BETER: A GIS Tool for Modeling Tranquillity User Guide

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About BETER:

BETER is comprised of two programs: Assembler and MapMaker. Assembler prepares GIS layers for mapping. MapMaker allows you to weight these layers and produce tranquillity maps. BETER was developed to run on ArcGIS version 10.3 or later, with Python 2.7. Future releases will run on other GIS software platforms.

I. BETER Components

Inputs.gdb: ArcGIS Geodatabase used to store GIS files gathered by the end user as input to BETER. These GIS files include vector, raster and tabular data.

Assembler: Runs individual GIS processes (Modules) that produce output layers related to tranquillity Topics.

MapMaker: Combines output layers from Assembler, using weights from the User Weights table to produce a final tranquillity map.

FinalOutputs.gdb: ArcGIS Geodatabase used to store outputs from Assembler, which serve as inputs to MapMaker. Also used to store MapResults produced by MapMaker.

BETER.ini: a text file containing simple parameters: location of BETER program; map resolution; and preference for user feedback. These are required before running Assembler.

User Weights: Excel worksheet in which the user enters or modifies existing weights for each tranquility topic. Topics with weights of zero have no impact on final tranquility scores.

MapResult: Tranquillity map produced by MapMaker and saved as raster file to FinalOutputs.gdb.

BETER requires three steps:

1. Gathering Data
2. Running Assembler
3. Running MapMaker

Please read Sections II, III and IV to become more familiar with each of these important steps. Once complete, please read 'Section V. How to Run BETER: A Step-by-Step Guide' to start using the program.

**BETER Topics emerged from the initial 'Broadly Engaging with Tranquility' Project led by Denise Hewlett, PhD, and the University of Winchester in 2013-2015 in collaboration with Dorset County Council, the team of the Dorset AONB and funded through the Economic and Social Science Research Council. The Topics were identified through an extensive and deliberative public process involving four user groups: Visitors, Residents, Institutions and Managing Agencies, and Households. See Hewlett et al. 2017 for more information. For data see: http://reshare.ukdataservice.ac.uk/851934/*

II Gathering Data

Data for BETER must be gathered from several sources and entered in inputs.gdb. Most data can be downloaded from Edina/Digimap, Ordnance Survey, Open Data UK, Forestry Commission, and Historic England. The remaining data must be gathered from local authorities and other sources. See Tables 1 and 2 '**List of BETER Inputs**' at the end of this document for more information.

List of BETER Inputs provides guidance on where to locate data, how to prepare data, and how to name files prior to importing them to inputs.gdb. File names in inputs.gdb *must match exactly* those names in the **List of BETER Inputs** (see Table 1 and Figure 1)

Some BETER Inputs require preparation in GIS, such as selecting features, converting between data types, and merging discrete files. Nearly all layers require clipping to a Study Area. As such, you must provide a polygon feature class representing your study area (StudyArea), as well as a buffered version of the study area (StudyAreaBuff). Buffering your study area to include outside areas ensures tranquility within your area of interest will depend on surrounding areas as well. The width of your buffer is dependent on your needs, and the characteristics of surrounding areas. **We recommend a Study Area buffer of at least 3km and no more than 10km.**

IIb. Gathering DSM and DTM files

Digital Surface Models and Digital Terrain Models are of critical importance to BETER. BETER's Assembler is designed to create a single mosaic file of both the DSM and DTM, using the tiled .asc files downloaded from Ordnance Survey. The end user places these .asc files into the respective folders 'DSMDownloads' and 'DTMDownloads,' which are provided with BETER. Assembler will find the files in these folders, regardless of how they are named or organized.

Please Note: If you already have a mosaic of either a DSM or DTM for your study area, at the desired resolution or finer, you do not need to download new files, or place anything in the DSMDownloads or DTMDownloads folders. Instead, simply name a copy of your existing mosaic files 'dsm' and 'dtm', and include these in outputsM.gdb and FinalOutputs.gdb. Assembler will then skip the process of creating them. If you provide your own mosaic, you will need to resample it to your desired resolution (the same resolution as defaultresolution in BETER.ini)

