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Signed: ____Mackenzie Boland Date: **10/04/2022**_____

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1. Introduction

The aim of this project is to find a suitable location for a cattle farm in county Cavan, Ireland, using the Multi Evaluation Criteria approach. Ireland has a long history and high reputation for producing high quality beef and dairy produce that is often exported and praised internationally. There are five primary objectives of this project, the first is to explore Cavan through examining its population and history of farming in a bid to justify the construction of a new cattle farm. Second is to investigate the Irish farming sector and market value while considering the future prospects of the area by reviewing the new Common Agricultural Policy. The third is to identify the essential components, such as land and soil type, for a successful farm. The fourth is to understand the Multi Evaluation Criteria approach and lastly the fifth is to apply the Multi Evaluation Criteria approach and find the most appropriate locations within Cavan.

2. Literature Review

2.1. Study Area

County Cavan is ranked 18th in the country with regards to total area at 1,932 km² and has a total population of roughly 76,176, giving it a national rank of 25th and one of the lowest population densities in the country. The agriculture, forestry and fishing industry is one of the most popular industries for residents to work in, with approximately 3,455 workers, just ten behind manufacturing for male workers in particular as documented by the 2016 Census. ((1) Census CSO). Cavan has a long history of farming with almost 17,900 active farms in 1915. As of 2010, following a nationwide decline in farming practices, it still remained in the higher half of farm population and had the 12th most farms at 5,282 farms, notable with regards to its size and population. ((2) Census CSO). As of 2016 there were 109,400 farms across the nation and a total of 7.2 million cattle. The average herd size per farm was 66 cattle. The Border region which comprises counties Cavan, Donegal, Leitrim, Louth, Monaghan and Sligo has a significant cattle population and market. It was recorded in the 2016 Census that there were a total 21,100 farms with an overall cattle population of 907,700 within the Border region ((3). Census CSO). It is evident that there is a market for cattle farming within Cavan.

2.2. Dairy and Beef Farming in Ireland

While the agricultural sector in Ireland does not hold the same importance it once did, when combined with the food sector it “accounts for 7 percent of Irish modified GNP and 7 percent of employment”. In 2019 the agri-food sector contributed to roughly 10% of merchandise exports equating to almost 40% “net forgein exchange earnings”, after profit repatriation and importer inputs are taken into consideration. (Matthews, 2021). Two of the most prominent agricultural exports are dairy and beef that have become known globally for their high

quality and account for 29.5% and 38.8% of all Gross Agricultural Output (GAO). In 2019 Irish dairy farms produced approximately 7.9 billion litres of milk following the abolition of production quotas in 2015, an excessive amount for the current population. This resulted in €4.4 billion of Irish dairy exports, and was the largest drink export within the drink and food exports for the third year running. In various forms such as butter at €1.1 billion in exports and cheese at €998 million, Irish dairy was exported to 124 different countries, including China and the UK. Notable markets include Malaysia and Indonesia that are responsible for almost €50 million of market exports.

Dairy farming in Cavan is an already established market with companies such as Lakeland Dairies, who play a significant role within the agri food sector and Irish dairy market. In 2019 alone they saw a revenue that exceeded €1.1 billion. As the market continues to grow, Bord Bia has started to implement the Sustainable Dairy Insurance Scheme (SDAS). The SDAS is a nation wide initiative that gathers information from farms in a bid to uphold the current standards while seeking to improve where possible. It also seeks to introduce sustainability methods to the farms and various levels of quality assurances to ensure a prosperous and resilient market. ((1) BoardBia, 2021 and (2) BoardBia, 2021).

The beef market is equally important to the Irish agri food sector and food exports. In 2016 alone an excess of 624,000 tonnes of Irish beef was exported and was valued at €2.25 billion. Also exported was 300,000 live cattle worth roughly €167 million. The greatest recipients include the UK, France and Holland. Similar to the SDAS, Bord Bia has introduced the Sustainable Beef and Lamb Assurance Scheme (SBLAS), which aims to promote a sustainable industry with returns that are consistently of a high quality. Much of the quality and uniqueness of Irish beef is due to 80% of them being grass fed. Under the SBLAS, all grass fed beef cattle must have an average of 220 days of grass stands and a minimum of 90% of their diet must be comprised of grass or "grass based forages". The term "grass fed" is often associated with the products being "premium, natural and healthy", which in turn is very important for the image and sale value of Irish beef, while also being perceived as following more ethical farming practices. ((3). Bord Bia and (4). Bord Bia). Thus, it is clear that there is a prosperous and pre established market for cattle farming in Ireland.

2.3. The New Common Agricultural Policy

The European Union (EU), has begun its efforts to improve the Common Agricultural Policy, (CAP), in an effort to secure "the future of agriculture" while implementing the European Green Deal. Some of the objectives of the reformed CAP aim to secure fair incomes for all farmers and improve their standing on the proverbial food chain, incorporating goal 13, Climate Action, of the UN Sustainable Development Goals all while preserving the environment, biodiversity and landscapes of the nation. In a bid to support farmers the definition of an active farmer has been altered to ensure that it is those actively farming that are receiving support. Smaller farms will benefit from a 10% increase of "redistributive income support", while young farmers will receive 3% in investment support, startup aid or income from the direct payments

budget. The EU has also pledged to help improve the gender balance within the farming sector as it is currently a male dominated industry.

The EU has also pledged to increase the digits of its two “pillar” funds; the European agricultural guarantee fund, (EAGF), and the European agricultural fund for rural development (EAFRD) to €291.1 billion and €95.5 billion respectively from 2021. €8 billion of the EAFRD budget has been allocated to the €2.018 trillion Next Generation EU (NGEU) operation, a recovery plan for the post COVID-19 market. However, the EU is using this opportunity to renew farming practices to become more environmentally friendly and technologically advanced while improving resilience across the EU. €723.8 billion of the NGEU budget will be available directly to countries in the form of grants and loans in a bid to support their new investments and rehabilitation. (EC.europa.eu). The new CAP era is focused on establishing and strengthening a profitable farming sector across the EU and would be a convenient and advantageous time to enter the farming sector.

2.4. What Farms Need

There are many different criteria that are essential for a productive and profitable farm, some are essential while others are benefits that can lead to higher quality yields of cattle or dairy or can help to reduce the need for additional supplements or infrastructure.

2.4.1 Access To Water

A primary example of this is proximity to lakes which can be used for farm irrigation and providing drinking water for the animals. (Hongdao, 1987). Accessing water from a large reservoir can be safer than the use of a farm well, as the well water is often polluted with manure effluent and other fertilisers. Previous studies such as Smoroń 2016, have found high concentrations of chlorides, ammonium nitrogen and orthophosphate as phosphorus, (NH4-N and PO4-P). It was also found that groundwater found in drainage ditches that had not yet been contaminated by animal waste had high concentrations of nitrate nitrogen, potassium and chlorine, (NO3-N, K and Cl-). (Smoroń, 2016). Historically, longos term exposure to certain fertilisers has been linked to increased death rates due to brain cancer. (Dean, 1994). Therefore, having access to clean drinking water is vital for farm safety.

