, NT and / or WT layers
Output Dataset: automatically generated, or your own name, e.g.
'Acc and Perm GI'
Field Matching Mode: Automatically generate fields consolidated
from all inputs
```

The new, merged layer includes all accessible GI within your area of interest.

Note: We recommend keeping the WT and / or NT layers for your area of interest within the project, for future reference.

6.1.Obtain the area of Accessible Greenspace for each LSOA

The area of AGS per LSOA is presented in the Social Statistics dataset. If there is permissive access land in your area of interest, i.e. if you have merged NT and / or WT land with your Accessible GI layer in previous steps, then you will calculate the area of permissive access land per LSOA and add this to the area of AGS from in the Social Statistics dataset.

6.2.1. AGS in m^2 per LSOA is taken directly from NE GI's social statistics dataset; add it to your project:
Green_and_Blue_Infrastructure_NE_FileGDB\DSP_AWS_Published_Outputs_OGL\Module 22 - Social Statistics\Module22.gdb\Module22_AGI_Statistics_LSOA_OGL

6.2.2. Select LSOAs within your area of interest using the 'Select By Attribute' tool with the following parameters:

```
Input Rows: Module22_AGI_Statistics_LSOA_OGL
Selection Type: New selection
Expression: Where:LAD22NM contains the text: X [the name of your area of interest]
```

Make a new layer from the selected features entitled Social Statistics. Remove Module22_AGI_Statistics_LSOA_OGL from your project.

Note: the above parameters assume you are working with a Local Authority District (LAD22NM). If you are working at another scale, then use an appropriate alternative selection method.

6.2.3. Copy and paste the attribute table for Social Statistics into the Social Statistics sheet of your workbook.

Note: There is a row numbering the headings starting in the column LSOA21NM; this numbering is used to promote easier formula writing at later stages.

6.2.4. Copy and paste column LSOA21NM from your LSOA_list sheet into the sheet entitled AGS provision. Populate the column AGS_soc stats from the TotalAGI_Area column in your Social Statistics sheet using the Vlookup formula provided.

<u>If there are NT or WT sites within your area of interest:</u>

6.2.5. Calculate the area of permissive access land per LSOA. To do this, use the 'Summarize Within' tool in the Analysis toolbox in ArcGIS Pro with the following parameters:

```
Input Polygons: LSOA boundary layer
Input Summary Features: NT or WT layer
Output Feature Class: automated, or add own name
Keep all input polygons: tick this box
Summary Fields: Field: ShapeArea
Statistic: Sum
Unit: Square meters
```

Repeat for the other NT or WT layers, as required so that you have a SummarizeWithin layer(s) for NT and / or WT land in your area of interest.

Note: The authors have several times had the same error with the summarize within tool: 'Error 100014: Summarize Within failed'. This can be due to the length of file names, as described here: https://support.esri.com/en-us/knowledge-base/error-100014-summarize-within-failed-000027089

6.2.6. Copy and paste the attribute table of the Summarized Within layer(s) into the respective data columns of the same sheet. Retain the columns LSOA21CD, LSOA21NM and Summarized Area in SQUAREMETERS, deleting all other columns of the attribute table you have just pasted in.

Repeat / rename for the other WT/NT dataset if applicable.

6.2.7. In the column NT land_m2, use the Vlookup formula to populate the column from the National Trust attribute table you have pasted into the sheet (Repeat for WT land if required).

6.2.8. In the column AGS total use the formula to add together the NT land, WT land and AGS_soc stats areas to give a total area of AGS per LSOA.

6.3. Calculate the m^2 of AGS per person for each LSOA

6.3.1. In the column population_2021 use the Vlookup formula to populate this column with data from the column Population_2021 in the Social Statistics sheet.

6.3.2. Populate the column AGS_m2 per person by using the formula to divide the AGS_total column by the population_2021 column.

6.3.3. In the AGIE calcs sheet, populate the column AGS provision_m2 per person from the AGS provision sheet using the Vlookup formula.

Note: When calculating the AGIE score for Plymouth, it was found that outliers were skewing the normalised data for this metric (see section 10: Calculating the AGIE score). The median was 7.2 m^2 AGS per person, and maximum 652 AGS m^2 per person, 90 times the median value. The 10 LSOAs that had >100 m^2 AGS per person were therefore rounded down to 100, this being an understandable and approachable method suitable for use in a composite indicator (OECD, 2005). When data are normalised, we advise checking for outliers and considering removing outliers that are skewing the normalised data and thus the final AGIE Score.

7. Metric 3: Manmade surfaces: percentage of LSOA

7.1. This metric is derived from the Greenness Grid in the NE GI dataset. Import the dataset into ArcGIS Pro:
Green_and_Blue_Infrastructure_NE_FileGDB\DSP_AWS_Published_Outputs_OGL\Module 1 - GBI Assets Maps\Module1.gdb\Greeness_Grid_OGL

7.2. Perform a Pairwise clip in ArcGIS Pro to clip the data to your area of interest using the following parameters:

```
Input Features: Green_Grid_OGL
Clip Features: the boundary of your area of interest
Output Feature Class: Greeness_Grid
```

Remove Greenness_Grid_OGL from your project.

Data are presented as the percentage of manmade surfaces per 250 m grid square, so need to be converted to percentage manmade surface per LSOA.

7.3. Use the Pairwise Intersect tool to create a layer that cuts up the greenness grid by LSOA boundaries, with the following parameters:

```
Input Features: Greenness_Grid and your LSOA layer
Output Feature Class: use automated name
Join Attributes: All attributes
Output Type: Same as input
```

7.4. Copy and paste the attribute table from the pairwise intersect layer into the Manmade Surfaces sheet in your workbook. Retain the columns Percentage Manmade (D), LSOA21CD (G), LSOA21NM (H) and Shape_Area (N).

Note: Be aware that the column Shape_Are (J) gives the area for each LSOA; column N, Shape_Area is the column that should be retained – this provides the area for each polygon that has been created in the pairwise intersect above. Note that the column headings in AGIE score_template.xlsx are those retained after deleting unnecessary columns as described above. Be cautious when deleting columns that you do not also delete the formulae in the spreadsheet.

7.5. In the column Area of manmade surface, use the formula to multiply Shape_Area by Percentage Manmade to provide you with the area of manmade surface per polygon.

7.6. Calculate the summed area of manmade surface per LSOA as follows: copy the list of LSOAs from your sheet LSOA_list and paste into the Manmade surfaces sheet in the

Data for each LSOA columns. In the column LSOA area use the Vlookup formulae to obtain this value from the Shape Area column in the Social Statistics sheet.

7.7. In the column LSOA manmade surface area use the Sumif formula to calculate the total area of manmade surfaces per LSOA from the output of the Pairwise Intersect operation.

7.8. In the column Manmade surface (%) use the formula to divide the LSOA manmade surface area by LSOA area to give the percentage of the LSOA that is manmade surfaces. In the AGIE calcs sheet, populate the column manmade surface from the Manmade surface (%) column in the Manmade surfaces sheet using the Vlookup formula.

8. Metrics 4: Tree canopy cover; 5: Heat disparity; 6: Air pollution; 8: Age dependency ratio and 9: Minoritized ethnicity

These metrics are all taken directly from the Tree Equity Score dataset, which will be added to your project for visualisation and to your Excel workbook for calculating the AGIE score.

8.1. Add the TES shape file to your project: england_tes.shp. Use the Select by attribute tool to select LSOAs in your area of interest using the following parameters:

```
Input Rows: england_tes
Selection Type: New selection
Expression: Where: la_name is equal to: X [the name of your area
of interest]
```

7.3. Make a new layer from the selected features entitled tes and add it to the Green infrastructure group. Remove england_tes from your project.

Note: The above parameters assume you are working with a Local Authority District (la_name). If you are working at another scale, then use an appropriate alternative selection method.

7.4. Select all rows in the attribute table for the tes layer and copy and paste this into the TES sheet in your workbook.

Note: TES uses different terminology for LSOAs: bge_code equates to LSOA21CD; see data_dictionary.txt which is downloaded with the TES data.

7.5. In the AGIE calcs sheet, use the Vlookup formula to populate the column canopy cover with the percentage canopy cover per LSOA from column treecanopy in the TES sheet.

7.6. Repeat step 7.3 for Heat disparity, Air pollution, Age dependency ratio and Minoritized ethnicity in the AGIE calcs sheet using Table 1 to identify the appropriate columns in the TES sheet.

Table 1 Metrics from TES dataset

Metric name	TES column heading	TES column number
Canopy cover	treecanopy	11
Heat disparity	temp_diff	23
Air pollution	apb_index	27
Age dependency ratio	dep_ratio	28
Ethnicity	pctmineth	33

9. Metric 7: Index of Multiple Deprivation: LSOA rank and decile

IMD rank is used to calculate the AGIE score; the IMD decile is included for reference. Both are taken from the English Indices of Deprivation 2025 dataset (IMD 2025 data).

9.1. In the IMD 2025 spreadsheet filter the data to your area of interest using the local authority column and copy and paste the data the IMD sheet in your workbook.

9.2. In the AGIE calcs sheet use the Vlookup formulae to populate columns L and M, IMD decile and IMD rank from the IMD sheet, using the formulae in those columns.

10. Calculating the AGIE score

Data for individual metrics are now all in the AGIE calcs sheet, ready for calculating the AGIE score following the methodology for calculating the Tree Equity Score priority index.

10.1. The nine component metrics, N_i, were normalised as follows, where for each metric, N_i:

x_i is the value for that LSOA for that metric, i

$x_{i,max}$ is the maximum value for that metric across the area of interest, i

$x_{i,min}$ is the minimum value for that metric across the area of interest, i

$N_i = (x_i - x_{i,min}) / (x_{i,max} - x_{i,min})$

Formulae for this are presented in columns P:X in the AGIE calcs sheet.

Note: So that higher numbers always indicate greater need, some of the normalised metrics are inverted by subtracting them from one. For example, a higher percentage of canopy cover indicates less need, so this metric was inverted; in contrast, percentage of manmade surfaces was not normalised as higher values for this metric indicate greater need for green infrastructure equity. AGS access, AGS provision, tree canopy cover and IMD rank are inverted; % manmade surfaces, air pollution index, heat disparity and age dependency ratio should not be inverted.

For example, tree canopy cover ranged from a minimum of 4% in the lowest LSOA to a maximum of 48% in the leafiest LSOA. So, for an LSOA with 11% cover, the normalised indicator was (11 – 4)/(48 – 4) = 7/44 = 0.16, and the inverted score is 0.84, indicating a high priority for increasing tree cover.

10.2. The metrics were then combined to create the AGIE score from 0.1 to 1, where 1 indicates greater priority. The AGIE score, A, is calculated as follows, where N_i refers to each indicator value:

$$A = 0.1 + (1 - 0.1) * (N_1 + N_2 + N_3 + N_4 + N_5 + N_6 + N_7 + N_8 + N_9) / 9$$

The calculations for this are in column Y, AGIE score, of the AGIE calcs sheet.

11. AGIE score categorisation

11.1. AGIE scores were used to place each LSOA in one of four equally sized categories, i.e. quartiles: low (25% of LSOAs with lowest AGIE scores), moderate, high and highest priority (25% of LSOAs with the highest AGIE scores). Formulae for this are in columns Z Priority category and AA Quartile values of the AGIE calcs sheet.

12. Data visualisation

12.1. ArcGIS Pro was used to create maps showing the distribution of green and blue infrastructure and accessible greenspace, scores for each of the nine metrics by LSOA, AGIE score and priority categories. Ward boundaries were overlaid to enable the findings to be described and discussed in policy- and practise-relevant geographies.

12.2. The area, (ward, if using) and LSOA boundaries are already in your map (section 3. Boundaries), as are those for (all) green and blue infrastructure (section 4. All green infrastructure) and accessible greenspace (section 5. Metric one: accessible greenspace (AGS) access).

12.3. The nine metrics are visualised by importing the results of your AGIE calculations into your ArcGIS project as a standalone table and joining it to a copy of your LSOA layer. Nine copies are made, one for each metric, each being named and symbology set for one of the metrics.

12.3.1. Copy the entire contents of the AGIE calcs tab to a new workbook. Save it as AGIE_visualisation.csv.

12.3.2. Add AGIE_visualisation.csv; it will appear as a standalone table.

12.3.3. Create a copy of your LSOA layer and name it AGS access.

12.3.4. Use the Add Join tool to link this new layer with your AGIE_visualisation table using the following parameters:

```
Input Table: AGS access
Input Field: LSOA21CD
Join Table: AGIE_visualisation
Join Field: LSOA21CD
Keep all input records: tick this box
```

Validate the join and then run it.

11.3.5. Repeat for all nine metrics. Set the symbology for each layer using the relevant field of the table, e.g. using the following parameters for AGS access:

```
Graduated colours
Field: AGS access
Normalization: <None>
Method: Manual interval
Classes: 10
Color scheme: as preferred.
```

You should now have all of the layers required to visualise the AGIE score and component metrics.

Congratulations on reaching the end of the AGIE methodology!

We know it's long, but hope it is useful.

We welcome questions and comments, which should be addressed to martha.crockatt@ouce.ox.ac.uk