A GIS Based Transportation Model of Cemetery En Echelon

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Abstract: This paper aimed at designing a transportation model of Cemetery En Echelon, a nobel cemetery in the Giza plateau. Roads in ancient Egypt were classified to 2 types: 1) those designed and paved by the state, and 2) the paths naturally made by the regular movement of humans and animals. Transportation networks were modelled in ArcGis using network datasets. The study has concluded that the accessibility of tombs declined as the cemetery grew with a large number of tombs not being accessible gradually. Thus, funerary service must have been disconnected for those tombs. However, the large Mastabas, 26 in number, remained accessible till the end of site’s history.

Keywords: road network, visibility, GIS, Cemetry En Echelon, Giza

The present study is concerned with modeling a network of routes for the Giza plateau, concentrating our analysis on the area of Cemetery En Echelon (hereafter CEE). The approach, theory and results described below are illustrative. Clearly much work needs to be done before we have an understanding of movement mechanisms in ancient cemeteries.

Land roads[1] in ancient Egypt can be classified into two categories according to their construction method: those which originated from no particular plan and those which were actively designed. To the former category belong the *Begehungshorizonte* and paths, and to the later streets and routes.[2] Actual examples of manmade roads in Giza were attested in the workmen settlement to the south-east of the valley temple of Khafre where three streets were discovered.[3] 5, 2 m wide, these streets were broad by ancient standards. The main street, covered by a bed of limestone and marl gravel, would perhaps be the first ancient paved street in the world. While these streets allowed ancient workers a direct east-west crossing of the Gallery Complex, the access to outside the complex was provided by another route which led south on a path starting at the open gateway in the Wall of the Crow. On the other hand, no manmade streets or routes are known in the cemeteries of the Giza plateau either because their existence was not recognized in the course of archaeological excavations, or because the records of such features are still unpublished. Within the limits of our current knowledge, it could be assumed that the road network in the Giza cemetery consisted of natural routes which were created by the constant passage of men and animals which

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[1] Throughout this paper the term road was used as a general name for all land ways: streets, paths, routes etc.

[2] KÖPP, *Sokar* 18, 31; PARTRIDGE, *Transport in ancient Egypt*, 80; FORBES, *Notes on the history of ancient roads* , 57.

[3] LEHNER, *Giza reports* I, 42-44.

compacted the ground and clearly marked the way. The tracks of those routes would have been bordered by the existing buildings in the occupied areas of the cemetery.

1. Methodology

Transportation networks are modeled in ArcGis using network datasets. Since there are no multiple-level[4] roads in the present model, a simple shape file-based network dataset was sufficient for the current study. The road network was represented by a large grid of 2 x 2 m squares along the surface of the Giza plateau around the Khufu and Khafre pyramid complexes, an area about 1 km^2 in size, covering the western part of Cemetery En Echelon (hereafter WCE), the eastern part of the cemetery (hereafter ECE) and the potential quarry site.

1. A. Creation of Cost Surface

Two locations which are at the same linear distance from a source location may not be equally easy to reach: for one it may be necessary to walk uphill, while there may be only flat terrain to cross to reach the other. Movement can also be affected adversely by barriers such as fences, or cultural no-go zones, or positively by the availability of roads. Consequently, it was necessary to develop models of the time taken and cost incurred in reaching any given target location from a source location rather than just the distance. ArcGis offers the facility of generating cost surfaces. By using the result of a cost surface algorithm, the program calculates the least-cost pathway between any given location in the landscape and a wished destination. In the current study cost was modeled by: 1) The metric distance of the length of roads, and 2) Multi-criteria time measures which were computed according to the length of the road, the gradient slope of the road derived from a Digital Elevation Model (DEM), and the speed of humans. The walking speed of humans varies considerably depending on terrain slope, nature of walking surface and individual physical conditions like height, weight, age and gender. The average human speed is estimated however to be 106 m per minute[5] and this value was entered as an input in the current model.

1. B. Representation of Chronology

Integration of chronology within the road network model was of utmost importance recognizing the fact that earlier tombs must have formed barriers for the transport of materials for the later constructions. The dating was based study presented by Farouk[6] of Cemetery En Echelon which produced a numerical order for 237 tombs of the CEE. Though it cannot be claimed that the conclusions obtained from that study attempt are final or perfectly correct, this serial arrangement of tombs was taken here at face value because of the absence of any other comprehensive chronological framework which is an essential requirement to carry out this type of study. Since such an order can only be tentatively indicative, the 237 tombs were classified into 6 classes according to their position on the seriation graph. Each was assigned a numerical code. It was relatively unproblematic later to represent the dating of the other large features of the Giza plateau following this same

[4] Multiple level roads occur in urban areas where bridges, streets and tunnels interact in the same location.
[5] 6,4 kilometers per hour = 4 miles per hour.
[6] Farouk, M., *A GIS Based Study of Cemetery En Echelon* (Ph.D. dissertation, Freie Universität Berlin 2010).

numerical order as demonstrated in the following table.

