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Proposed solution for Cycle path scenario

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Background

This report discusses the cycle path scenario. It proposes an efficient cycle path solution for the Leicestershire area.

This project will utilise GRASS GIS, this is a free geographical information system platform intended to provide the organisations and people with data management tools, geospatial evaluation, graphs and maps production, visualization, image processing, and spatial modelling functionalities.

Geographic information systems (GIS) are utilised to obtain, handle, analyse and manage data. GIS is essentially the creation of maps which enables users to visualize and interpret data. GIS is generally used in urban planning and routes planning, and how this impacts the people who live in surrounding areas. The significance of GIS is that it blends digital maps with traditional databases and delivers visual representations of information. Geographic Information Systems offer spatial modelling alternatives that accounts for the influence of various factors, for instance for cycle path creation it would analyse type of roads, distance, cost, and land uses. Geographic information systems have the potential to aid planning functions in both data processing and decision making, which enables better route planning. (I Zorica, 1994).

One of the problems geographic information systems has solved is the approach to determine the fastest delivery route. (Mohammad Abousaeidi et al, 2016) studied implementation of the Geographic Information System (GIS) modelling approach to decide the fastest and most efficient routes for fresh vegetable delivery. To calculate the most efficient route the GIS application contained 3 map layers, road networks, land use and population. All these layers overlap each other and need to be accurately classified to prepare the data for analysis. From GIS analysis the cost of different routes can be obtained. Then decide which route is most efficient based on the data obtained from the GIS. Similarly, for the proposed cycle path solution, there is a need for an efficient path. (Mohammad Abousaeidi et al, 2016) solution can be likewise applied to the proposed cycle path solution where these layers can be utilised to create a safe and efficient cycle path.

Geographic information systems can be used in cycle path planning. According to (Heinen et al, 2010), The cycling is one of the most alluring approaches to travel in a city as it is inexpensive, does not pollute, and consumes little energy; additionally, under some traffic conditions, it may be faster than other means of transport. Cycling has become more popular in cities as a form of transport that encourages sustainability and liveability. (Dimitris Milakis, 2014) studied the concept of applying participative multicriteria GIS analysis on cycle network planning. His methodology involved multicriteria analysis with deliberation and the help of GIS software for the quantification and mapping of urban and road environment characteristics. Dimitri's methodology included four stages. The identification of key metropolitan poles, the development of cycle route scenarios, the evaluation of the cycle route scenarios and the selection and quantification of the evaluation criteria. One of the main procedures of the study was the quantification of the criteria for each cycle route scenario using GIS software, this enabled better analysis of each route, also enabling the selection of the most efficient route. This can be applied to the proposed cycle path solution, where multicriteria can be used to create a suitable cycle route with the aid of GIS to quantify data.

Furthermore, Sevim Pelin Özkan, 2020 studied cycle Route Infrastructure Planning Using GIS in an Urban Area. His study involved the creation of a cycle path in an urban area of turkey, izmir. His methodology utilises many different layers and evaluation criterions to construct a cycle path. The study establishes the most suitable area for cycle route using multi-criteria decision analysis GIS environment. As cycle route planning requires dealing with various spatial data at the same time.

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The use of GIS provided him with a versatile environment to analyse all these data simultaneously, even though the data on demographic characteristics, users' preferences and physical infrastructure for cycling are limited, as in the case of Turkey (Sevim Pelin Özkan et al, 2020). The proposed solution could aim to solve the Shepshed and Loughborough solution in a similar way.

Cycling is known to be one of the answers to urban transportation challenges. The Local agency's recent survey has shown that many car journeys between Shepshed and Loughborough are being undertaken by single drivers, who could possibly cycle. (Shin Huoy Terh et al, 2018) "paper proposes a GIS-based path planning support framework that incorporates multiple criteria to address the questions of where to build cycling paths, and secondarily, whether and how the preferred cycling paths will change based on different stakeholders' preferences. The methodology utilised here is a use of a list of criteria's to be evaluated for planning of new cycling paths. The criterions are derived from research and the justification for their inclusion in the planning of cycling paths in Singapore". Similar for the proposed solution, a list of selected criterions can be used to evaluate possible cycle routes for instance minimal hills or away from major roads.

