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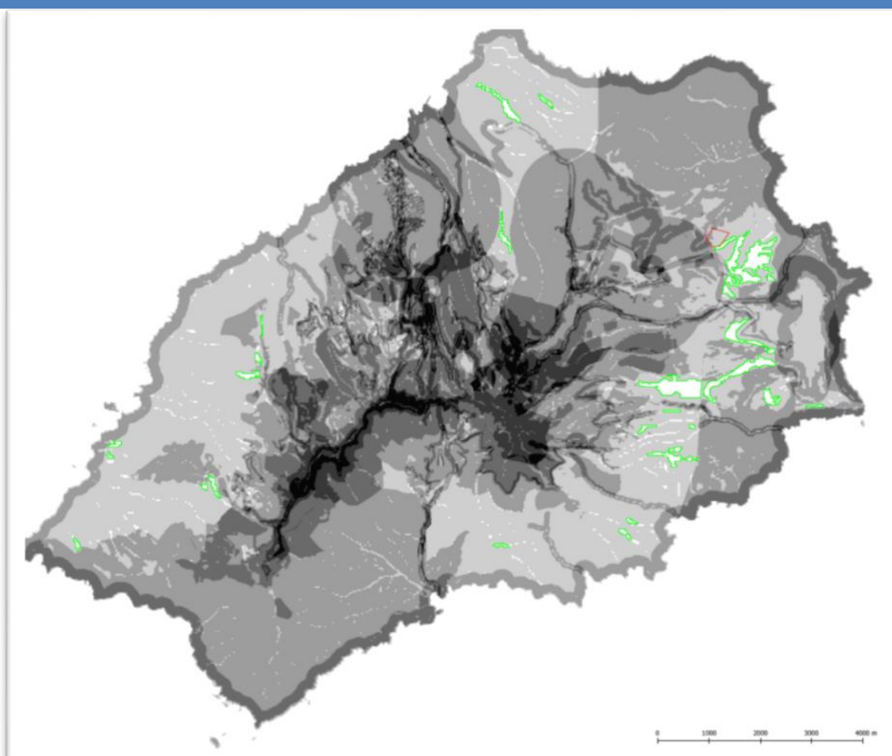
South Atlantic Overseas Territories Natural Capital Assessment: Constraints mapping to identify suitable land-fill sites on St Helena



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Background

Human wellbeing is dependent on the benefits – or natural capital – which we obtain from the environment such as food, fresh water, tourism, spirituality and protection from flooding and erosion. Yet these benefits and the trade-offs made between them are often not considered when economic decisions need to be made. Values – both monetary and non-monetary – can be assigned to this natural capital which allow us to make longer-term, more strategic, decisions about how to manage them both now and for future generations.

The UK Government, through the FCO managed Conflict, Stability and Security Fund, is supporting a suite of natural capital projects across the UK's South Atlantic and Caribbean Overseas Territories. This work is designed to improve economic stability in the Territories through enhanced environmental resilience as part of a programme led by the UK's Department for Environment and Rural Affairs (Defra). The natural capital project began in September 2016 and will be completed by March 2019 with the Joint Nature Conservation Committee (JNCC) as the Implementing Body. In the South Atlantic, the natural capital project work is being undertaken by South SAERI under a Memorandum of Agreement with the JNCC.

On St Helena, SAERI and JNCC are working with the Government and other key stakeholders to deliver a suite of natural capital assessments which will provide new evidence for future decision making and environmental management on the island. One of these assessments is a cost benefit analysis to explore different waste management models for the island, including improved recycling to extend the life of the existing land fill site. Another option being explored as part of the analysis is construction of a new land fill site once the existing one is full. With flat land at an absolute premium on the island, identifying suitable locations was going to be a challenge.

GIS spatial analysis

The use of GIS spatial analytical techniques proved an ideal solution, and the recently completed Darwin Initiative Plus project on "Mapping St Helena's Biodiversity and Natural Environment" (DPLUS052) provided a wealth of data for the analysis. The working group comprised of Ness Smith (SAERI), leader of the NCA project, Mike Durnford, Environmental Risk Manager at the Environmental Management Division (SHG), Samantha Cherrett, GIS specialist and project leader of the DPLUS052, and iLaria Marengo, GIS specialist and data manager of the IMS-GIS data centre (SAERI).