Feature	Numerical code of dating class
Pyramid complex of Khufu	1
Main mastabas of WCE except those of CEE (a group of 99 mastabas)	2
Pyramid complex of Khafre and the and southern wall of WCE[7]	3
The first 26 mastabas of seriation graph	4
The following 48 mastabas of CEE on seriation graph	5
The following 48 mastabas of CEE on seriation graph	6
The following 48 mastabas of CEE on seriation graph	7
The following 47 mastabas of CEE on seriation graph	8
The following 20 mastabas of CEE on seriation graph	9
All other secondary tombs of WCE, CEE and ECE	10
Unoccupied roads	11

The 190 tombs of CEE which were not included in the seriation graph in addition to all the secondary tombs of WCE and ECE were given the code 10 as a dating class attribute. Such a code was assigned to those tombs only for the purpose of differentiation but was not used during the analysis as a dating class because the last mentioned tombs do not represent a homogeneous group. Whenever possible, those tombs were added individually as barriers on the network analysis layer. Intrusive shafts in the streets of CEE were also added as barriers during the analysis. A selection by location was made for the roads intersecting with the

[7] The position of this feature in chronology was taken here after the opinion of Reisner who believed that the CEE was constructed between the middle reigns of Khafre and Menkaure, see supra p. 97. It was also agreed that the southern enclosure of WCE was built during the reign of Khafre. LEHNER, *MDAIK* 41, 1985, 124.

tombs of each dating class and each road was assigned the same numerical code as the corresponding tomb. A parameter called (dating of tomb) was assigned to the restriction attribute in the network dataset properties. Other roads of the cemetery which do not intersect with any tombs were given the code 11 to indicate that they remained free of occupation. The restriction evaluator in the network dataset properties was then defined by the function: *dating class < dating class of tomb*. Before performing each operation of the network solver, the numerical code of the dating class of the tomb being considered as the destination in the analysis was entered manually in the parameter box.

2. Transportation of Tomb Construction Materials in CEE

Even long before the evolution of the modern location theory,[8] the preliminary evaluation of the economics of energy consumption must have played a central role in decisions concerning choosing the location of tombs. Energy consumption during tomb construction included the quarrying of materials, the costs for transportation and the effort expenditure related to the digging of the substructure and the building of the superstructure. While the effort expenditure was dealt with in a previous chapter, the current analysis focuses on analyzing the cost and energy consumption associated with the transportation of stone from an optimal quarry to the construction sites in CEE.

The transportation of stone in ancient Egypt was an enormously laborious task. What is known about how stone blocks were transported has been deduced from a few reliefs, tool models and construction ramp remains. Apparently, and based on the great number of representations, sledges pulled either by men or oxen were the main instrument for the transportation of heavy objects in ancient Egypt. Most representations of sledges show the transport of funerary equipment, such as *kA* statues, coffins, canopic boxes, and other shrines,[9] but there are also representations of the transport of building materials.[10] A graffito in Tura dating to the New Kingdom depicts the transport of stone on a sledge drawn by oxen.

It has been estimated that a ratio of three men per ton would be required for moving sledges over flat surfaces;[11] nine men per ton would be required for moving loads up a 9° slope. To what extent animals could have been used for pulling sledges is unknown. A relief from the quarries of Tura-Ma'asara[12] represents the hauling of a block, the size of which may be estimated to have been 1×1×3 meters (about 5 tons), on a sledge pulled by three pairs of oxen guided by three drivers. Examples from a modern quarry[13] show that twenty-eight animals could be properly arranged and guided. They would easily have had a pulling force of 150 to 200 tons.

On horizontal surfaces, multiple parallel tracks overlaid with wooden planks and rollers were also used. Since rollers are not easy to operate on uneven or soft ground, a double row of skid poles used to be inserted as tracks in the direction of movement. Arnold[13] concluded

[8] Location theory is concerned with the geographic location of economic activity; it has become an integral part of economic geography, regional science, and spatial economics. Location theory addresses the questions of what economic activities are located where and why. Location theory rests-like microeconomic theory generally - on the assumption that agents act in their own self-interest. Thus firms choose locations that maximize their profits and individuals choose locations that maximize their utility.
[9] FISCHER, *JEA* 67, 166, fig. 1; NEWBERRY, *Bersheh i*, pl. 15; BADAWY, *MIO 8*, 325, 332.
[10] G. Goyon, *BIFAO* 69, 11-41, pls. 3-5; Fischer, *JEA* 61, 33-34. fig. 2.
[11] ARNOLD, *Baukunst*, 265.
[12] DARESSY, *ASAE* 11, 263-265.
[13] From observations made in the marble quarries of Carrara in Italy: CONTI, *Marble*, figs. 134-137, 245, 248.

that the use of rollers and skid poles was restricted to work under such special conditions, whenever transport sledges had to be left behind. Friction was the main obstacle during transportation of stones, as heavy blocks would create a ground pressure over each square centimeter of their bases, and a greater force would be required to overcome the friction. Friction could however be reduced to nearly zero by wetting the track with a lubricant. Ancient scenes show that the surface of the ground was turned slick by pouring small amounts of water on it.[14]

Few comparable examples of roads that linked quarries to construction sites or to stone working areas have been discovered in Egypt. A rare paved Old Kingdom road connected the Basalt quarry of Gabal Qatrani to the lake Moeris.[15] Perfectly straight and 2,1 m wide at the best preserved area, the road was covered with slabs of sandstone and limestone and even some logs of petrified wood. This pavement facilitated the movement of sledges loaded with basalt stones along the 11, 5 km long road from the quarry to the quay for shipment by barge across the lake and on the Nile to construction sites. The transport network at the Roman quarry Mons Claudians has been studied by Maxfield and Peacock[16] who noticed that the stone would have been brought down from the quarries to Wadi level using slipways,[17] which were usually steep generally taking the line of the least resistance from the quarries to the Wadi floor. Numerous cairns, whose purpose is unclear, were placed at regular intervals along the route. Some slipways terminated with loading ramps. Footpaths are another feature of landscape at Mons Claudians. They zigzag up steep mountain sides leveling out when the desired height has been reached. They are substantially built and often reverted and in many cases have been used to transport porphyry.