Requirements

The proposed cycle path solution will combine Dimitris Milakis, 2014, Shin Huoy Terh et al, 2018 and Sevim Pelin Özkan et al, 2020 methodologies.

Below is a set of selection criterions for the cycle path solution:

- A cycle path from Shepshed to Loughborough.
- Route must be cheap to build.
- Route must be separate from major roads.
- Route must be safe.
- Route must have the minimal number of hills along its course.
- Route should have good view.
- Route should be circular (Different return route back to Shepshed.)

Additional criterions:

- Less pedestrian traffic on cycle route
- Does not destroy rare species habitats and protect nature/ wildlife.

With the list of selected criterions, the Shin Huoy Terh et al, 2018 method can be used to evaluate the criterions, whilst also using GIS to quantify the criterions in the design section of this report.

'A cycle path from Shepshed to Loughborough'- this is one of the main criterions of this project. The Local agency's recent survey has shown that many car journeys between Shepshed and Loughborough are being undertaken by single drivers, who could cycle. Many drivers could take advantage of a good cycle route from Shepshed to Loughborough.

'Route must be cheap to build': this criterion about the cost of creating the cycle path. There are several costs that needs to be considered, for instance the path could be more expensive if its utilising main roads. The path must be cheap; this means the different land uses having to be analysed to retrieve the cheapest and most efficient path.

'Route must be separate from main roads' and 'Route must be safe': for the route to be safe it needs to be away from major routes to avoid potential accidents. The roads layer needs to be reclassed here so the different types of roads can be analysed. For the route to be safe and cheap to build the water and quarry areas should be reclassed as they are not safe for cyclists or cheap to build.

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‘Route must have the minimal number of hills along its course’: the path should attempt to avoid hills as much as possible, this is one of the essential requirements, this would make the route more attractive to cyclists. To construct this on GIS, a hills layer needs to be created- where costs can be assigned for the hills.

‘Route should have good view’ and ‘Route should be circular’. This requirement is to make sure that the route is more attractive for the cyclists, the route should have a different path back to Loughborough.

The additional criterions are used to make the cycle path more attractive and safer. Less pedestrian traffic would make the route safer for cyclists as pasture and arable areas are cheaper to build in, they are also more attractive. Moreover, there will be some layers utilised to ensure that the construction of the cycle path does not harm wildlife.

The landcov layer is one of the information layers that will be employed in this project. This layer contains several land-uses that can be reclassed to assign costs to the different land uses. This layer comprises of some land uses that is required within this project to create the most efficient route. For instance, a higher cost can be assigned to woodland, which would mean that there is a penalty (higher cost) building cycle route in the woodland’s areas. Using this layer, a restriction can be applied to the cycle path. From this layer, essential data can be derived, which could be used for analyses to ensure the cycle route is safe for cyclists.

Another layer that can be applied is the roads layer. Utilising this layer, major roads can be distinguished from minor roads by reclassing this layer. One of the requirements is that the cycle path should be separate from major roads, this layer can be used to assign a higher cost to motorway category so later when the GIS is calculating the efficient route it would avoid the route with major roads. This would also ensure the route is safe. From this layer, important data can be obtained to analyse the different types of roads between Shepshed and Loughborough.

Topo Layer is another information layer that can be considered. One of the proposed solutions requirements is for the cycle path to have minimal hills. The topo layer is the raster map that contains the digital elevation mode. Based on the ‘topo’ elevation map layer, a GIS command can be entered to produce an output file that contains the direction of local slope at each cell location. this ensures the path has minimal hills. It would be inefficient for the cycle path to be located on a hill and would be unattractive for some cyclists, therefore it essential that this layer is used to identify the hills between the Shepshed and Loughborough areas.

The image layer will be used to provide a satellite image of the Leicestershire area. This layer can give us a better view of the Shepshed and Loughborough areas.