The first stage of the analysis was to define the requirements for a new landfill site. First of all, the time span for any future site was set at 25-50 years (and possibly longer if waste minimisation efforts are fully supported and adopted across the island) to ensure the scheme would be cost-effective. The new site would therefore need to be larger than the existing 10 hectare site at Horse Point.

Other requirements, or constraints, which limit where land fill developments could be sited, included both environmental and socio-economic factors, for example; a minimum distance from water sources, agricultural land, protected areas and urban areas and maximum steepness of slope, also needed to be considered. These were identified and provided by Mike Durnford. Table 1 illustrates the initial list of variables and constraints criteria.

Table 1. Initial list of datasets to be considered for the GIS spatial analyses and their matching constraints criteria

Dataset	Suitable (0 = good)	Constraint (1 = bad)
Land ownership	Crown Land only	Not Crown Land
National Conservation Areas	Non-NCAs	NCA
Distance from the shore line	outside 200m	within 200m
Sites within 50-200m from waterways	outside 50m	within 50m
	outside 50m	within 50m
Distance from drinking water caption points	outside 200m	within 200m
Must not be upstream of bore-holes/wells		
Must not be upstream of rivers		
Must not be in areas with history of/potential for flooding		
Must not be in areas with geological faults and weak crusts		
Distance from High clay content soils - at least 50%	within 100m	outside 100m
Distance from urban areas	outside 1000m	within 1000m
Distance from airport	outside 300m	within 300m
Distance from cemeteries	outside 200m	within 200m
Distance from highways	outside 60m	within 60m
Distance from trunk roads	outside 40m	within 40m
Distance from intermediate roads	outside 30 m	within 30m
Distance from local roads	outside 20m	within 20m
Distance from areas of considerable artistic, historical, archaeological value	outside 100m	within 100m
Distance from land use with highlighted highly valuable Agricultural fields (or fields with highest productivity)	outside 100m	within 100m
Distance from reservoirs	outside 200m	within 200m
DEM	Less than 11°	Over 11°
	Less than 25°	Over 25°
Soil Quality	>200	<200

The second stage was focussed on gathering the data and running the spatial analyses in QGIS. The work flowed as follows:

a) Data were checked for availability, using both local knowledge and also the metadata catalogue online provided by the IMS-GIS data centre.

b) The constraints criteria were assessed against available data and, where data were deficient, the working group was consulted to decide whether proxy data could be used instead. Individual archaeological, artistic and historical areas were not included as the NCA Heritage Conservation Areas included the main sites. As one of the landfill location criteria was a preference for clay soils, which are not generally used for agriculture, soil quality and highly valuable agricultural areas were not analysed. A robust reference to identify areas with a history of, and potential for flooding, could not be found and therefore it was not possible to create the dataset or apply the criteria. Finally only wet valleys, which represent a continuous year-round constraint, were included in the analyses and not the entire hydrological network of the island. The final data set used for the GIS spatial analyses is documented in table 2.

Table 2. Final datasets for the GIS spatial analyses and their matching constraints criteria

Dataset	Suitable (0 = good)	Constraint (1 = bad)	Notes
Land ownership	Crown Land only	Not Crown Land	Only includes data classed as Crown (not inc Crown Leased for example)
National Conservation Areas	Non-NCAs	NCA	Split into each type of NCA to be assessed separately
Distance from the shore line	outside 200m	within 200m	Based on main island boundary only (not islands)
Distance from waterways	outside 50m	within 50m	50m used - 'wet' valleys only
Distance from drinking water caption points. Must not be upstream of bore-holes/wells	outside 50m	within 50m	50m used in this instance, can increase
Must not be upstream of rivers	outside polygon	inside polygon	
Distance from High clay content soils - at least 50%	within 100m	outside 100m	63 available point locations only and therefore indicative - 100m buffer used but can be amended. 29 locations