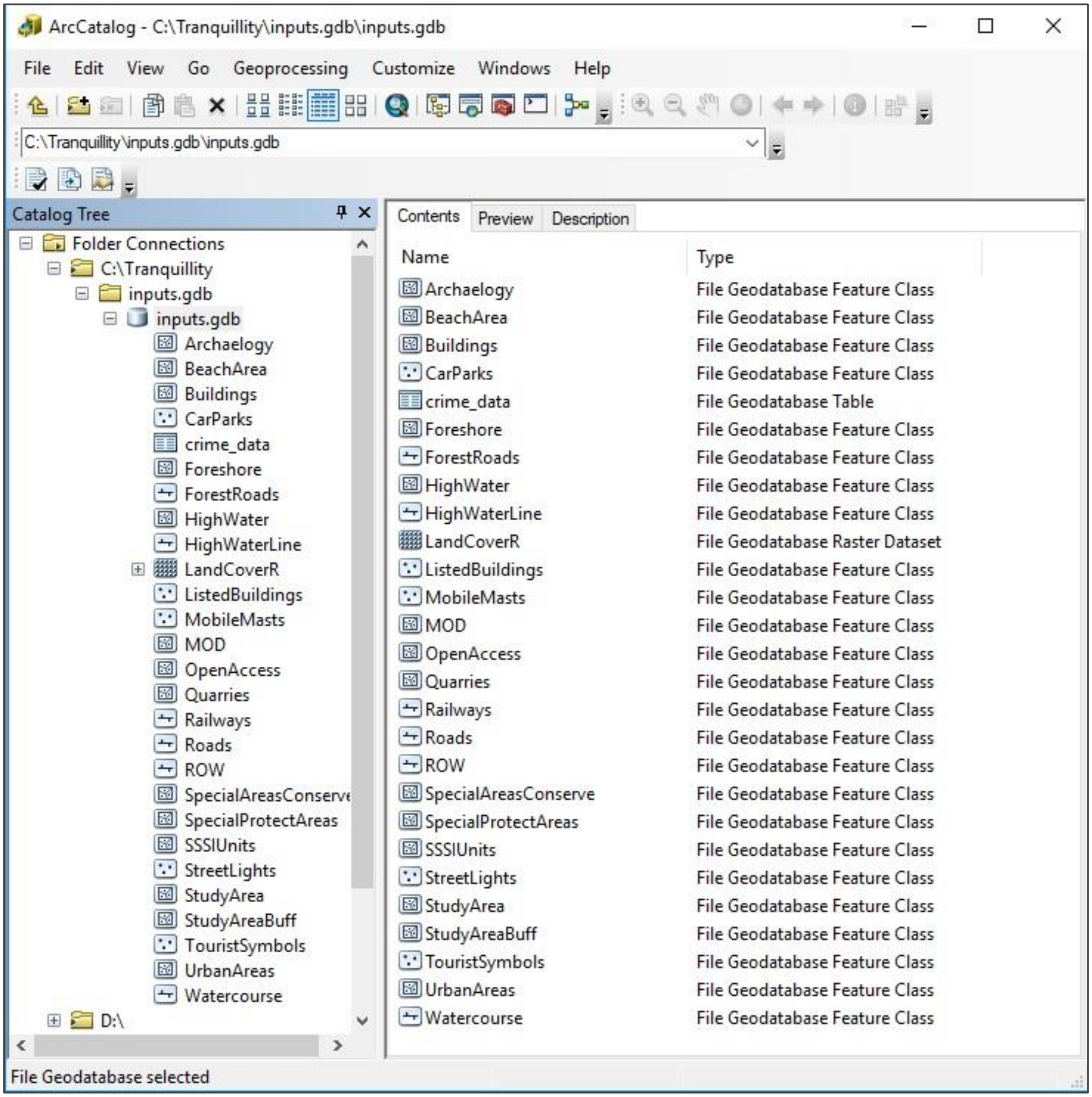


Figure 1. *A populated inputs.gdb*

III. Assembler

What Assembler Does
Assembler takes existing GIS layers and runs them through a variety of geoprocesses to create new layers. The existing GIS layers are stored in inputs.gdb and the new layers are saved in FinalOutputs.gdb. The new layers are used by MapMaker to produce tranquillity maps.

Assembler has three modes:
0 Assembler -- runs Assembler, or re-runs Assembler after a partially completed run.
1 CleanStart – deletes all GIS layers from the FinalOutputs.gdb, and runs Assembler from scratch.
2 WhereAmI – lists the BETER.ini variables and indicates the location of all inputs and outputs.

Assembler Run Time
Assembler run time is based on a number of factors: the extent of StudyAreaBuff, your selected Resolution, the density of settlement (roads, buildings, etc.), as well as the processing capacity of your computer. The authors were able to run Assembler on a Dell Tower 1450 workstation in less than 2 hours for an area of approximately 1500 square miles. Less powerful computers could take considerably longer.