Additional layers that will be used outside of what has been provided is the toads, otters, orchid and skylarks layers. From this layer, essential data can be derived that will enables the creation of a cycle road that does not harm wildlife or nature. These layers include rare and protected species and poisonous plants. For the safety of cyclists and the protection of wildlife these layers are utilised.

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DESIGN

For this project there is a list of selected criterions, below is the description of how its constructed using GIS, and factors that are considered.

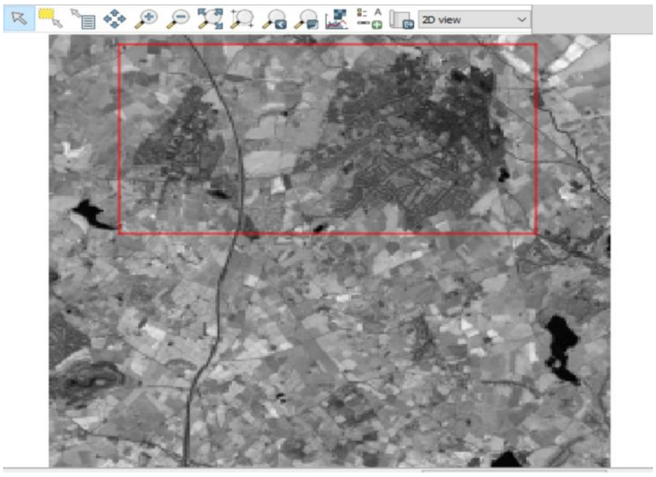
To begin the design of the cycle pathway on GIS, the image layer is imported. This layer gives us a satellite image of the Leicestershire area. Only the northern quadrant of the full study region is required since both the Shepshed and Loughborough are located within this sub-region. Also, handling smaller files enables better speed and enhanced efficiency. Fig 1 below illustrates the sub region where both locations are located.

The r. region functionality from grass GIS was utilised to specifically focus on the northern quadrant of the study region.

Command:

g. region n=321700 s=316886 w=445521 e=454408

Fig1



One of the main requirements for this project was that there should be minimal hills. Thus, there is a need to distinguish areas where, if the cycle path were developed, it would be travelling uphill. This needs to be avoided as it is unattractive to cyclists. Hence, by avoiding these areas, costs can be lowered and therefore the path could also be more attractive for cyclists. On the specific sub region defined in fig 1, there needs to be a method to operate the topo layer which includes the digital elevation model.

GRASS GIS has the capability to calculate and handle both slope magnitude and direction, the digital elevation model can be utilised by using command r.slope.aspect. The command below will produce the output file ‘elev1’, which contains the direction of local slope at each cell location.

Command:

r.slope.aspect elevation=topo aspect=elev1

The output file is saved as elev1 on the GIS manager layers (fig 2). This layer created contains the elevation model on the sub region as displayed on fig 3.

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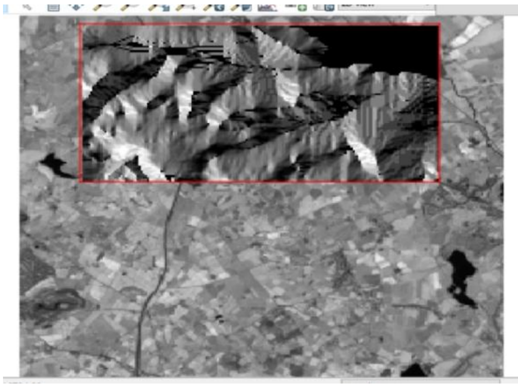
Fig 2

Fig 3



Furthermore, a cost must be assigned for creating the cycle path through any given cell, based on its direction of slope. This can be accomplished by re-classing the ‘elev1’ file’s values from degree intervals to either north or south sloping.