			show >50% clay. Additional modelling could produce more accurate layer.
Distance from urban areas	outside 1000m	within 1000m	Based on 14.5.1 Urban Areas & Buildings and 14.4.1 Rural Gardens - restricted to Jamestown, Half Tree Hollow, Longwood
Distance from airport	outside 300m	within 300m	Airport 'restricted area'/fenceline extracted and used as boundary
Distance from cemeteries	outside 200m	within 200m	Only mapped as and buffered from points currently - could extrapolate to parcels - all are on private land
Distance from highways	outside 60m	within 60m	Based on current FCC 1-4 classification: 22-1-5-1 (A / Primary)
Distance from trunk roads	outside 40m	within 40m	Based on current FCC 1-4 classification: 22-1-5-2 (B / Secondary)
Distance from intermediate roads	outside 30 m	within 30m	Based on current FCC 1-4 classification: 22-1-5-3 (C / Tertiary)
Distance from local roads	outside 20m	within 20m	Based on current FCC 1-4 classification: 22-1-5-4 (R / Residential)
Distance from reservoirs	outside 200m	within 200m	Based on Level 3 Classification 15.1.1 Reservoir
DEM	Less than 11°	Over 11°	Could increase this slope value if required
	Less than 25°	Over 25°	Could reduce this: ALC classes are 0-7, 7-11, 11-18, 18-25, >25, can also do in 5 degree increments
Must not be in Green Heartland LDCP (NEW)	outside polygon	inside polygon	Excluded due to likely planning restrictions

c) Final data (table 2) were processed in QGIS and the constraints were calculated accordingly; for example buffering roads, selecting specific land use types, keeping only some slopes, avoiding Nature Conservation Areas etc. In the attribute table of the new constraints layers a new field was added and the value 1 "constraint" was attributed to it.

d) The processed vector data were converted from vector (geometric file: either a point, line or area) to raster (image file comprised by array of cells) as depicted in figure 1. The gdal "rasterize" processing tool was used. The size of the cells of the rasterised files was equal to 10X10 metres and considered to represent the variables adequately (figure 2).

e) The raster files were clipped to only the land mass of St Helena using the GRASS "r.mask.vect" processing tool. Some of the resulting files are depicted in figure 3.

f) Raster files were combined using the algebraic sum (raster 1 + raster 2 + raster 3 etc) in the GDAL raster calculator. The extent of St Helena boundaries was taken as reference for all rasters (figure 4)

g) the file resulting from the combined raster files showed values ranging from 7 (not suitable, many constraints overlapping) to 0 (suitable, no constraints on the map). The raster file was then classified using quantile method to highlight better the areas that are suitable for a landfill. The range from 0 to 7 is converted into a more convenient and self-explanatory qualitative scale "suitable-unsuitable" (see figure 5 left)

h) Finally, all potential sites over 9.9 hectares were extracted from the overall suitability map and overlapped onto it (figure 5 right). The final map was delivered to the Environmental Management Division.

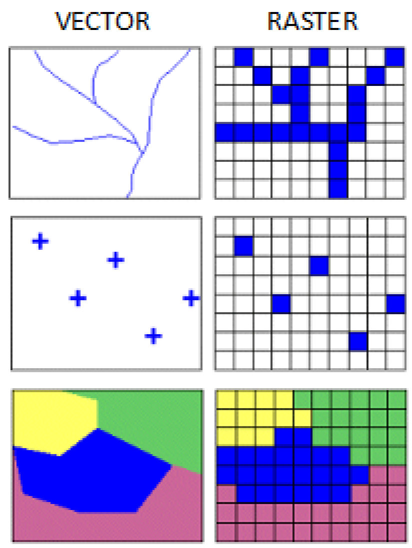


Figure 1. Vector (geometric dataset) versus Raster (cells array) file. Copyright: Azavea (www.azavea.com)