Determination of the Optimal Quarry for CEE

Since all network analyst solvers require two main locations as inputs, the origin and the destination, one or more quarries should be determined as the provider for stones for the CEE. There are a number of potential quarries located in several sites on the Moqattam formation (map1). The below listed quarries have been observed by Reisner[18] and Lehner.[19]

2. A.1. Quarries Located in the Area to the North of Khufu Pyramid in the ECE

1. Just north of the First Pyramid the edge of the rock platform can be followed roughly. Reisner believed that this edge had been quarried back, though the scarp was covered with a mass of masons' debris thrown out when the pyramid enceinte was cleaned up after the construction of the First Pyramid. Lehner[20] has questioned the existence of a quarry in this location because the rock forming the nummulite bank is not suitable for extracting building stone.
2. Following the edge of the cliff around to the east, an indeterminable amount of stone has been quarried away and the face of the rock scarp was taken by rock-cut tombs, generally of the Fifth and Sixth Dynasties.

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[14] NEWBERRY, *El Bersheh i,* pl. 15*; Badawy, MIO 8,* 325-332.
[15] HARRELL and BOWN, JARCE, 71-91.
[16] PEACOCK and MAXFIELD, *Mons Claudianus,* 259-61.
[17] Man-made, steeply sloping road used for moving of stones to a lower area.
[18] REISNER, *Giza* I, 12.
[19] LEHNER, *MDAIK* 41, 109-143.
[20] LEHNER, *AFO* 32, 148.

3. Directly in front of the great pyramid, from near the northern small pyramid of a queen to the edge of the cliff, runs a quarry which has been partly filled up with the masonry foundations of the Khufu causeway, and partly occupied by mastabas (G 7810 and 7820) and the tombs of funerary priests of the Sixth and Fifth Dynasties.

2. A.2. Area South of Khufu Pyramid and East of Khafre Pyramid

4. The area to the south of Khufu pyramid (B 24[21]), beyond cemetery GIS. While this quarry may have been started under Khufu, it is probable that it was exploited under Khafre.
5. A quarry in the south east corner of the Khufu pyramid (B 9- C 12) for supplying the construction of the ECE. Most of this quarry must have been excavated under Khafre, but it is possible that the eastern half could have been begun under Khufu, thus it might have supplied the construction of the great pyramid as well.
6. A large basin quarry (B10) located 600 to 300 m south of Khufu pyramid in the western part of the central field. The quarry measures 230 east-west at the widest part, and at least 400 m north-south. The depth and size of this quarry allows the conclusion that it was the source of the local limestone used for the building of the Khufu pyramid.

2. A.3. In the WCE

No quarries in the WCE were noticed by Klemm during his survey 1986-1987 because they were either overbuilt by secondary tombs or filled by debris.[22] According to Reisner, however, two quarries are located on either sides of the south enclosing stone wall of the WCE:
7. The old Khafre quarry to its south.

8. Another quarry examined by Schiaparelli to its north. The exact borders of the Schiaparelli quarry are not clearly published. Reisner[23] mentioned however often that it is located to the west of G 6000 in the space which would have been occupied by the extension of the three southern lines of G 4000.
9. A small basin quarry about 170 m west of Northwest corner of Khafre pyramid (B 8), measuring about 140 (NS) x 80 m (EW).[24] It appears to date earlier than Khafre´s reign because the Northwest corner of the so called workmen barracks is partially built over this quarry. It is assumed that this installation is contemporary with the building of the Khafre pyramid.[25]

2. B. Origin-Destination Cost Matrix

Because network solvers accept only point shape files as inputs, the above mentioned potential quarries were represented on the map by points located at their centroids. To determine the optimal quarry for the tombs of CEE in terms of the minimum effort used for the transportation of stones, an Origin-Destination cost matrix was created. The cost factor

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[21] Numbers between brackets refer to the isometric projections made by Lehner, MDAIK 41, figs. 3B and 3C.
[22] KLEMM, *Steine* , 54.
[23] REISNER, *Giza* I, 13, 14, 25.
[24] Another nearby quarry has been described by Lehner (MDAIK 41, fig. 3A) by being located to the west of A Since point A 8 is located on the Maadi formation, this must be a mistake of Lehner .
[25] MARAGIOGLIO and RINALDI, Piramidi Menfite, 96-7, 132-133.

which was used in this case was the metric length of routes multiplied by the slope of land. The network solver takes thus three factors into consideration while performing its calculations: the proximity of the quarry to the stone delivery destination, the barriers existing between both and the slope of the terrain. Those factors are the only indicators of effort of the transportation of stones available for the current research. A more precise estimation of effort would require a study of the nature of the ground in different areas of the Giza plateau and should involve practical experiments to determine the friction of wooden sledges on sand per square meter and the local factors affecting the transportation process.