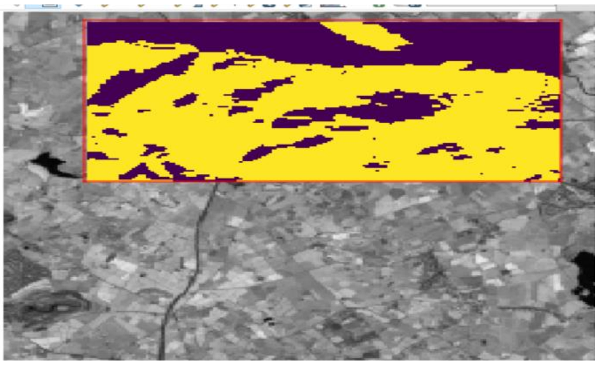
The reclass rule below is applied and a new layer is created called elevcost (fig 2). This elevcost is a new raster map layer which northerly slopes have a category value of 10 and southerly slopes and flat areas have a category value of 1.

The regular cost for placing the cycle path through a cell has been assigned a unit value of 1. Therefore, those cells that incur no penalty- they are cheaper to build a cycle path on. The cells containing up-hill slopes have been assigned a relative cost of 10 units. Later, when locating the optimal efficient path, the GRASS GIS software will attempt to find the most efficient path, whilst avoiding hills as much as possible. Fig 4 illustrates the elevcost layer, where the Darker (purple) areas represent the flat areas, whereas the lighter (yellow) area represents the hills.

Reclass rule:

0 thru 1 = 1 1 thru 180 = 10 181 thru 360 = 1 end

Fig 4



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This project acknowledges environmental effects of building a cycle path. Therefore, the cycle route attempts to avoid areas where constructing a cycle path would cause deforestation or destruction of nature and wildlife.

The cost of the creation of cycle path depends on the land cover over which it lies on. These costings can be generated by re-assigning values in the ‘landcov’ map layer and renaming the new layer as landcovercost.

Below is the rationale of why there are different figures for the land uses.

Firstly, the pasture and scrub lands signify areas with no difficulty building a cycle path, as they also have attractive sceneries which was requested by the local communities, therefore are assigned the base cost of 1 unit.

The Arable land is assigned a cost of 4 units, because this area may be utilised by farmers or owned privately, they may need to be bought/ leased or some cost paid to the landowners for the loss of crops during the installation process.

The Woodland is given an even higher cost rating 8 units, this is largely due the access to that area may be severely impaired. It may also be difficult to access that area if there is a potential accident, therefore it would not be the most ideal land conditions. A further reason for a higher cost is that the falling of trees and leaves could pose a little danger to the cycle path if not managed properly by the council. It could cause an obstruction to cyclists. It may also be difficult for emergency services to access this area if there is a need.

Finally, water must always be avoided since it is more expensive to build a cycle path to pass through these areas easily and cheaply. Building a bridge would be expensive and inefficient. Likewise, with quarry areas- due to its nature its unsafe for cyclists. They are assigned extremely large cost to these cells they are effectively rendered impassable barriers.

Greater distance from major roads can reduce exposure to the real and perceived dangers of vehicular traffic and to vehicular emissions. Therefore, its essential that the cycle path is away from major roads. To construct this on Grass GIS, the road layer is imported. The road layer displays all the types of roads on the region. Subsequently, they can be reclassed by giving the motorway category a very high value. The reclassed version will be called road cost. This reclassing action would make it so expensive and almost impossible to build a cycle path on the major roads. Minor roads are also assigned a cost, but they would be significantly cheaper to use than major roads.

Fig 5 below illustrates several additional grid files (raster layers) imported to create an even better and safer cycle route.

Fig 5

Once imported to the local GIS data folder, they need to be converted to a binary raster format. The ri.in.ascii command is used to convert the grass ascii raster file to a binary raster map.

Once this command is entered a modal pop up, which enable the file required to be imported and outputted in different format. All the above files went through this same process.

The r.reclass command is utilised here on all these files to reclass them.

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The Orchid layer represents areas where rare orchids grow. The orchids can provide excellent scenery as requested by tourists. However, some can be poisonous, and they are very rare. Building a cycle path along a rare orchid area would destroy the rare plants and could have environmental impacts. Hence, the orchid layer is reclassed zeros to nulls to create an orchid cost layer.