Assembler Outputs
All outputs produced by Assembler, including GIS layers and AssemblerTable, are written to FinalOutputs.gdb. The user can view these interim layers in ArcGIS to better understand how each contributes to a subsequent tranquility map. Assemblertable lists for every topic the name of the corresponding GIS layer and its status. Any layers with status “skipped” have not yet run to completion without errors.

Console and Text File Feedback
Assembler can be run in ‘testmode,’ which will provide feedback about each step in the program. Assembler can also save this feedback to a text file using the ‘saveconsole’ setting.

Error Handling
Assembler will continue to completion, even if it encounters errors. Feedback messages will describe what errors were encountered, and what output layers were *not* created as a result. If you encounter errors, you will need to resolve these and re-run Assembler.

Re-running Assembler
Assembler can be re-run as many times as necessary until all layers have been processed without errors. It will automatically skip those topics for which a result was successfully created in a previous run, saving considerable processing time.

Clean Start
Running CleanStart will delete all layers from FinalOutputs.gdb and start the Assembler process from the very beginning. The user will generally want to re-run Assembler as errors are encountered, rather than go back and start from scratch, but we provide this as an option.

IV. MapMaker

What MapMaker Does

MapMaker takes the outputs of Assembler and combines these using weights provided by the end user, to produce a final tranquility map. The inputs to MapMaker are stored in UserWeights.csv and FinalOutputs.gdb. The outputs of MapMaker are a raster map (Figure 2), and a results table containing the layer weights; these outputs are stored in FinalOutputs.gdb.

MapMaker Run Time

MapMaker is designed for non-technical users, and takes only a few minutes to produce results.

MapMaker Outputs

MapMaker produces two outputs: MapResult, a raster map of tranquility, and ResultsTable, which documents the layers and weights that contribute to a MapResult. Both files are written to FinalOutputs.gdb, with a unique Date/Time stamp as part of the file name (e.g. mapresult_MMDD_HHMM and maptable_MMDD_HHMM).

User Weights Table

The User Weights table contains three columns of information (Figure 3). In the first column are BETER Topics, the variables that impact tranquility. The second column indicates if the Topic has a negative or positive impact on tranquility. Negative Topics reduce tranquility, while Positive Topics increase tranquility. The third column contains a weight value for each Topic.
There are also worksheets containing weights for user groups from the original BET project**.