The Origin-Destination Cost Matrix is actually a categorization of the potential destinations for each origin according to the effort invested in reaching them. The output of this tool can be represented visually to demonstrate which destination is to be reached from the given origin using the least possible effort and vice versa. This operation was carried out for tombs of CEE categorized to the six dating classes listed in the above table. Map 1 shows the matrix represented visually by lines[26] for the first 26 tombs of CEE. It could be noticed that the least effort is associated with quarries number 1 and 8. A similar result was obtained when performing the same operation with the remaining five dating classes of CEE. The use of more than one quarry simultaneously is possible. Reisner once remarked: It is obvious that the various beds of stone were being worked practically simultaneously during the construction of the nucleus cemeteries.[27] The means of effort estimation for the transportation of stones from quarries 1 and 8 during the different dating classes were represented on a line graph (graph 7.1). The difference in effort estimation between the two quarries in the first phase leads to the conclusion that that quarry number 8 was used as the source for stone for the first 26 mastabas of CEE. For stages 2 through 6, it could be noticed that the effort estimation to reach both quarries was in the same range so that it probably did not cause a significant effect on the decision concerning the choice of the source of stone. Archaeological evidence of the use of quarry number 8 exists in a form of a transportation ramp[28]. That rubble ramp traverses the CEE coming from the space between cemetery G 4000 and the great southern boundary wall of WCE passing diagonally across the unoccupied site of G 4810, along the back of G 4920, between that core and 4930, eastward between G 4920 and 4930, over the northern addition to G 5020, under the later mastaba G 5131 (built against the southern end of G 5130) and so to the back of the large mastaba G 5230. According to Reisner, this ramp was later in date than the three En Echelon lines, and previous to the construction of the later mastabas G 4811, G 5131, and G 5230. The destination of the transported stone is obscure, though Reisner suggested it might be mastaba G 5230, a mastaba which belongs to dating class 2 in our proposal. When an Origin-destination cost matrix was created for this tomb entering its dating class as a parameter, the results assured that quarry number 8 is the best reachable source of stone, in terms of least effort (map 2). Using the best route tool from a point in quarry 8 to the back of mastabas G 5230 produced an itinerary for the transportation of stones similar to the real road described by Reisner (map 3). The difference between the two roads is most probably due to the undated secondary mastabas between the main cores of cemetery G 4000, whose dating is beyond the scope of this study. It seems though possible that the space between cemetery G 4000 and the southern wall of WCE was free of occupations at the time of the construction of G 5230, while the spaces the fifth and sixth rows of G 4000 were already occupied by secondary mastabas standing nowadays in that location.

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[26] The lines on map 7.1 do not represent routes, they only represent the relation between the origin and source in means of the given effort factor.
[27] REISNER, *Giza* I, 38.

A consideration for the typical scenario of the transportation process which took place during the installation of the body and the funerary equipment would be useful in this context. Our knowledge about the conveyance of the body of the deceased to the burial location is provided by tomb scenes of the Old Kingdom, as well as by the more elaborate scenes of the same type dating to the New Kingdom.[28] Bolshakov[29] presented a list of 16 tombs containing all attested Old Kingdom burial scenes. Successive performances during the burial rituals included many transportation intervals, normally beginning on the east bank of the Nile and crossing over on ferries to the cemeteries on the west. The next step was carrying the coffin after disembarking it from the ship on a bier to a special structure called *ibw*,[30] where the purification rituals took place. Following purification the body would be taken to the embalming workshop *wabt*, where, assumingly, it was left for a period of time[31] until the mummification was accomplished. In more detailed scenes, the now mummified corpse would be placed upon a sledge covered by a shrine and drawn by oxen to the tomb, with a second sledge following to transport the chest containing the viscera[32] The adequate route capacity to handle large numbers of pedestrians at one time must have been considered an advantageous quality since the funeral procession was accompanied usually by large crowds of people including mourning women, a number of servants carrying items of tomb-furniture and a detachment of several officials and priests. On the arrival at the tomb, the bier would be greeted by ritual dancers and by the lector priest. A large proportion of the materials transported during private funerals consisted of large items such as beads, chairs and furniture-boxes. Cosmetic equipment, toys, musical instruments, tools and weapons are also known to have originated from tombs. Even long after the burial took place accessibility of the tomb was essential to maintain the cult. Inscribed offering formulas attested from the Fourth dynasty onwards presupposed, realistically or otherwise, that people would visit the necropolis and would read and activate the offering formula.[33] Regular real offerings on the other hand were supplemented by visits of family members or cult personnel to the tomb.

In the following we will focus on measuring the revealed spatial accessibility[34] of different areas in the CEE during the six dating classes to measure the variations in access to and from tombs.[35]

Among the approaches which have been developed in various disciplines to set accessibility measures are the floating catchments area[36] and the gravity-based methods.[37] The gravity based method seems to be more theoretically sound than the two-step floating catchments area because it reflects a continuous deterioration of access in distance, rating a nearby destination

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[28] SPENCER, *Death in ancient Egypt*, 51.
[29] BOLSHAKOV**,** *GM* 121, 31-54.
[30] HASSAN, *Giza* IV, 69-72.
[31] On the period between death and burial: WILSON, *JNES* 3, 201ff.
[32] Old Kingdom scenes: DAVIES, *Deir el Gebrâwi* I, pl. 10, 7, and another scene of a funeral procession on the papyrus of *Hn-nfr* 19th dynasty: SPENCER, *Death in ancient Egypt*, pl. 7.
[33] BAINES AND LACOVARA, *Journal of social archaeology* 2(1), 12.
[34] For types of accessibility: WANG, *Applications in GIS*, 78.
[35] For accessibility study cases in archaeology using GIS: VAN DER ELST, 'Low budget geospatial methods', 465-471.
[36] RADKE and MU, *Geographic Information Sciences*, 6(2), 105-112.: LUO and WANG, "Measures of spatial accessibility", 865–884.
[37] HANSEN, "How accessibility shapes land use", 73-76; JOSEPH and BANTOCK, "Measuring Potential Physical Accessibility"**,** 85-90, SHEN "Spatial technologies", 447- 464.