The Otter layer signifies territory currently occupied by otters. Otters hardly ever attack humans, but can occasionally be territorial, especially when they are protecting their babies. Constructing a cycle path would be destroying their habitats, therefore an Otters layer is imported to highlight otter areas to avoid building a cycle path on them.

The Skylark layer represents areas currently occupied by a diminishing skylark population. Its essential that skylarks are protected as their population is on a decline. Constructing a cycle route on a skylark home/area would destroy their homes and therefore endanger these animals. A skylark cost is created to ensure a path is not built that would affect skylarks.

The Toad layer shows the protected and rare species of toads. A cycle path through this area would endanger these rare species, the toads can be poisonous and toxic to humans. Constructing a path would not be a viable on toad habitat areas. Hence, the toad layer is reclassed to create a toad cost layer.

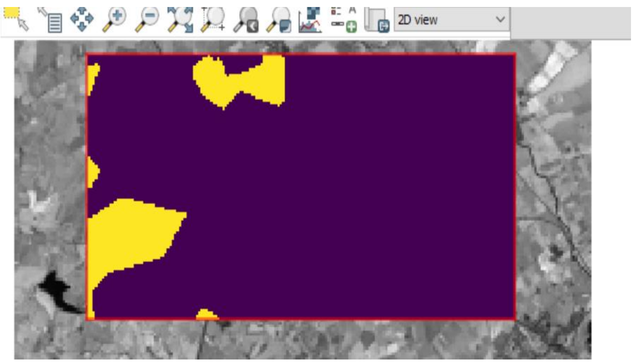
This project acknowledges the protection of wildlife and rare species. This cycle path avoids areas inhabited by animals to Protect species from extinction, maintaining habitats. The construction of cycle path on these locations would have numerous negative effects and may cause intinction of rare species.

Fig 6 below illustrates the sub region that includes Shepshed and Loughborough. To this sub region, all the 4 layers costs has been added together to display them all together. This is then stored in all@abdullahi. This layer includes the toad's cost, orchid cost, skylark cost and otter's cost. Once displayed on the GIS map display it should look like fig 6. The yellow areas represent areas that the cycle path should not go over. As these are areas where the toads, skylarks, orchids, and otters are located. The mapcalc command enables us to combine the raster maps to form a single map.

Command used:

r.mapcalc expression=all = toadscost@abdullahi + skylarkcost@abdullahi + orchidcost@abdullahi + otterscost@abdullahi

fig 6



Next, it is necessary to obtain a final combined cost for the surface. The final cost associated with any cell location can be produced by combining (simply adding on a cell-by cell basis) the separate hills, land cover, toads, otter, skylark, orchid and road costings. The mapcalc command is utilised here again.

Command:

The r.mapcalc command is utilised to pop up the calculator dialogue to enter the following:

r.mapcalc cost= landcovercost + elevcost + toadscost + otterscost + skylarkcost + orchidcost + roadcost

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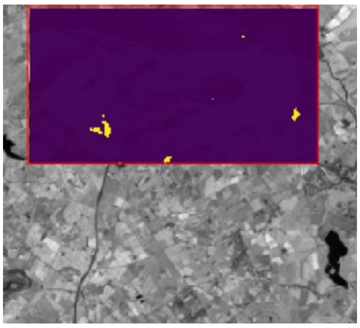
Below fig 7 illustrates the total cost for all layers utilised. There may only seem to be two main colours displayed on the image. This is because most of the disparity in cost occurs in classes under 20. Since the quarried area has a class of 1000, GRASS is unable to scale its colour table equally among classes.

After creating the cost layer, we can now produce a map layer which records the cumulative cost incurred by moving out radially, cell-by-cell, from the location of the first point of the cycle path. A cost-distance surface is generated in GRASS by using the r.cost command.

Fig 7



To utilise the r.cost command, it is necessary to give the geographical coordinates of the point from which you wish to calculate the cost-distance, which is starting point of the cycle path in Shepshed.