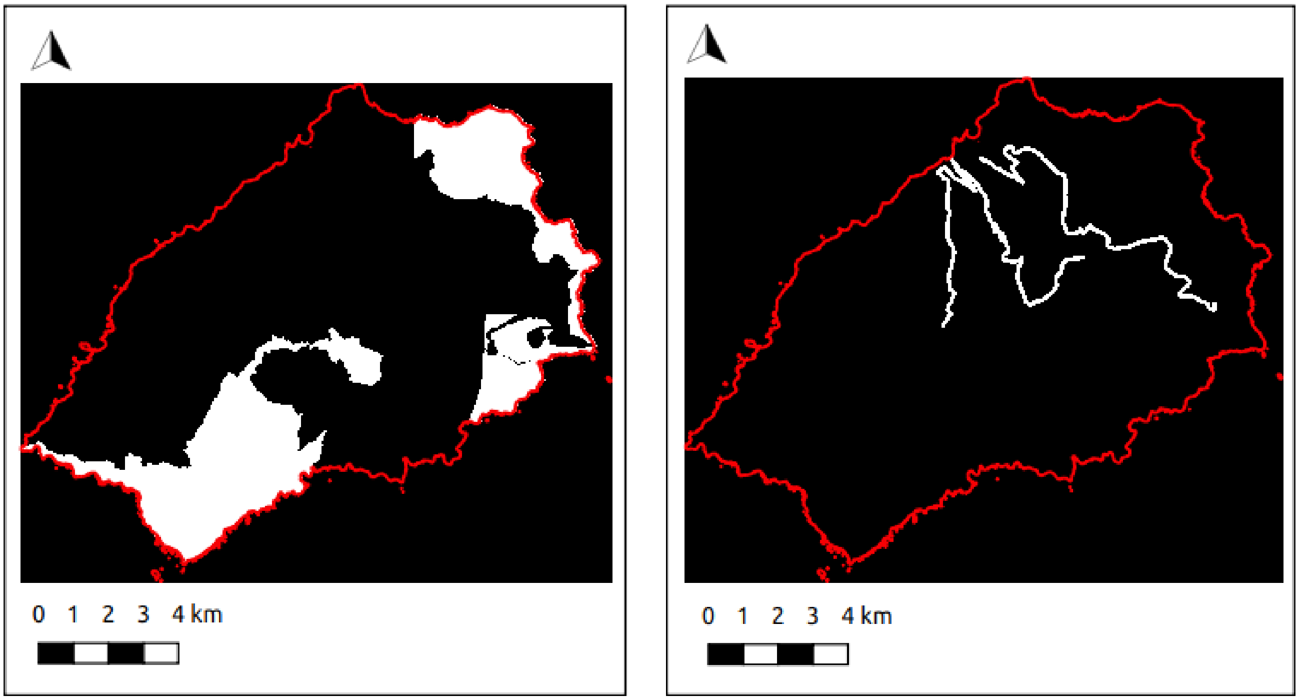


Figure 2. Examples of rasterised files: Nature Conservation Areas (left) and Distance from primary highways (right). Black means suitable (good), white indicates the constraint (bad area for the landfill).