2.4.2 Soil Nutrients

Cows require large amounts of nutrients to ensure high quality yields of both dairy and beef. Farmers are often required to add various buffers to the cattle feed in order to maintain the ruminal pH, the acidity levels of a cow's stomach, and “reverse depressions in milk fat tests”. Limestone is one of the most popular buffers as unlike potassium and sodium it can be absorbed from within the cows gastrointestinal tract rather than the digestive tract. This is extremely important for lactating cows. (Emery and Brown, 1961; Hill, 1962; Miller *et al*, 1965; Scott, 1975; Wheeler, 1980). Brachtell, Allen and Monroe found that soil with low levels of lime has a high acidic pH of 4.6 which in turn is unhealthy for both cattle and the soil. (Brachtell, Allen and

Monroe, 1934). Limestone in soil has also been known to add “distinctive flavours” to cheese and milk. (Bowen and De Master, 2014). From these sources it is evident that proximity to limestone can have a positive impact on cattle.

2.4.3 Land Type

There are many land types that are appropriate for cattle farming. Natural grasslands are a popular choice for farming practices. The land is often healthy and home to many flora and fauna. Hopkins and Holz suggest that farming on natural grasslands may provide the opportunity for “green tourism”, which would greatly encourage the local economy and income of the farm itself through various “diversification opportunities” such as accommodation, providing activities and sale of produce. Natural grasslands can also provide high quality grazing for cattle. (Hopkins and Holz, 2006). Areas of natural vegetation are beneficial for cattle with popular dwarf shrubs such as gorse and heather that provide viritity to their diets. Cattle are an effective method of managing vegetation on both lower lands and upland. (O’Rourke, Kramm and Chisholm, 2014).

2.4.4 Road Proximity

The transportation of livestock and farm produce can be a delicate task. There is a high mortality rate associated with the transportation of calves who have one of the highest slaughter values. Keeping them alive during transport is of high economic interest for the farmer. (Hails, 1978). Many cattle can experience a loss of .75% of their total body weight for each day they are being transported. This is due to food and water deprivation and can't impact the live weight price of the cow. (Warriss, 1990). Bruising is quite common during the transport of live cattle and can severely affect its quality as it mars its physical appearance. Severe bruising leads to a loss in volume as it must be trimmed off. (Tarrant *et al*, 1992). The physical and emotional stress of transportation also affects the quality of the meat as the cows' stores of muscle glycogen are depleted. Following slaughter, the muscle glycogen converts into lactic acid, altering the pH and decreasing its longevity. This can also alter the texture and colour of the meat as it becomes dry and dark and can be unpopular among customers. (Warriss, 1990; Knowles, 1999). The distance to the slaughter house plays a key role in the final value of the stock and thus it is paramount that the farm be located close to well maintained roads, improving journey time and the comfort levels of the cattle. Additionally Teagasce recommends that farm roads exceed 3.7 metres to ensure herd safety. (Ryan, 2009).

2.5. Multi Criteria Evaluation

Multi Criteria Evaluation, (MCE), is a GIS process that is used to solve problems of “spatial resource allocation” when there are multi criteria or constraints that must be taken into account. There are two main approaches to solving a MCE, the first is to convert the criteria into individual Boolean statements called constraints and the second is to convert them into continuous variables called factors. Boolean statements operate by adhering to a binary system

with values being either True or False. Therefore, they have the ability to delineate the areas that do not meet the criteria and produce “crisp mapping”. Boolean statements often include logical conjunctions such as AND for intersection or OR for union. However, when factors are used for qualitative criteria, a surface is created that expresses the “varying degrees of suitability” within the constraints that must be adhered to, on a numeric scale. (Voogd, 1983). Once the factors have been standardised they are multiplied by a predetermined weight and produce the MCE. Figure 1.

The standardisation of criteria in a MCE can be considered as being fuzzy measures due to the transformation of the criterion into a “set of suitable choices”. Fuzzy measures follow the principles of De Morgan's Law when formulating the AND and OR logical conjunctions. (Bonissone and Decker, 1986). Determining the weights associated with the fuzzy sets and criteria is important and one of the most influential steps in the MCE. Saaty devised a procedure using “pairwise comparisons” to decide on the best weight. Each factor is given an individual rating based on its relative importance to the other factors based on a “9-point reciprocal scale”. This creates a factor by factor, c*c, matrix of the ratings. (Saaty, 1997; Rao *et al,* 1991; Eastman, 1999).

3. Methods

There were various factors that defined the specific criteria for the MCE with the aim of finding the most suitable location for a cattle farm in Cvana. There were two main factors followed by three criteria that had to be considered. The two factors were both taken from Cavan County Council’s guidelines on the use of agricultural products such as fertilisers, both organic and chemical, and farm wastes such as manure. Firstly, the council decreed that no fertiliser may be used or manure disposed of within 250 metres of a water reservoir that may supply more than fifty people and that is within 20 metres of a lake shore line. This was considered factor one as if it was not met no planning permission would have been granted by the council. Additionally, the council required that no fertiliser or manure may be used or stored within 50 metres of any karstified limestone features. This became factor two.

The first criterion ensured that the farm was located within 5 km of a primary and/ or secondary road as in Ireland both exceed the recommended 3.7 metre width. The second criteria aimed to find areas that are a minimum of 2 km from any Natural Heritage Areas, Special Areas of Conservation or Special Protection Areas to ensure they remain protected. Lastly, the third criteria ensured the farm was situated in a location with the appropriate land type to provide the best nutrients for the cattle and thus yields of produce. Once the criteria had been successfully standardised, the formula (w1 * C1 + w2 * C2) * C3 * C4 * C5 was used where w refers to the determined weights following Saaty’s reciprocal approach and C1, C2, C3, C4 and C5 refer to the individual criteria.

Before the analysis began the extent of the project was defined. This was done in Environments from the Analysis section. The Processing Extent was set to Same As Layer: LA2016, as it provides a well constructed and accurate representation of Ireland and thus Cavan

the study area. The Cell size was set to 50. As the analysis relied on various datasets and the creation of multiple rasters it is key that they are constructed under unanimous conditions. Lastly, the Mask was set to Same As Layer: LA2016. This allows all results to fit the designated layer.