more accessible then a remote one.[38] The equation model which was used in the present study is

$$A_i^{\mathrm{H}} = \sum_{j=1}^{n} S_j d_{ij}^{-\beta}$$

Where S_j is the number of accessible tombs at location j, $d_{i\,j}$ is the travel cost (defined here by distance) between a pedestrian location i (a fixed point in the southeast corner of CEE) and tomb location j, β is the travel-friction coefficient, and n is the total number of tomb locations. Applying the last mentioned method as an accessibility measure for the present case requires the definition of a key parameter: the travel-friction coefficient β. A larger travel-friction coefficient β-value implies that persons are more discouraged by longer travel times in visiting tombs and vice versa. Since finding the actual value of this parameter requires travel data which are inaccessible for the current study, reasonable values for β ranging between 1 and 2 were defined, and sensitivity analysis was conducted by experimenting with those values. The final results presented for the current analysis were derived using a travel friction coefficient value of 1. That value did not only simplify the calculations required for the analysis but also expressed the statement of the above mentioned equation directly and in a simple manner: accessibility of different areas in the cemetery decreases as distance from origin increases and as accessible tombs in each dating class become less in number.[39] This simple accessibility measure emphasizes the proximity of the destination to the origin.[40]

The results obtained from the gravity -based method for the accessibility index for CEE during the 6 dating classes were represented on graph 7.2. To avoid misunderstanding the graph it is necessary to stress that the values calculated for the accessibility index are dependent on the number of tombs built during a dating class. In other words the graph is partly representative for the number of accessible tombs of each dating class along the history of the cemetery. A common observation about the 6 dating classes is the decline in the accessibility condition for their tombs over time. While this decline was drastic for the last 5 dating classes, the first dating class, that is the first 26 mastabas built in the cemetery, preserved for a long period a good accessibility level. Most of these large mastabas could be approached until the last phase of the cemetery development.

The results of the above illustrated accessibility index remain however tentative, since they are sensitive to many parameters whose determination is beyond the means of a theoretical study. The dependency on the tentative chronological frame is yet another weakness for such an approach. It may be more visually indicative to represent the tombs of CEE as accessible versus inaccessible during the last phase of the cemetery: i.e. in their present condition. To achieve this, the polygon of each tomb was transformed to four points representing its corners. The intrusive shafts of the cemetery were uploaded as barriers and dating class 11 was entered. A network solver was then run and results were represented on map 4. Since

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[38] On examples of the applications of gravity models see: MORYADAS, *The Geography of Movement,* 182. A similar version of a gravity-based model is discussed by CROMLEY and MCLAFFERTY, *GIS and Public Health*, 233-258.

[39] A similar version of a gravity-based model is discussed by CROMLEY and MCLAFFERTY, *GIS and Public Health*, 233 - 258.

[40] BRABYN and GOWER also used minimum travel distance to the closet service provider to measure accessibility: BRABYN and GOWER, ‘Mapping accessibility’, 289-307.

each tomb is represented by four points, it is possible to determine from which direction each mastaba was accessible.

3. A. The Journey of a Priest

Let us now reconstruct the walk of a priest named *nfr-mHi* (G 2391) through the CEE. *nfr-mHi* was a *Hm-kA* priest who belonged to the second generation of a family whose members were in the service of the great *snDm-ib* family. It is reasonable thus to assume that *nfr-mHi* visited the CEE on a regular basis to maintain the cult of his patrons and of his own ancestors. No textual evidence exists that would allow us to determine exactly the tombs of s*nDm-ib* family for whose service *nfr-mHi* was engaged. Nevertheless it will be assumed here that he visited the tombs of this family whose owner's identity is well attested (G 2370, G 2378, G 2374, G 5560, G 2381, G 2381 A). In his capacity of a Hm-kA, nfr-mHi would bring offerings and perform rituals such as burning incense and pouring libations, carrying out the rites of ‘removing footprints’ and ‘making glorification‘ as scenes which depict the funerary cult rituals during the Old Kingdom demonstrate.[41]

The journey of the Giza plateau visitors must have started in the valley, where many peasant villages would have been located. In his reconstruction of the Giza plateau landscape, Lehner[42] proposed the existence of two conjectural villages on a topographic high at the site of Nazlet El Batran, about 1 km to the southeast of the valley temple of Khafre. Presumably the visitors had to cross water bodies as well in their journey to the Giza plateau. The Old Kingdom scenes frequently show the funeral cortège crossing a body of water.[43] In the proposal of Lehner there are many water canals to the east of Giza plateau. Even without this illustrated reconstruction of the landscape at Giza, Wilson noticed long ago that it was impossible to go very far in Egypt without crossing some body of water.[44] A priest who served a tomb in the WCE would thus have travelled from his village in the valley crossing one or more water canals. He would then walk uphill the slope of the plateau passing by the ECE, than the GIS cemetery, until he reached his target in WCE. A point in the site of Nazlet El Batran was taken to be the origin of the journey in the present analysis. For the visual illustration of the proposed route, the 3 D Isometric projection of the Giza plateau executed by Lehner[45] was mixed with an ArcScene view (pl. 1). To simplify the ArcGis operations during the analysis, the road was modeled by a single line which was linked to the road network of the plateau.