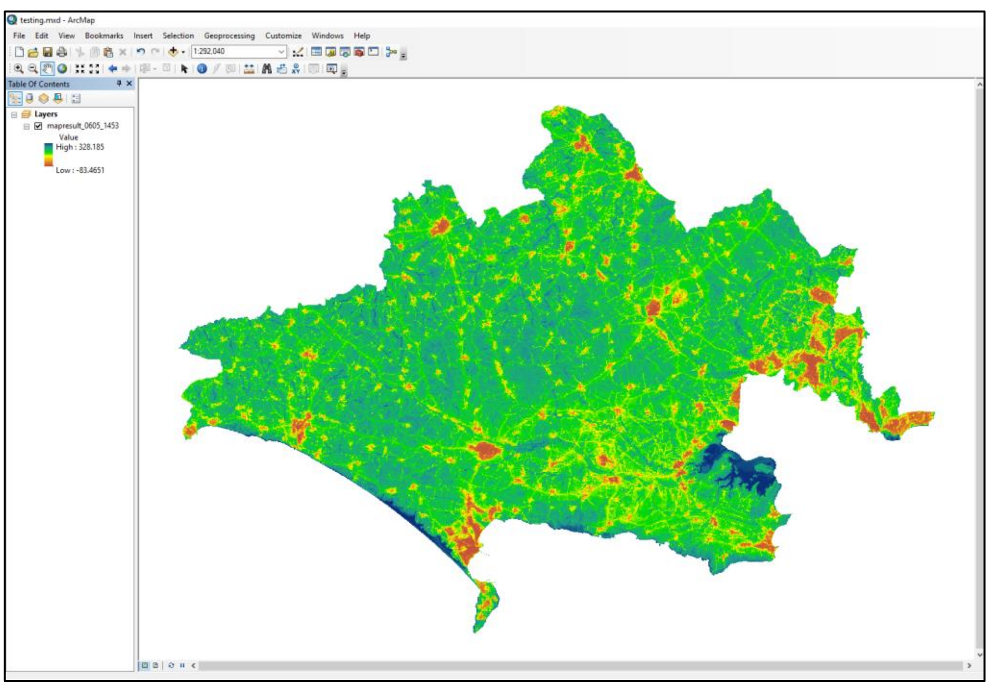
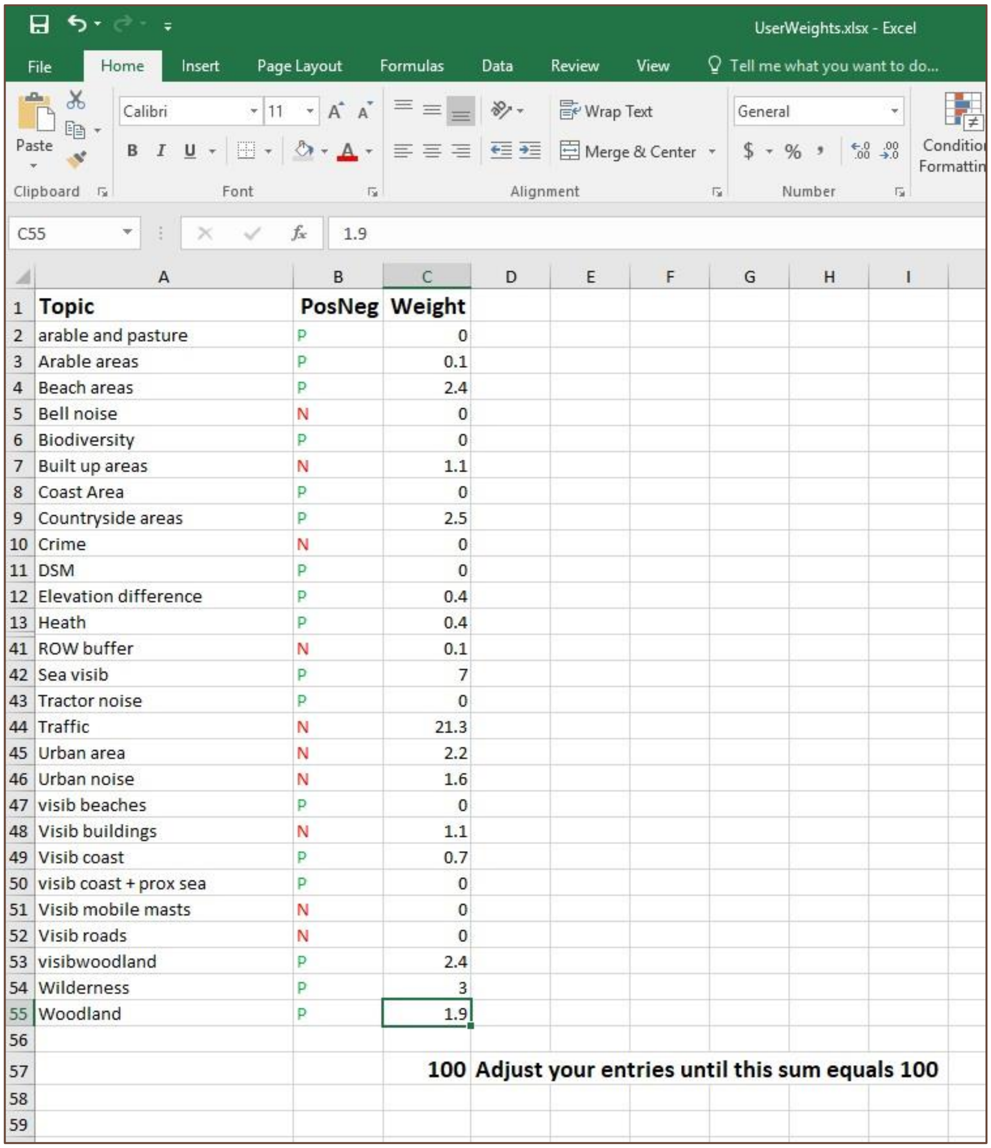