3.1. Criterion 1

As aforementioned, it was vital that the farm be located a minimum of 250 metres from any water resources or lake shores. As it was unclear during this time which lakes were active reservoirs, a 300 metre exclusion zone was constructed. The extra 50 metre distance was to insure the 250 metre distance was sustained in the case of any changes in the lake boundaries, examples include flooding or man-made expansion. This 300 metre boundary also satisfies the condition from the Council; that there be a 20 metre distance from any shore lines. However, it can be very useful for farms to have access to natural water sources to give to the cattle and thus it was important to have water access nearby. Therefore, the specifications for the first criterion were: the farm must be a minimum of 250 metres from a reservoir, lakes in this instance, but be as close to the water as possible while satisfying both requisites. The goal of criterion 1 and criterion 2 was to create two continents surfaces showing each of the particular constraints.

This was calculated using the Euclidean Distance Spatial Analyst Tool. The purpose of this tool is to calculate the distance for each cell from the specified features, in this case, lakes that were obtained from the IrelandLakes shapefile. Lake cells will be given a zero and each cell will increase in number across the extent and their distance from the source cell/ lake. The product of this calculation is a raster called disttolakes. To find the areas exceeding 300 metres from a lake the Spatial Analyst Raster Calculator was used. Using the expression: "disttolakes" >= 300, a boolean layer called LakeDist300 was created. The values of 0 are less than 300 metres from a lake whereas those with a 1 are 300 metres or more from a lake. This layer was then normalised using the maximum value of disttolakes; 85674 minus 300, and the formula: $f(x) = \ - \ x/max\ pixels \ + \ 1$. 300 is subtracted to satisfy the need for distances greater than or equal to 300. In the Raster Calculator this translated to $- \ disttolakes/85371 \ + \ 1$, and the layer normLakes was created. To find the areas that satisfy all criereai for criterion 1, LakeDist300 was multiplied by normDistLakes and the output raster layer was named C1. Figure 2.

3.2. Criterion 2

The second factor criterion relates to the farm's proximity to limestone features. The Cavan County Council requires all fertilisers and farm waste to be a minimum of 50 metres from any Karstic/ Limestone features. However, limestone has many important nutrients such as calcium, which is one of the most important minerals for cattle. Low calcium intake can lead to poor bone growth, poor overall development, low milk output and in some cases milk fever. Therefore, while it was important that the farm be 50 metres from these landscapes it was also in its best interest to be as close to them as possible in the hopes of having mineral rich soils, benefiting both the cattle and the farmers wallet.

This was calculated similarly to factor 1, however prior data aggregation was required. The first step was to isolate areas with limestone. This was done using the Select by Attributes feature of the Feature Layer Selection Tools. The Geology layer was used as the Input Row. The expression used was: Where UnitName contains the text Limestone. Following this a new layer called Limestone was created by right clicking on Geology and choosing Make Layer From Selected Features under Selection. Limestone was then entered into the Euclidean Distance tool and the layer disttoLimeS was created. The raster layer was then used in the Raster Calculator with the expression disttoLimeS >=100, to create distLime100. This was a boolean layer in which 0 represented areas within 100 metres of limestone and 1 represented all other areas. 100 metres was chosen in the event that more limestone became uncovered in the future and thus extended the safe boundary around the features.

The disttoLimeS was normalised using the Raster Calculator and the same expression as above. In this case, it read as: $- \ disttoLimeS/135304 \ + \ 1$, with the max pixels having subtracted 100 for the 100 metres. Once the normLime layer was created it was multiplied by the distLime100 layer to create the final factor 2 layer. Figure 3.

3.3. Criterion 3

Criterion 3, criterion 4 and criterion 5 were constraints as opposed to criterion 1 and criterion 2 which were factors. Each of these criterions created boolean surfaces that had two values, 0 and 1, that represent the areas that do or do not represent the specific constraints of each criterion. The first of which was to find areas that are within 5 km of a primary or secondary road. To calculate this, first the IrelandRoads layer was aggregated using the Select By Attributes feature and the expression: Where type is equal to Primary or type is equal to Secondary. The selected features were made into a separate layer calledRoadsPandS, using the Make Layer From Selected Features under Selection option by right clicking on IrelandRoads. Using RoadsPandS and the Analysis Gallery Buffer tool a 5km buffer was created around the roads. The Input for the tool was the RoadsPandS layer, the distance was 5000 metres and the Dissolve type was set to dissolve all output features into a single feature. This buffer incorporates areas that lie within 5 km of a primary or secondary road, the output was called Roads_Buffer_5km.

To turn this into a boolean layer the Raster Calculator was used. First, a new Field called VALUE was added to Roads_Buffer_5km by opening the attribute table and selecting Add+. The data type was set too short and the Number Format to Numeric with 0 decimal places. Once saved and the Add+ table closed, it was added to the VALUE in the attribute table. This was important for the boolean aspect. To make the final C3 raster the Feature to Raster tool was used with Roads_Buffer_5km as the Input, the field was VALUE and the output was named C3. Figure 4.

3.4. Criterion 4

The aim of the fourth criteria was for the farm to be positioned a minimum of 2 km from any Natural Heritage Areas, (NHA), Special Areas of Conservation, (SAC), or Special Protection Areas, (SPA). The goal is to find the areas that satisfy this true/ false boolean logic. The first step was to merge the NHA, SAC and SPA layers into one. This was done using the Data Management Merge tool. The three layers where the input data and the output file were called Protected_Areas. To satisfy the 2 km boundary a buffer was created using the Buffer tool and Protected_Areas as the input, a linear distance of 2000 metres and the Dissolve type was set to dissolve all output features into a single feature. The output was named Protected_Buffer_2km. A new field was added to the attribute table using the Add+. It was named VALUE, data type was set too short and the Number Format to Numeric with 0 decimal places. Once saved it was given the value of 1 in the attribute table and saved. Following this the Feature to Raster tool was used to complete the aggregation. The input was the Protected_Buffer_2km, the field was VALUE and the output was called C4. Figure 5.

3.5. Criterion 5

The aim of the final criteria was to find the areas with the most suitable land. The CLC18_IE layer was used. First the land types suitable for farming needed to be extracted from the main file. These were Pastures, Complex Cultivation Patterns, Land principally Occupied by Agriculture, with Significant Areas of Natural Vegetation and Natural Grassland. This was done using the Select by Attributes query feature. Using the query: Where CODE_18 is equal to 231 or CODE_18 is equal to 242 or CODE_18 is equal to 243 or CODE_18 is equal to 321. The selected features were extracted using the Make Layer From Selected Feature under Selection of CLC18_IE and renamed Appropriate_Land. In a similar approach to C3 and C4 a new field called VALUE was added to the attribute table using the Add+, with a data type that was set too short and the Number Format to Numeric with 0 decimal places. However, to fill in the values for each line the Field Calculator was used to speed up the process. The input table was Appropriate_Land, the field VALUE and in the VALUE = section, 1 was entered in and the query was run and saved. Lasty the Feature to Raster tool was used to render the final layer and the output was called C5. Figure 6.