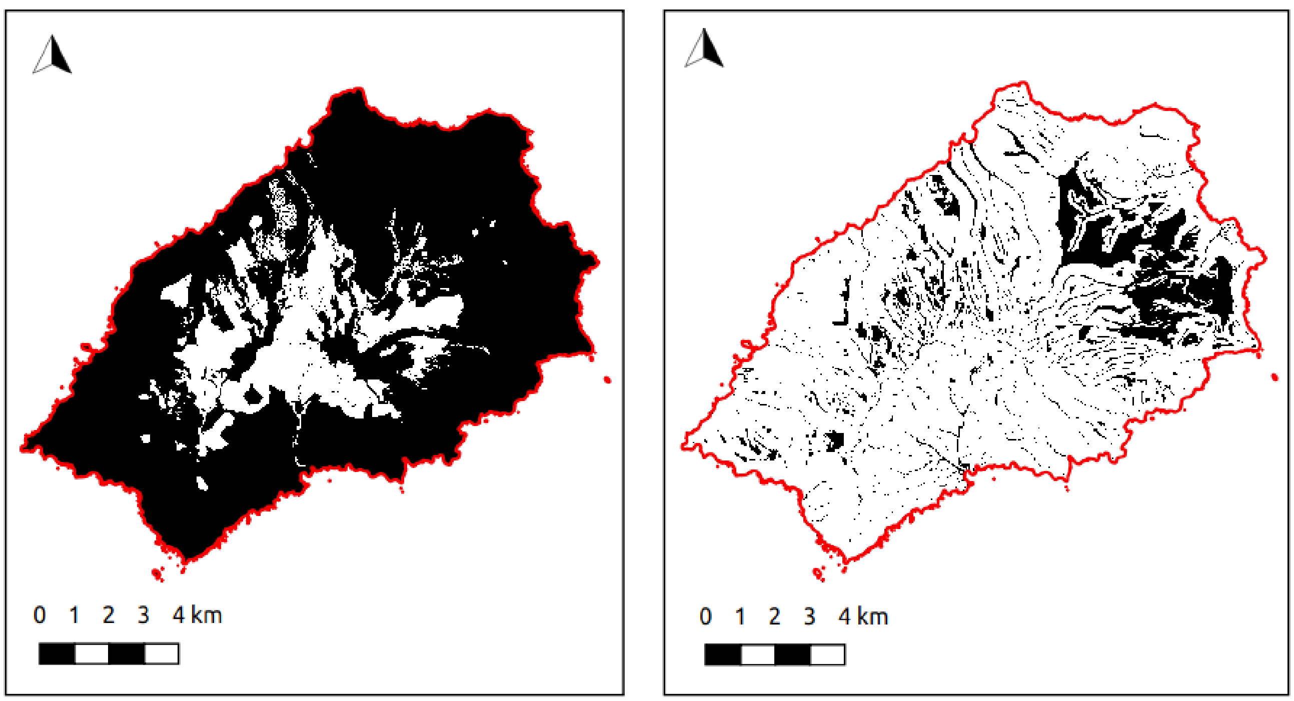


Figure 3. Examples of masked rasterised files: Crown land (left) and Slopes (right). Black means suitable (good), white indicates the constraint (bad area for the landfill)

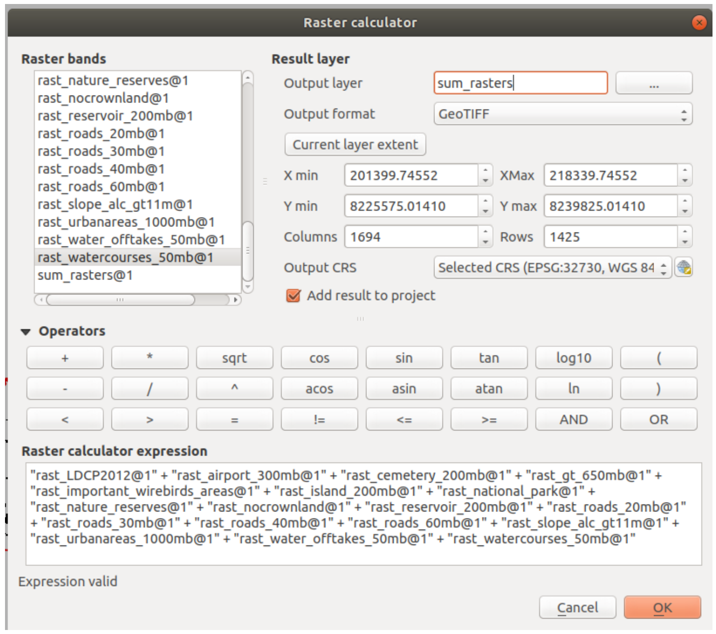
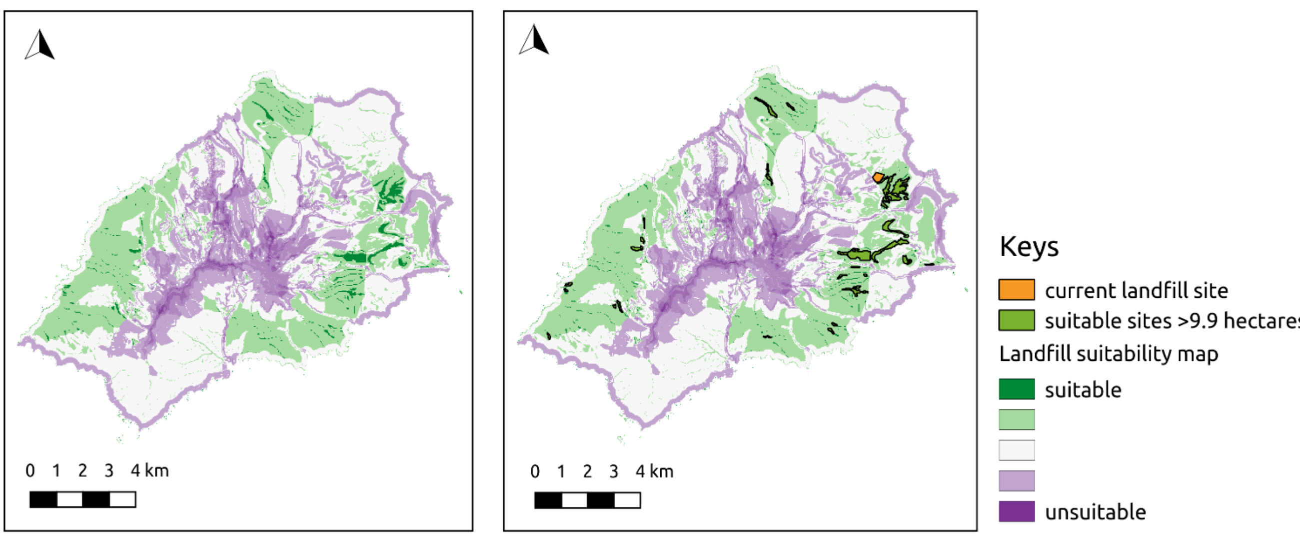


Figure 4. Simple algebraic addition of all raster files in the raster calculator tool of QGIS.