nfr-mHi would thus approach the CEE from the south eastern corner. That area, being less occupied with constructions, was most probably more adequate for pedestrians who visited the cemetery as a whole. Though nfr-mHi himself would reach the cemetery walking, as the major means of getting around for short distances in ancient Egypt was by foot, he would have also brought some objects and offerings which require a beast of burden. For the transportation of objects during the Old Kingdom, donkeys were utilized. They would be loaded with burdens divided into equal portions on either sides of its saddle as portrayed by numerous tomb scenes.[46] *nfr-mHi* probably witnessed the cemetery in its final stage of

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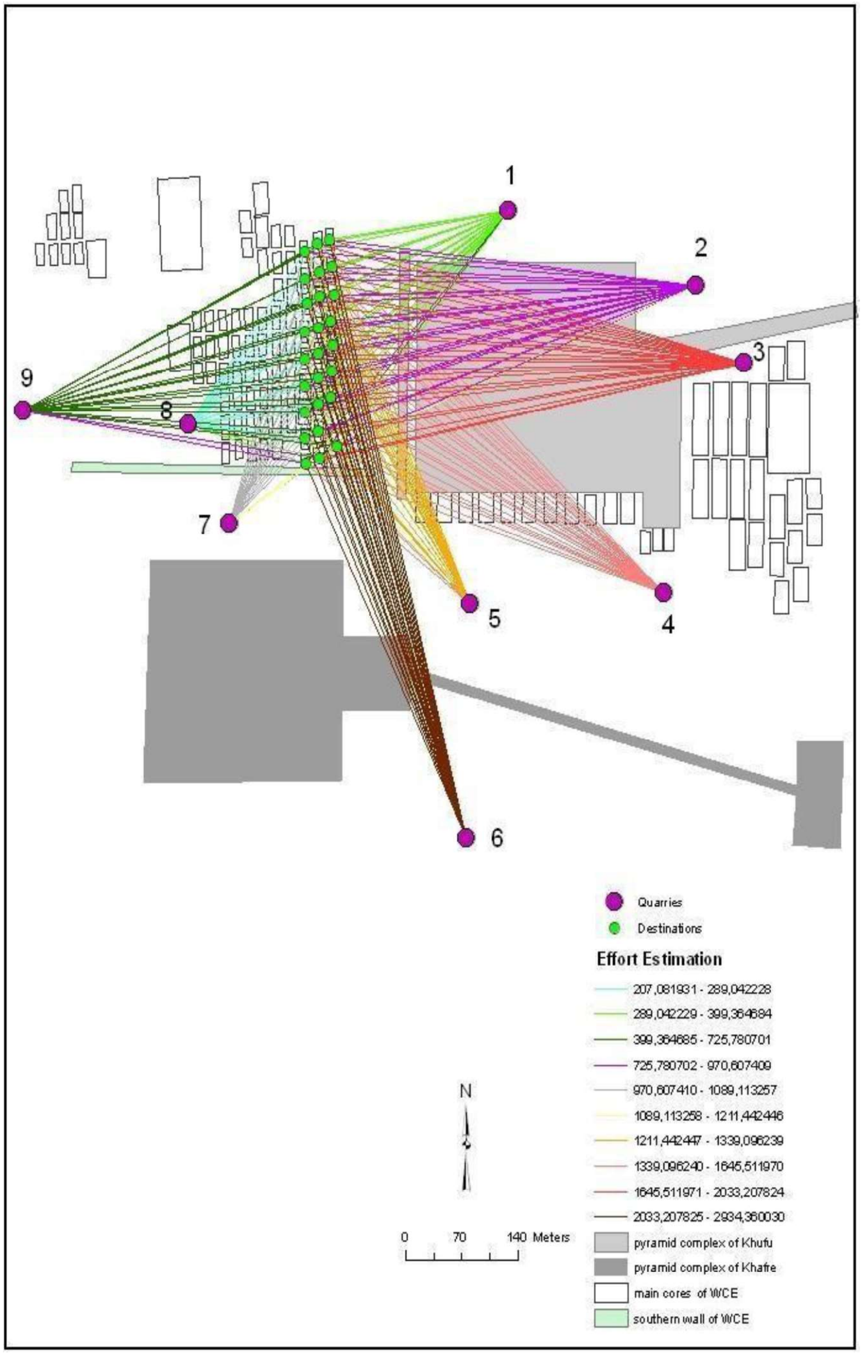
[41] For examples of such scenes: FITZENREITER, *OLA* 103, 67–140.
[42] LEHNER*, MDAIK 41*, 137, C25 and C26.
[43] For instance: MACRAMALLAH, *Le mastaba d'Idou***t,** 8; DUELL, *The mastaba of Mereruka* pl. 130.
[44] WILSON**,** *JNES* 3 , 205.
[45] LEHNER, *MDAIK* 41, fig 3C.
[46] JANSSEN, *Egyptian household animals*, 37.