3.6. Calculating Suitability

The last step was to execute the formula. As the Cavan County Council mandated that all farm waste and agricultural fertilisers be a minimum of 250 metres from a lake and a minimum of 50 metres from any limestone, while it also being in the best interest of the farm to be close to both, they were each allocated the same weight of 0.5. As the other criteria were dependent on a boolean they do not need weights. The equation was inserted into the Raster Calculator and the output named suitability map. To view the areas ranked from most appropriate to least, the layer

was opened in Symbology and the Primary Symbology was changed to Classify and the number of Classes was changed to 4. Figure 7.

A map was made of each criteria to examine them individually. For each criteria the Clip Raster Data Management tool was used with the Criteria Layer as the input and the Cavan Border layer as the output extent and ticking the Maintain Clipping Extent check box. The Cavan Border layer was taken from the LA2016 file by using the Select By Attributes function and the query: Where COUNTY is equal to CAVAN. A map was also made of the criteria prior to the aggregation and full MCE analysis. Figure 8.

4. Results

From Figure 2 and Figure 8, it is evident that there were many water bodies in Cavan, with many clustered within the centre and southern sides of the countly. There appeared to be few areas that were suitable for a cattle farm due to their dispersed pattern. Criterion two appeared to have less coverage than criterion one with only three areas of limestone visible. From figure 3 and figure 8 it is evident that there were areas where both a lake and limestone area were present. This was a positive find as the addition of limestone did not greatly decrease the remaining suitable area. For Criterion three it was evident that there were few primary and secondary roads in Cavan. With only a small valid area in the north west and two sections that did not appear to be adjacent to a lake, this appeared to be very restrictive towards calculating the final result. Notably an intersection of the roads was adjacent to a large section of limestone and a cluster of larger lakes. Figure 4 and Figure 8.

Criterion four appeared to have had a similar pattern to both Criterion one and Criterion two with many protected areas being located within the limestone - lake area in the centre of Cavan. This was also the case for the lakes in the south and south eastern border regions. There were also clusters close to the small section of road in the north west of Cavan, potentially making that entire section of road and the county unsuitable for the cattle farm. Figure 5 and Figure 8. Lastly, Criterion five appeared visually to be the least influential as the majority of Cavan had the appropriate land type. There were areas in the north west that did not have the appropriate land type, however notier of these sections were located near a road and were adjacent to a protected area. Figure 6 and Figure 8.

Following the MCE there were four main areas in Cavan that were deemed suitable for a cattle farm. The largest of which was situated around the cluster of lakes and limestone in the centre. This coincided with the first two criteria that the location be as close to a water body and limestone, while remaining within the councils specified limits. Figure 7. From Figure 9 there appeared to be some discrepancies within the large suitable area, particularly with the protected areas as some were located in the red, more appropriate zones.

5. Discussion

5.1 Critiques

Despite the error the MCE provided the most appropriate areas to build a cattle farm in Cavan based on the given criteria. It is important to note that the previously established farms were not taken into account during this analysis, nor were the towns and houses. It also did not incorporate the actual area of land that would be needed to construct a profitable farm. The lack of road access appeared to have limited the location the most, followed by the desire to be as close to limestone and thus enriched soil as possible. The least influential factors appeared to be the land type and aspiration to be as close to water as possible but remain outside the 300 metre exclusion zone. There also appeared to be some disparity between the actual border of Cavan and the location of lakes when using the basemap. This may have been due to incorrect translations of coordinate systems or mapping extent in the beginning phase of the analysis.

5.2 Potential Improvements and Suggestions

There are many ways in which the project approach and its results could be improved. The analysis was carried out using the full information for the entire Isle. This led to long processing times of almost ten minutes when aggregating data sets such as the CLC18_IE land types layer and large amounts of storage were needed . It may have also influenced the scale of the results. Clipping the necessary files to the Cavan Border extent may improve this greatly. Additionally, re-evaluating the land types deemed appropriate may help to hone in the results as there may be pre-existing farms in these areas. It may also be beneficial to define the size of the farm prior to beginning the analysis to ensure the area is approutopate. Lastly, future studies may benefit from including a topographically related criteria as the council also decrees that fertilisers may not be used on steep land that is close to any water bodies, this includes rivers and streams which were noy included in this analysis. (cavancoco).

6. Conclusion

To conclude, with the use of an extensive literature review and a successful MCE the most appropriate locations for a cattle farm in Cavan were established. The MCE is a dependable approach for solving spatial allocation problems by incorporating many criteria and finding and ranking areas that are deemed the most suitable. It is evident that there is a history and pre established market for farming in Cavan and that through increased EU funding and the renewal of the CAP, farming is a thriving industry that will continue to grow and prosper.

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9. Figures

$$\text{suitability} = \sum w_i X_i * \prod C_j$$

where w_i = weight assigned to factor i
X_i = criterion score of factor i
C_j = constraint j

Figure 1: MCE Formula

Source: Eastman, J.R., 1999. Multi-criteria evaluation and GIS. Geographical information systems, 1(1), pp.493-502.