Figure 2. *An example mapresult (final tranquility map).*



	Topic	PosNeg	Weight	
2	arable and pasture	P	0	
3	Arable areas	P	0.1	
4	Beach areas	P	2.4	
5	Bell noise	N	0	
6	Biodiversity	P	0	
7	Built up areas	N	1.1	
8	Coast Area	P	0	
9	Countryside areas	P	2.5	
10	Crime	N	0	
11	DSM	P	0	
12	Elevation difference	P	0.4	
13	Heath	P	0.4	
41	ROW buffer	N	0.1	
42	Sea visib	P	7	
43	Tractor noise	P	0	
44	Traffic	N	21.3	
45	Urban area	N	2.2	
46	Urban noise	N	1.6	
47	visib beaches	P	0	
48	Visib buildings	N	1.1	
49	Visib coast	P	0.7	
50	visib coast + prox sea	P	0	
51	Visib mobile masts	N	0	
52	Visib roads	N	0	
53	visibwoodland	P	2.4	
54	Wilderness	P	3	
55	Woodland	P	1.9	
56				
57			100	Adjust your entries until this sum equals 100
58				
59				

Figure 3. *User Weights Table (note that rows 14-40 are hidden in this figure)*

*** The User Weights table defaults to an identical weight of 1.887 for each topic. The Excel file also includes four worksheets of weights used in the original Broadly Engaging with Tranquility Project. These weights were informed through extensive consultations that resulted in >15,000 views being collated from and weighted by more than 1,000 people representing community groups, householders, management agencies and authorities in the Purbeck region of Dorset County. These weights are specific to that project, however, they have derived from a robust and valid research study that adopted best practice in public consultations, and on comparing these results with those of other studies conducted, the topics raised and the weightings generated by the public are highly comparable. They therefore provide a useful starting point for any user weighting exercise.*

V. How to Run BETER: A Step-by-Step Guide

1. Ensure that you have the required software installed: ArcGIS version 10.3 or later, with Python 2.7.
2. Download BETER.zip from the web and copy the file to a directory on your computer.
3. Right-click to extract the zipped file to an empty folder on your computer. Your folder contents should resemble **Figure 4** below:

Please note that the DSM and DTMDownloads folders, as well as the .gdb folders are empty. *This is by design*. As you work through the following steps, these will be populated with data.

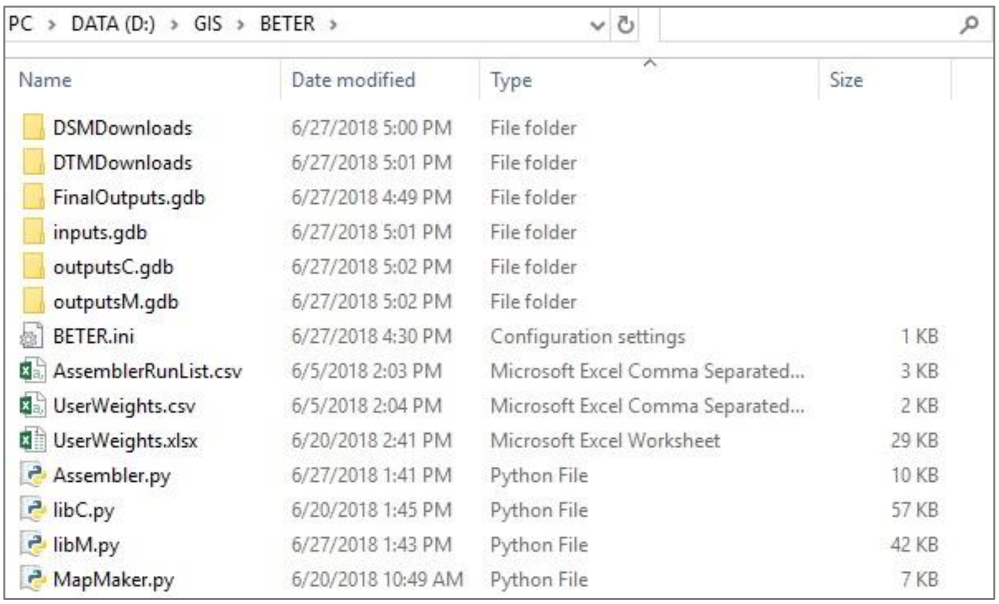


Figure 4. *Folder contents of BETER.zip*

4. Populate your Inputs Geodatabase (inputs.gdb) with data for your study area. See Section II ‘Gathering Data’ above.
5. Populate the DSMDownloads and DTMDownloads folders with .asc files for your study area.
   OR
   Provide a complete DSM and/or DTM mosaic and import these to outputsM.gdb and FinalOutputs.gdb. If you provide your own mosaic, you will need to resample it to your desired resolution (the same resolution as defaultresolution in BETER.ini)
6. Right-click on BETER.ini and choose ‘Edit’ to open in a text editor (Figure 5).