development. The cemetery would have then been fully occupied by tombs in an appearance similar to its current state, though there would have been of course less intrusive shafts intruding into the streets here and there. The destinations were represented by points located in front of the entrance to the seven chapels[47] of the six above mentioned tombs of the snDm-ib family and the mastaba of the *nfr*-mHi family (G2391). Maps 5, 6 and 7 demonstrate the itinerary of the journey during different dating classes. With dating class 9 the course of the route was direct represented almost by the linear distance between the destinations. The first stop in nfr-mHi´s journey would be the tomb of *f*tk-ti (G 5560). The priest would head then to the complex of snD-ib where he would visit the other 5 tombs of the family. He would finally proceed to his last stop: the tomb of his own family (G2391). As time passed, the sons of nfr-mHi, who were most probably responsible for the service of the snDm-ib family tombs as well, had to travel a longer distance to reach the same tombs. Map 6 demonstrates the route between the same stops when dating class 10 was used. Now the visitors had to make several detours taking turns around the new tombs. Their walk would even take them outside the limits of CEE, going as far as the eastern border of mastaba G 2000 to reach their target.

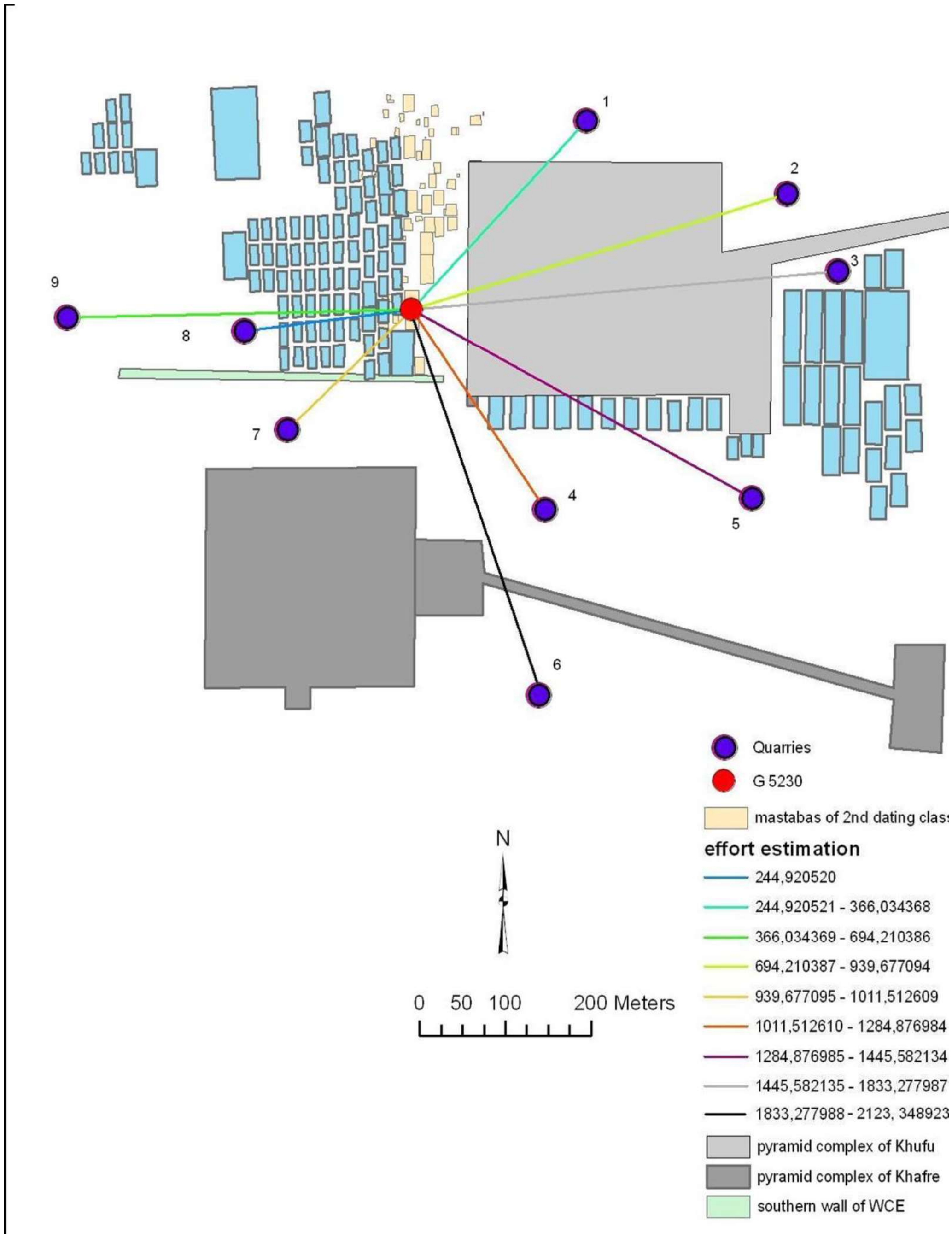
The increasing complication of the route must have continued until it caused the *snDm-ib* complex to be inaccessible from the southeastern corner of CEE. To represent the accessibility condition for the complex in the final phase of the cemetery dating class 11 was entered and all the intrusive shafts of the cemetery were used as barriers for the network analyst route solver. The result obtained assured that it was not possible to reach the complex from the south when the cemetery reached its current state. Theoretically there would have been an access to the complex by walking along the southern wall of CEE until its end, turning to the west around the Abu Bakr cemetery and then returning all the way down to the eastern edge of the western cemetery, where it would be possible to reach the complex from the north eastern corner. It is worthy of attention too that during the final phase of the cemetery, the mastaba of *ftk-ti* became to be isolated from the snDm-ib complex, so that it was not possible any more to serve all the tombs of the family during one visit to the cemetery. The fact that several visits were now necessary to perform cult maintenance must have increased the effort required and consequently the expenses invested as well.