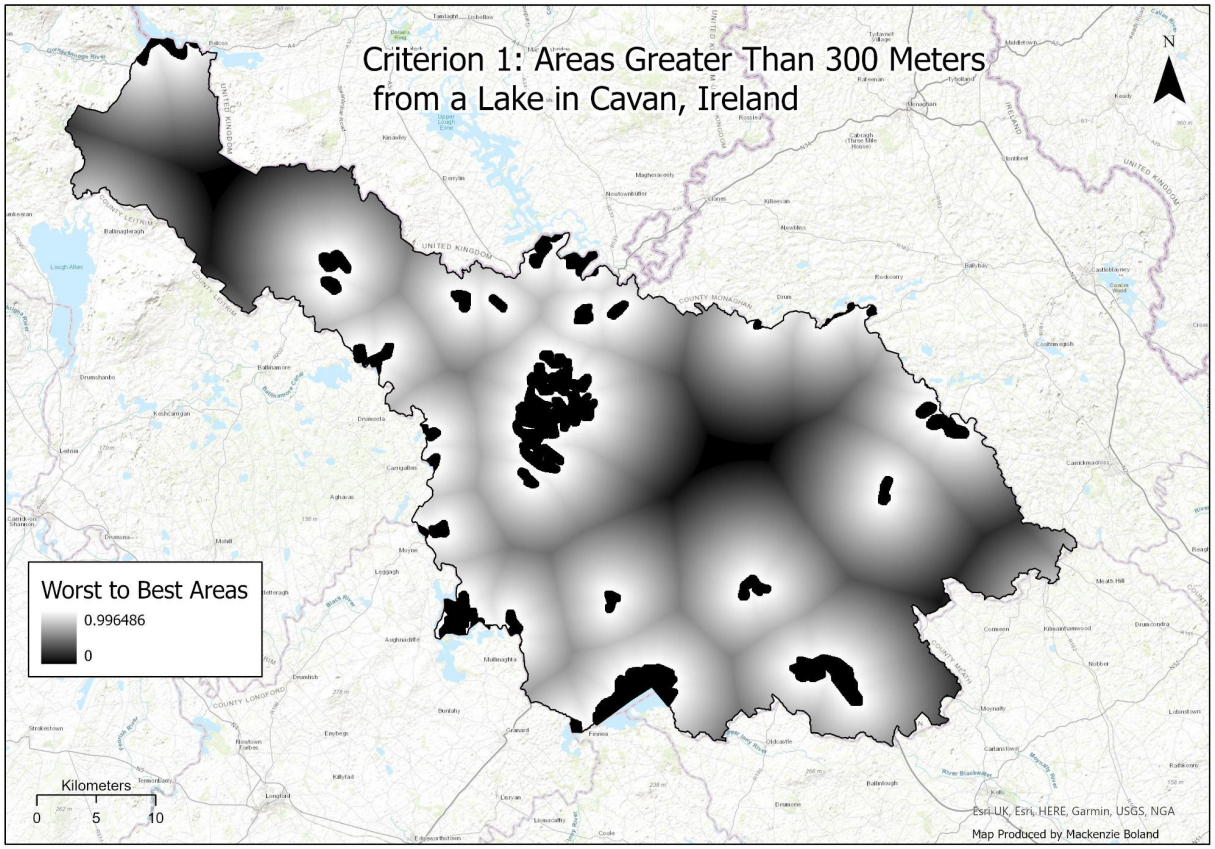

Figure 2: C1

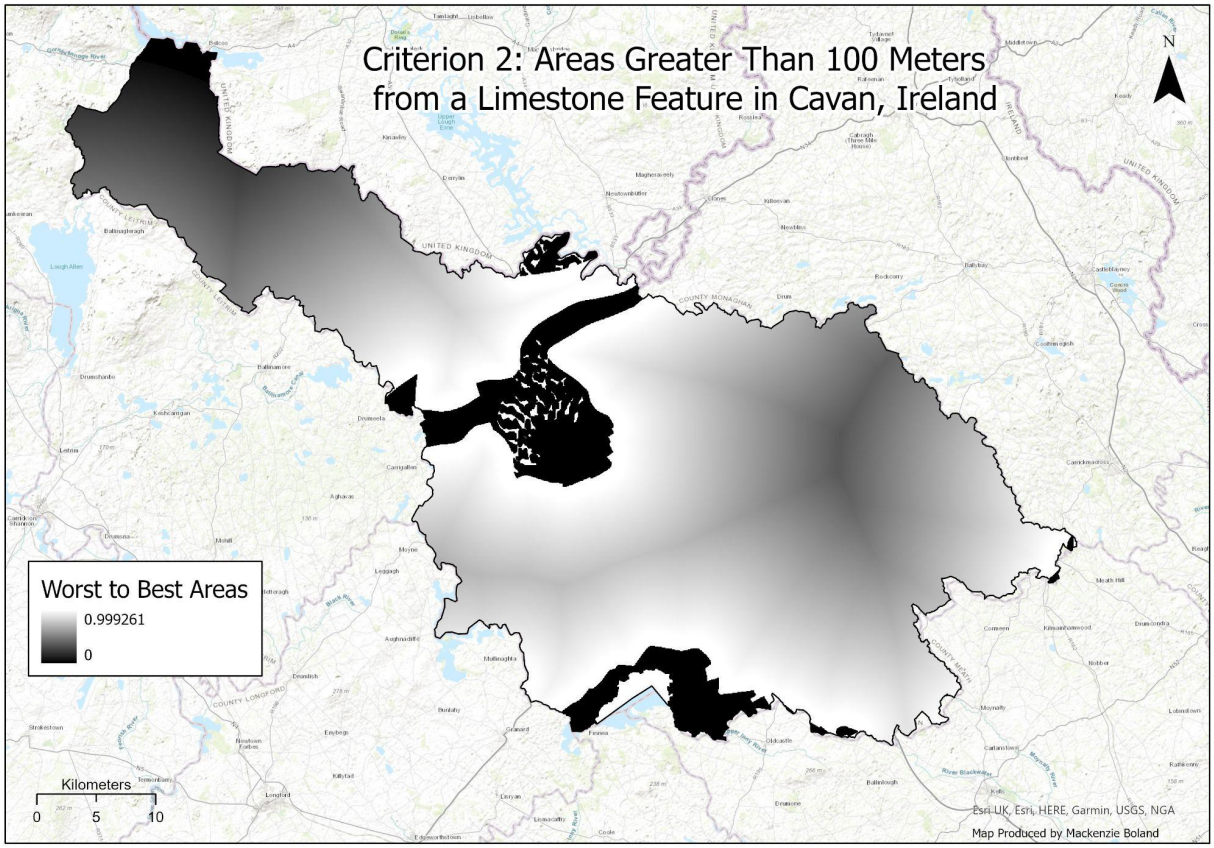
Criterion 2: Areas Greater Than 100 Meters from a Limestone Feature in Cavan, Ireland
N
Worst to Best Areas
0.999261
0
Kilometers
0
5
10
Esri UK, Esri, HERE, Garmin, USGS, NGA
Map Produced by Mackenzie Boland