Command used: r.cost input=cost output=costdist1 start_coordinates=447353,319154

Subsequently, the GRASS command r.drain is used to trace the lowest cumulative cost route from the source cell to the target cell on the cost distance surface ‘costdist1’.

The path starts from a central area of Shepshed to enable easy access to all people living in Shepshed. It connects to minor road to allow people to access the cycle route. The ending of the cycle route in Loughborough ends at a minor road to indicate the end of the cycle route.

The command below displays the first path. It takes in the starts coordinates defined earlier and attempts to create the cheapest path to the end point of the cycle route. The -a enables the accumulation of the cost along the path and can thus be used to work out the total cost of the cycle route.

Command used: r.drain -a input=costdist1 output=path1 start coordinates=451779,319372

Fig 8

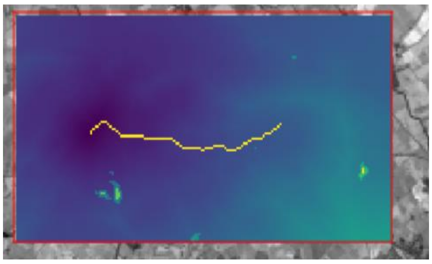


fig 8 displays the optimal route determined by GRASS for the proposed cycle path, based on the costings that were assigned to land cover, slope aspect, road, toad, otter, orchid and skylark categories. This below is the proposed path for route 1. As one of the requirements for this project is to have a circular route, another route is created following the same commands. Fig 8 illustrates the first cycle path from Shepshed to Loughborough.

This project utilises 2 diffrent routes to makes the route circular.To create the second cycle route, take few steps back to r.cost command. A new starting point is entered, like the starting point before.

Command used: r.cost input=cost output=costdist2 start_coordinates=447054,319641

Like before the r.drain command is utilised to trace the lowest cumulative cost route from the source cell to the target cell on the cost distance surface. Fig 9 displays the second cycle path from Loughborough back to Shepshed.

Command used: r.drain -a input=costdist1 output=path2 start_coordinates=451687,319760

Now after the cycle paths have been identified, it will be beneficial to find it relative to the different land use types. This is easily achieved by overlaying the cycle path onto the ‘landcov’ map layer.

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Using r.reclass command with the input raster map as path1 and output raster map as path11. The re-classing rule is to reclassify the old values to 9. Likewise, for path2, path2 is inputted and the output is path22.

Command used: 1 thru 50000 = 9 path end

fig 9

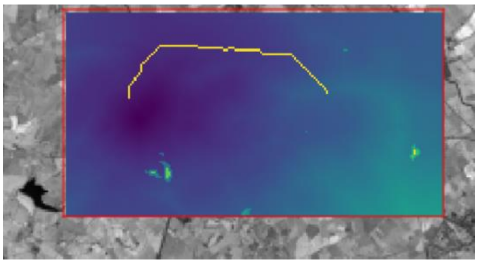


fig 10

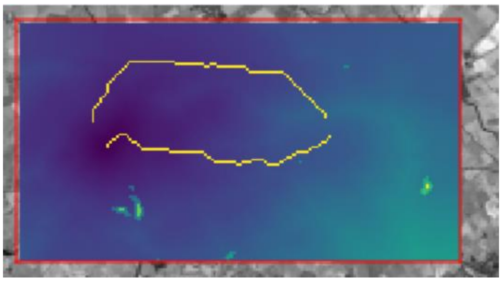
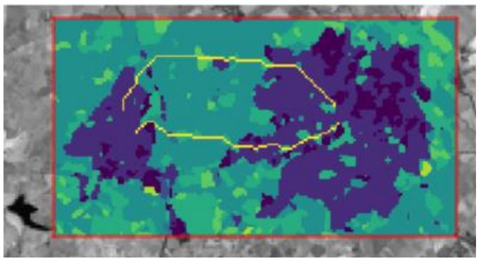


Figure 10 displays both cycles paths constructed. The local cycling and tourist communities have requested a circular route, meaning a route Shepshed to Loughborough and a different route back. The cycle path above utilises minor roads and is perfectly safe for cyclists.