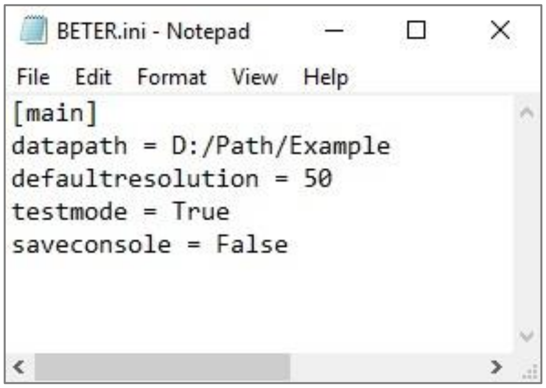


Figure 5. Contents of BETER.ini

datapath – File path to the folder where you extracted BETER.zip
defaultresolution – The desired resolution, in meters, of the final tranquillity map
testmode – when True, will provide feedback to the screen as the program runs.
saveconsole – when True, will produce a file named AssemblerOut.txt in the data path directory. This file will contain the same content as testmode output, including error messages.

7. Change the datapath in BETER.ini to match the location where you installed BETER on your computer. For example, your folder path might look something like: C:/GIS/BETER
8. Change defaultresolution to your desired resolution in meters. We recommend a resolution no smaller than 50 meters, as it directly impacts Assembler run time. Your chosen resolution should not be smaller than that of the DSM and DTM files. *Read more about the impacts of changing resolution in Section VI Additional Considerations.*
9. Define testmode and saveconsole as either True or False
10. Save and Close BETER.ini
11. Double-click Assembler.py and choose 1 to run CleanStart, and close when complete.
12. Double-click Assembler.py and choose 0 to run Assembler.
13. Monitor feedback on-screen or in AssemblerOut.txt to see if any errors were produced. Make any necessary changes to inputs.gdb or your DSM and DTM folders. Common errors include missing input layers, misspellings of input layers, or a misnamed datapath. Other errors are described in *Section VI. Additional Considerations* below.
14. Once errors are resolved, re-run Assembler.
15. Repeat these steps until Assembler successfully completes all modules.
16. Open UserWeights.xlsx and enter new, or modify existing, weight values in the third column, making sure that the values sum to 100. Not every Topic requires a weight. By entering zero or no value, you are indicating this Topic variable will not participate in this run of MapMaker.
17. Save UserWeights.xlsx as UserWeights.csv
18. Double-click MapMaker.py and follow the on-screen prompts.
19. Once MapMaker completes, open ArcMap and view your mapresult.

VI Additional Considerations:

Assembler

Modifying Assembler (Advanced GIS users only)

Assembler runs a series of Python modules. These were written as discrete tasks that can be edited by a user with sufficient ArcGIS and Python experience. Note that any changes to the Python code could cause a module to fail during processing, and thus produce no results, or erroneous results. A copy of the original module should always be saved before making any modifications.

CUDA and SHELL Errors

ArcGIS can produce CUDA errors if the resolution of BETER is defined at too small a number. CUDA errors relate to the computational requirements of Viewshed2, a tool relied on for much of BETER output. To resolve CUDA errors, try changing the **defaultresolution** variable in BETER.ini to a larger number. Occasionally, Assembler will produce a SHELL error, and provide no error messages. This is usually due to a CUDA error. Again, changing the **defaultresolution** variable to a larger number is the best solution.