Figure 3: C2

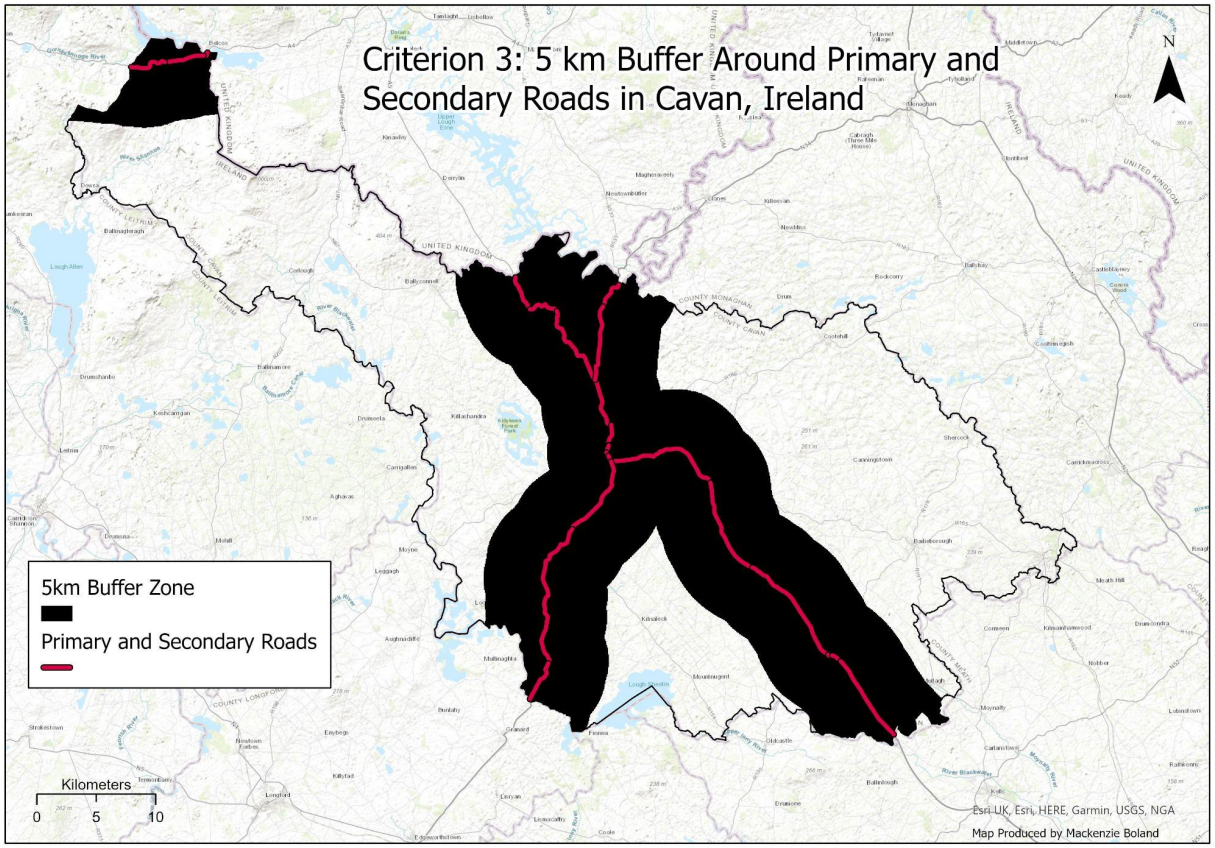
Criterion 3: 5 km Buffer Around Primary and Secondary Roads in Cavan, Ireland
N
5km Buffer Zone
Primary and Secondary Roads
Kilometers
0
5
10
Esri UK, Esri, HERE, Garmin, USGS, NGA
Map Produced by Mackenzie Boland

Figure 4: C3

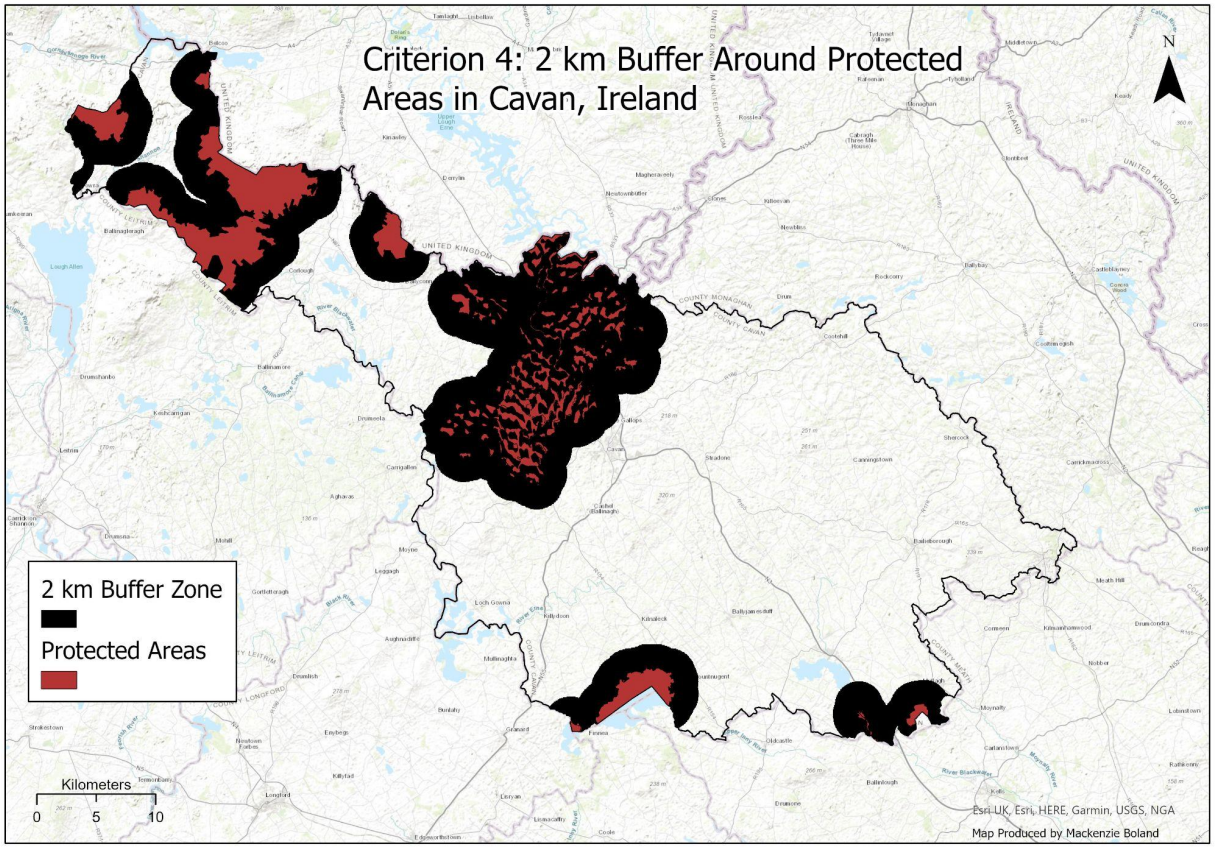
Criterion 4: 2 km Buffer Around Protected Areas in Cavan, Ireland
N
2 km Buffer Zone
Protected Areas
Kilometers
0
5
10
Esri UK, Esri, HERE, Garmin, USGS, NGA
Map Produced by Mackenzie Boland