To improve the presentation of the map above (fig 10), the overlay operation is performed. Utilising the r.patch command to combine the map layers. After the command below is entered an image like fig 11 should be displayed. The second path is very close to the first apth to make it somehwta a circular route, so cyclists have to option to use either of them routes for the journey between shepshed and loughborough.

Fig 11



Command used:

r.patch path11, path22 ,landcov output=finalpaths

Evaluation

The methodology utilised enables the calculation of the most efficient route. This method takes in all the cost layers created and calculates the cheapest route from Shepshed to Loughborough, which is the main requirement for this project.

One of the main advantages of this solution is that it considers wildlife and nature. The otters, orchid skylark, and toads' layers enables this solution to avoid these areas. This solution considers all environmental factors which in hand enables a better and environmentally friendly cycle route. Likewise, this project also considers land uses to ensure the cheapest path is used. The landcov layer is utilised on GRASS GIS to categorise and reassign values for different land uses. This ensures that the cycle path is not built on quarry or water areas as this are not safe and more expensive not built on. This layer also provides us with other land uses that can be considered for the construction of the cycle path.

However, in the proposed solution soil type was not considered. The soil type could have determined how comfortable the cycle route would have been for cyclists. A soil layer could have been used which includes the different soil types, then reclass them to assign costs to soil types depending on whether they are expensive or preferred by cyclists.

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Using GRASS GIS has some negatives as this software was developed over 30 years ago. However, this software has all core features that are required for this project. Grass GIS methods enabled the optimal efficient route based on the layers inputted.

The proposed solution considers the issue of safety. The roads layers are used to ensure the road types are categorised to make major roads very expensive and minor roads less expensive. This ensures the cycle path attempts to avoid roads. Nonetheless, this was quite difficult for the proposed solution, some minor roads were utilised. However, overall major roads were avoided which was a requirement for this project.

Moreover, this project acknowledges local communities and tourists' requests, the proposed solution ensures the cycle route as attractive as possible, the hills are minimised along the cycle route. This was one of the core requirements for this project. The topo layer is used on GRASS GIS to identify hills on the sub region, hence we can assign costs to the hill areas. Less hills would make the route attractive to more cyclists. Additionally, the prosed cycle route is somewhat of a circular route, it utilises two different routes from Shepshed to Loughborough. These two factors ensure that the cycle is as alluring to potential cyclists.

Nevertheless, the methodology could have been improved. A layer that calculates pedestrian traffic or population could have been utilised as part of multi criteria analysis for this project. It is common knowledge that areas with high pedestrian traffic increases possibility of collision and conflict which hinders cycling momentum. Therefore, this is a factor that could have been considered to enable safer route for cyclists. The demographics could have additionally been studied for this project; this may have led to a more efficient cycle route.

Furthermore, other potential factors that can be considered to enable a better cycling route include proximity to residential areas. A cyclist could be in an accident and to enable access for emergency services the route has to b reachable and not too far into the woods. Moreover, proximity to bus stops could have been considered, for instance, if a cyclist's bike breaks down or cyclists is late to work or anything, a bus journey could be utilised. A cycle route near a community amenity could have been considered as this would make the cycle route more attractive to cyclists.

conclusion

Overall, the proposed solution has managed to meet all the requirements. The GRASS GIS methods utilised in this project has enabled the quantification of diffrent factors and enabled the construction of an efficient and safe cycle route. GRASS GIS enabled us to view numerous layers simultaneously to aid in the decision-making process. This proposed solution combined various diffrent methodologies identified in the background section of this report. The use background research has enabled this project to combine diffrent proven solutions. However, this project could have utilised more layers to ensure an even safer and aesthetically pleasing cycle route. Nevertheless, the proposed solution considers all core factors that effect the construction of the cycle path. In additional, it considers requests from the local community and tourists to ensure the route is circular and attractive. Hence, overall, this project has been a success.

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