Changing Resolution

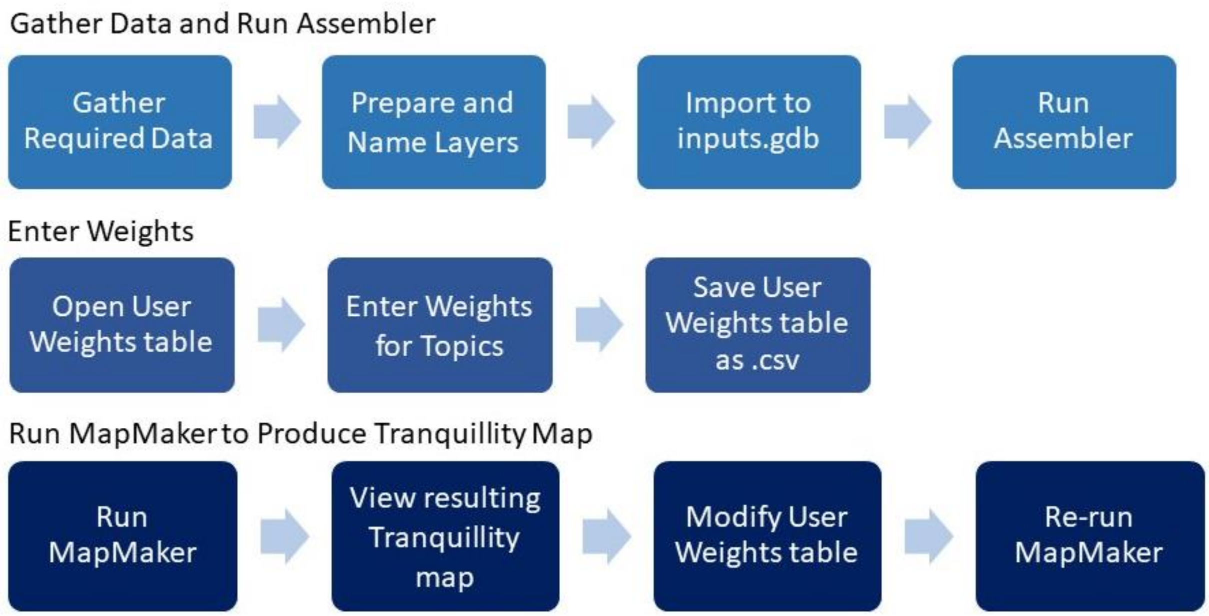
If you decide to re-run Assembler at a different resolution, don't run a Clean Start. Modify the resolution in BETER.ini, and *delete the existing dsm and dtm from FinalOutputs.gdb*. Next, run Assembler. It will look at previous DSM and DTM intermediate results, and resample these to the new resolution, saving considerable processing time. Note, however, that if you provided your own DSM and DTM layers, you will have to resample them yourself and replace the ones you provided with the new ones.

MapMaker

Tips for Setting Weights

Start with an initial set of Topics and run MapMaker to produce an initial tranquillity map. Modify weights in the User Weights table for subsequent runs, to produce new tranquillity maps. Exclude topics by changing weights to zero, and include topics by changing zero weights to a positive value.

VII. Flowchart of BETER Model



VIII BETER Project Team

Denise Hewlett is Senior Fellow in the Faculty of Business, Law & Sport, University of Winchester, UK. Her professional experience is reflected equally in her research and includes leading on the development and implementation of planning policies designed to enhance decisions taken in rural protected areas and coastal destinations through public engagement. Denise is a member of IUCN-WCPA, Trustee for National Association AONBs and a Fellow of Royal Geographical Society. Denise is Principal Investigator for Broadly Engaging with Tranquillity (Dorset) Project.

Ainara Terradillo [bio sketch TBA]

Christopher Brehme is an Associate Professor of Geography at Keene State College, New Hampshire, USA. His research interests are in Geographic Information Science, specifically on the application of GIS to resolve natural resource conflicts, protect the environment, and promote health and well-being.

John C. Woodward is a GIS Research Assistant at Keene State College. He recently completed the Keene State GIS Certificate Program, and works on a variety of GIS projects for the College. His skills are in GIS programming and analysis, with application to environmental projects.