Figure 5: C4

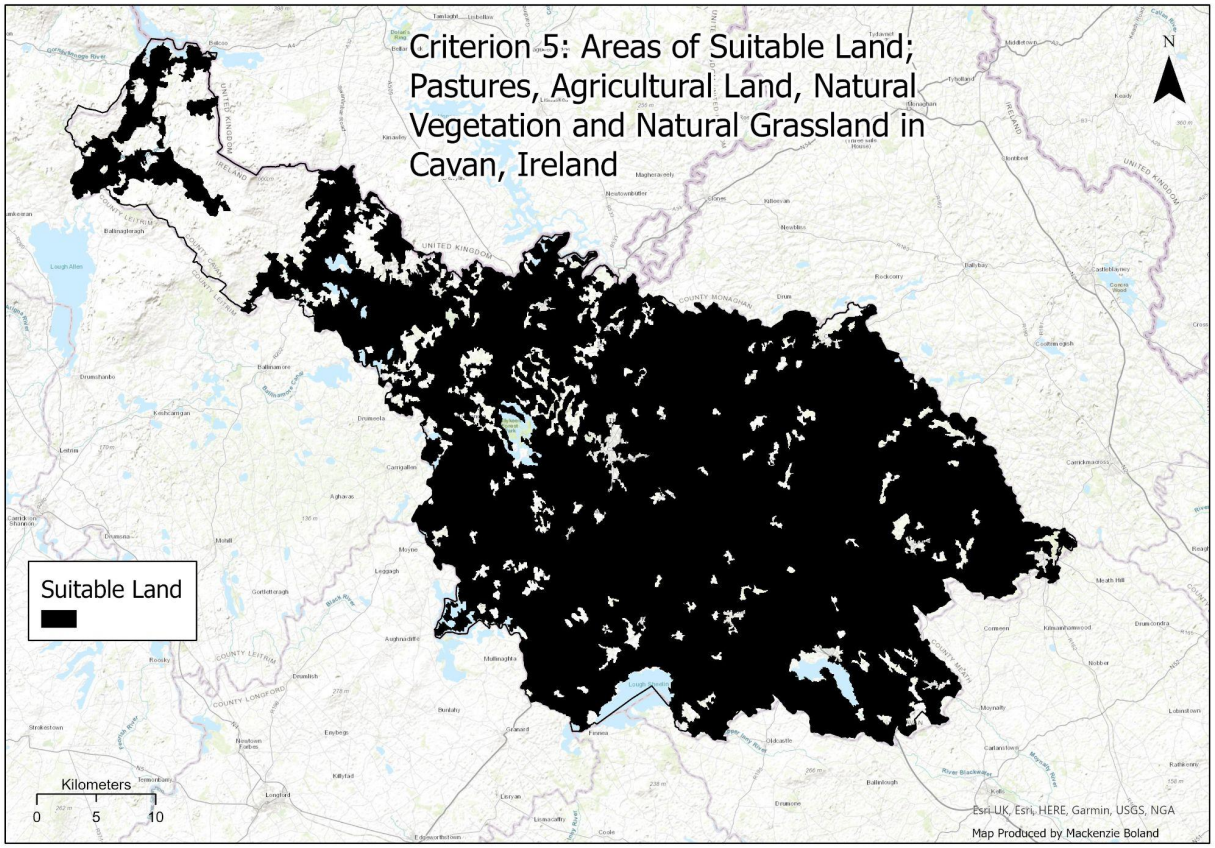
Criterion 5: Areas of Suitable Land; Pastures, Agricultural Land, Natural Vegetation and Natural Grassland in Cavan, Ireland
N
Suitable Land
Kilometers
0
5
10
Esri UK, Esri, HERE, Garmin, USGS, NGA
Map Produced by Mackenzie Boland