Both data and map are a first iteration, and the analytical process described above can be run again with different constraints criteria as and when new regulations, results from public consultation, or new data become available.

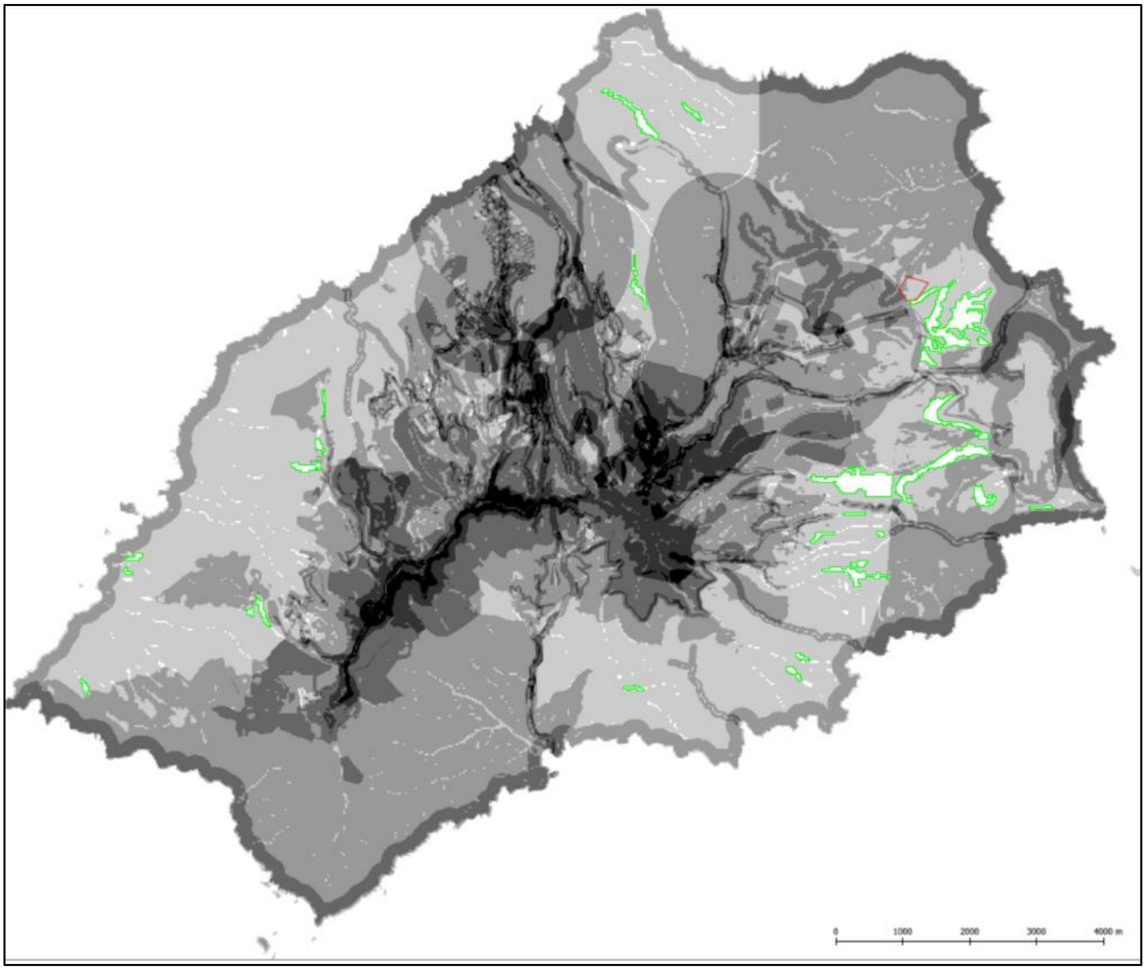


Figure 5: Final map showing suitable areas for a new land-fill site.

Reference

https://www.azavea.com/blog/2014/08/21/summer-of-maps-raster-versus-vector-visualization/