Table 1. List of BETER Inputs

	LAYERS REQUIRED	FORMAT	BETER FILE NAME	INSTRUCTIONS
1	Digital Surface Model (LiDAR)	Raster/asc	DSM	Place .asc files/folders in DSMDownloads Folder
2	Digital Terrain Model (OS Terrain)	Raster/asc	DTM	Place .asc files/folders in DTMDownloads Folder
3	Study Area (e.g. county boundary)	Shapefile	StudyArea StudyAreaBuff	Obtain from OS Boundary-Line Buffer desired distance to create StudyAreaBuff
4	Coastline	Shapefile	HighWater HighWaterLine	high_water.shp from OS Boundary-Line, convert to poly, Clip to StudyAreaBuff, name HighWater. Clip high_water.shp to StudyAreaBuff, name HighWaterLine
5	Foreshore	Shapefile	Foreshore	Part of OS VectorMap District, Clip to StudyAreaBuff
6	Buildings	Shapefile	Buildings	Merge 100km tiles (if necessary), then Clip to StudyAreaBuff
7	GB Land Cover Map 2015	Raster	LandCoverR	Extract to StudyArea
8	TopographicArea	Feature Class	BeachArea	Select 'Sand' and 'Foreshore' from [Descriptive Term], Clip to StudyAreaBuff
9	Roads	Shapefile	Roads	Select ConnectingLinks, Merge (if necessary) then Clip to StudyAreaBuff
10	Railway lines	Shapefile	Railways	In Vector Data/Strategi, Clip to StudyAreaBuff
11	Urban Areas	Shapefile	UrbanAreas	In Vector Data/Strategi, Clip to StudyAreaBuff
12	Tourist Symbol	Shapefile	TouristSymbols	Clip to StudyAreaBuff
13	WatercourseLink	Shapefile	Watercourse	Clip Watercourse_Link to StudyAreaBuff
14	Sites of Special Scientific Interest Units	Shapefile	SSSIUnits	Clip to StudyAreaBuff
15	Special Protection Areas (England)	Shapefile	SpecialProtectAreas	Clip to StudyAreaBuff
16	Special Areas of Conservation (England)	Shapefile	SpecialAreasConserve	Clip to StudyAreaBuff
17	National Forest Estate Roads	Shapefile	ForestRoads	Clip to StudyAreaBuff
18	Scheduled Ancient Monuments	Shapefile	Archaelogy	Clip to StudyAreaBuff
19	Listed Buildings	Shapefile	ListedBuildings	Clip to StudyAreaBuff, Select and Save only Grade = I or II*
20	Crime	Table	crime_data.xls	Download most recent year, combine June and Dec into single Excel file, retain Lat, Long, CrimeType, remove rows with No Location
21	Mobile Phone Masts	Shapefile	MobileMasts	Clip to StudyAreaBuff
22	Car Parks	CSV file	CarParks	Add XY data using Lat/Long, Project, and Clip to StudyAreaBuff
23	Military Areas (poly)	Shapefile	MOD	Clip to StudyAreaBuff
24	Public Rights of Way (line)	Shapefile	ROW	Clip to StudyAreaBuff
25	Street Lights	Shapefile	StreetLights	Clip to StudyAreaBuff
26	Open Access Land (poly)	Shapefile	OpenAccess	Clip to StudyAreaBuff
27	Quarries	Shapefile	Quarries	Clip to StudyAreaBuff

Table 2. List of BETER Inputs (part 2)

	DATA SOURCE	ONLINE SOURCE
1	Edina/Digimap LiDAR	https://digimap.edina.ac.uk/datadownload/lidardownload
2	Edina/Digimap	https://digimap.edina.ac.uk/datadownload/osdownload
3	Edina/Digimap	https://digimap.edina.ac.uk/datadownload/osdownload
4	Edina/Digimap	https://digimap.edina.ac.uk/datadownload/osdownload
5	Edina/Digimap	https://digimap.edina.ac.uk/datadownload/osdownload
6	Edina/Digimap	http://digimap.edina.ac.uk/webhelp/os/osdigimaphelp.htm#data_information/os_products/os_vectormap_district.htm
7	Edina/Digimap	http://digimap.edina.ac.uk/datadownload/environmentdownload
8	Edina/Digimap	https://digimap.edina.ac.uk/datadownload/osdownload
9	Edina/Digimap	https://digimap.edina.ac.uk/datadownload/osdownload
10	Edina/Digimap	http://digimap.edina.ac.uk/datadownload/osdownload
11	Edina/Digimap	http://digimap.edina.ac.uk/datadownload/osdownload
12	Edina/Digimap	https://digimap.edina.ac.uk/datadownload/osdownload
13	Open OS	https://www.ordnancesurvey.co.uk/opendatadownload/products
14	Data.gov.uk	http://naturalengland-defra.opendata.arcgis.com/datasets/sites-of-special-scientific-interest-england
15	Data.gov.uk	http://naturalengland-defra.opendata.arcgis.com/datasets/special-protection-areas-england
16	Data.gov.uk	http://naturalengland-defra.opendata.arcgis.com/datasets/special-areas-of-conservation-england
17	FC Open Data	http://data-forestry.opendata.arcgis.com/datasets/national-forest-estate-roads-england
18	Historic England	https://historicengland.org.uk/listing/the-list/data-downloads/
19	Historic England	https://historicengland.org.uk/listing/the-list/data-downloads/
20	UK Police	https://data.police.uk/data
21	Edinburgh DataShare	https://datashare.is.ed.ac.uk/handle/10283/2626
22	Data.gov.uk	http://www.britishparking.co.uk/Park-Mark-car-park-data
23	Local Authority	
24	Local Authority	
25	Local Authority	
26	Local Authority	
27	Local Authority	