Figure 6: C5

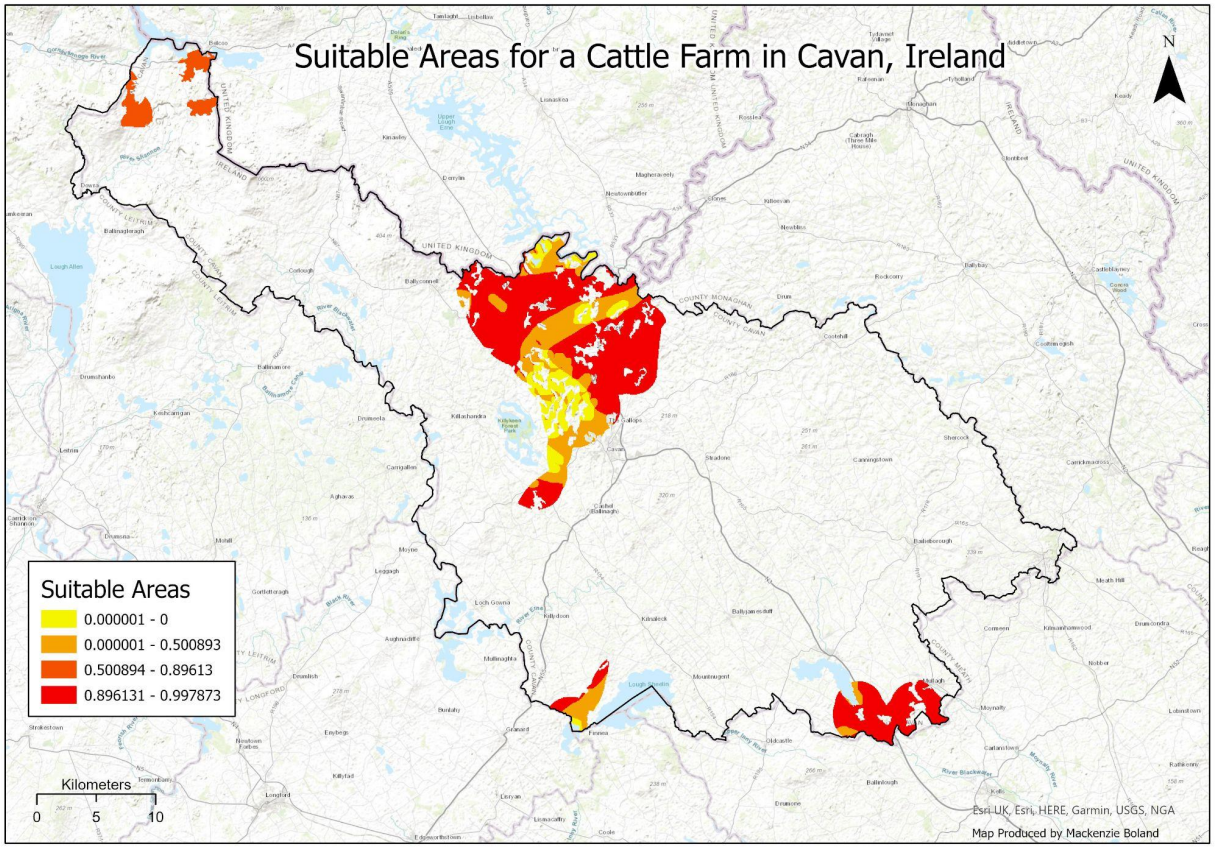

Figure 7: Suitable Areas

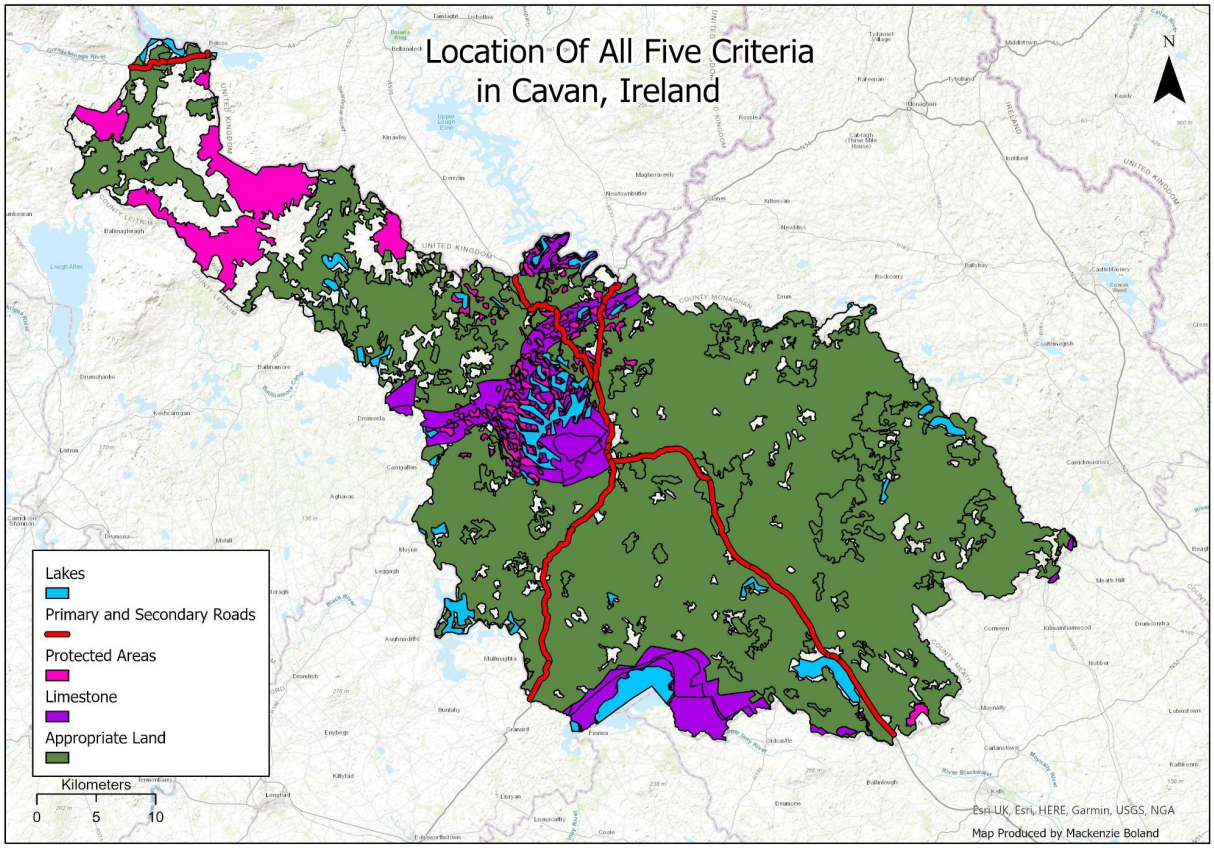

Figure 8: All Criteria

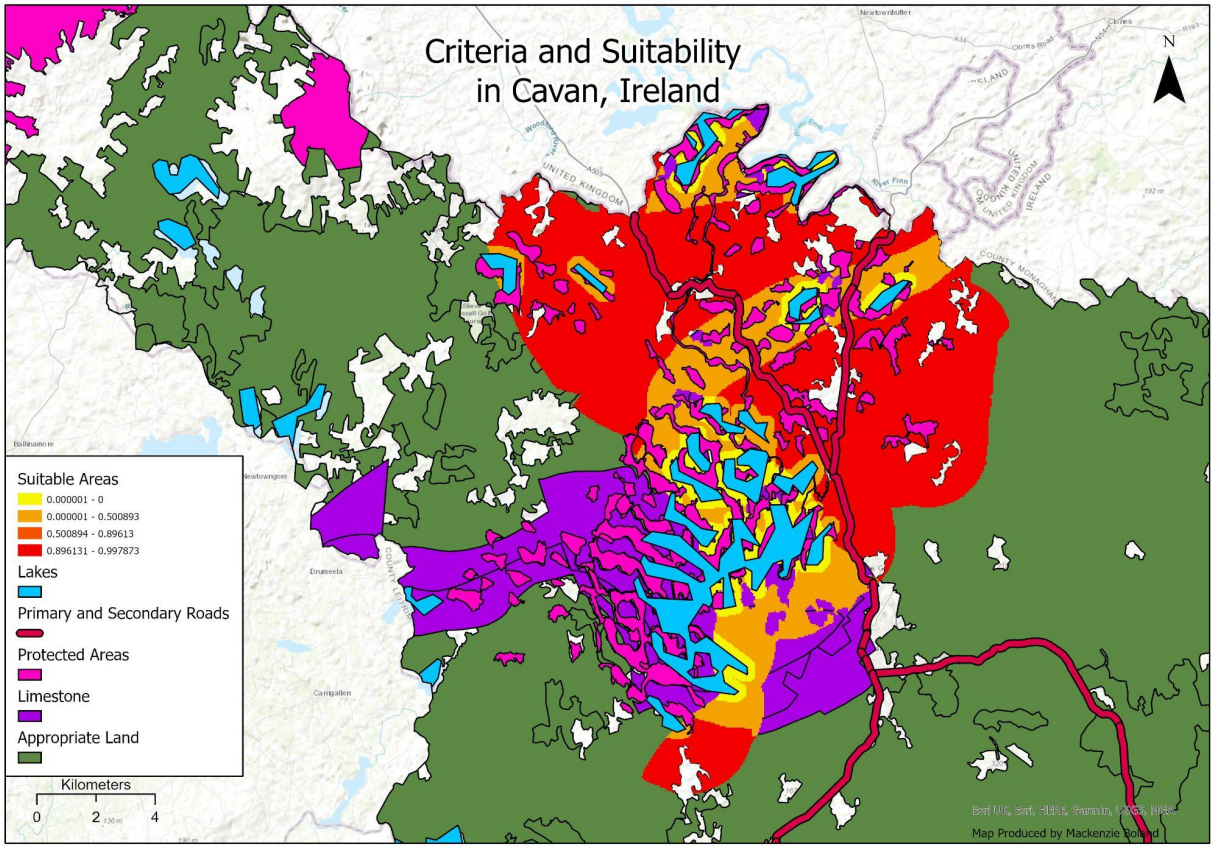

Figure 9: Main Area Suggested with All Criteria and Suitable Areas