The complicated accessibility conditions were not limited to the snDm-ib complex but were common to the entire area of CEEN as another similar case demonstrates. nfr-Htp was responsible for bringing offerings to the tomb of *pn-mrw* (G 2197) from his iti sSm-nr III. The exact origin of such offerings is not explicitly mentioned, but it had been suggested that it might be the tomb of sSm-nfr III (G 5170). If so, nfr-Htp and his successors in the service of pn-mrw had to pass by the tomb of the later each time they headed to the tomb of their employer. Such a mission remained possible for a long period following the death of *pn-mrw* whose tomb belongs to dating class 5. Map 8 shows the itinerary of the proposed journey using dating classes ranging between 5 to 10. When the dating class 11, which represents the cemetery at its full growth, was however entered, both tombs became inaccessible.

[47] G 2381: the chapel is not fully detectable but the point was inserted on the northeastern corner of the mastaba following the proposal of Reisner for the reconstruction (*snDm-ib,* 150, 1). G 2381 A: the point was placed east of serdab of G 2381, where the entrance of G2381A was located according to Reisner (*snDm-ib*, 185).

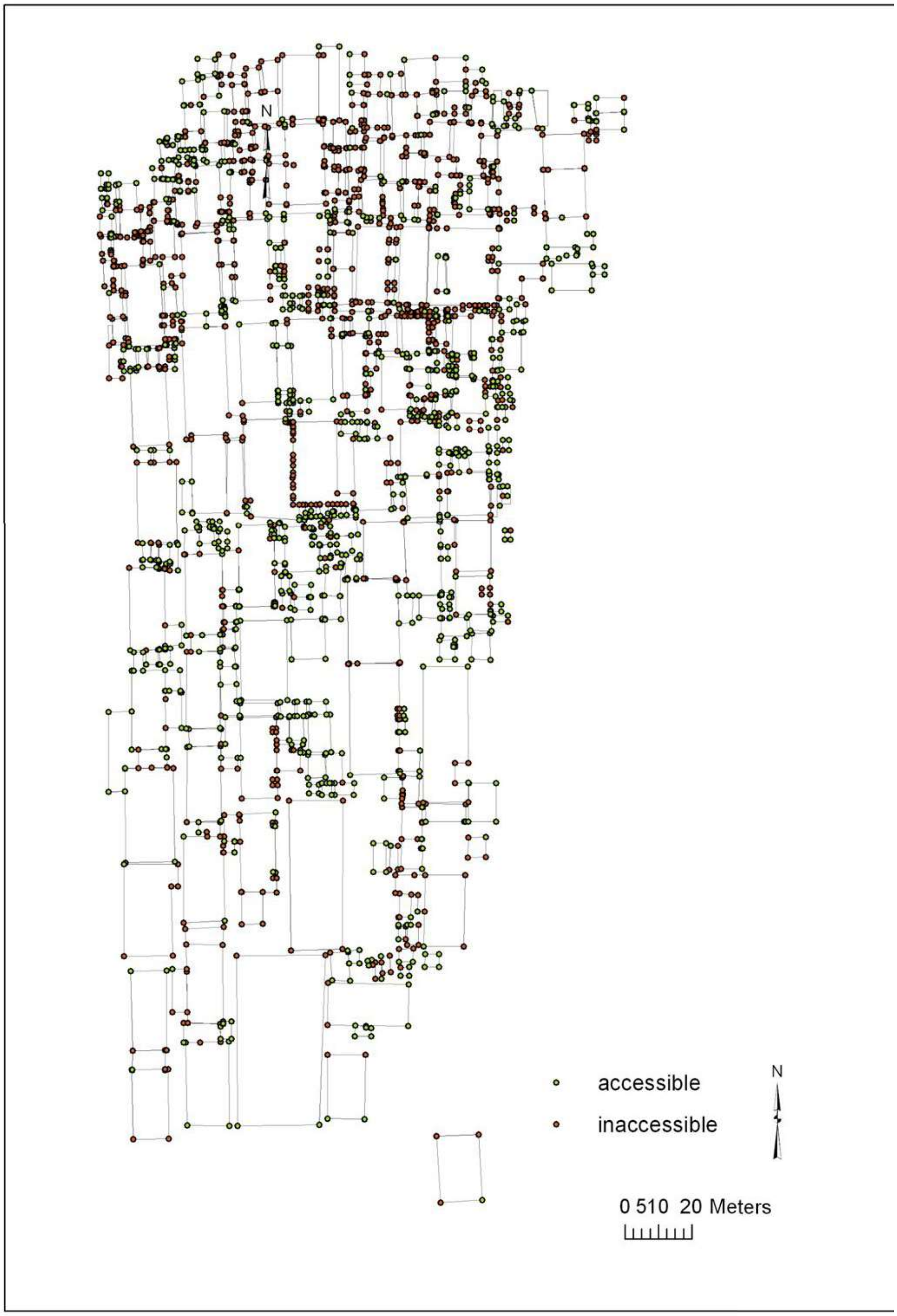


Map 1: Effort estimation for the transportation of stone from 9 quarries to the first 26 mastabas of CEE

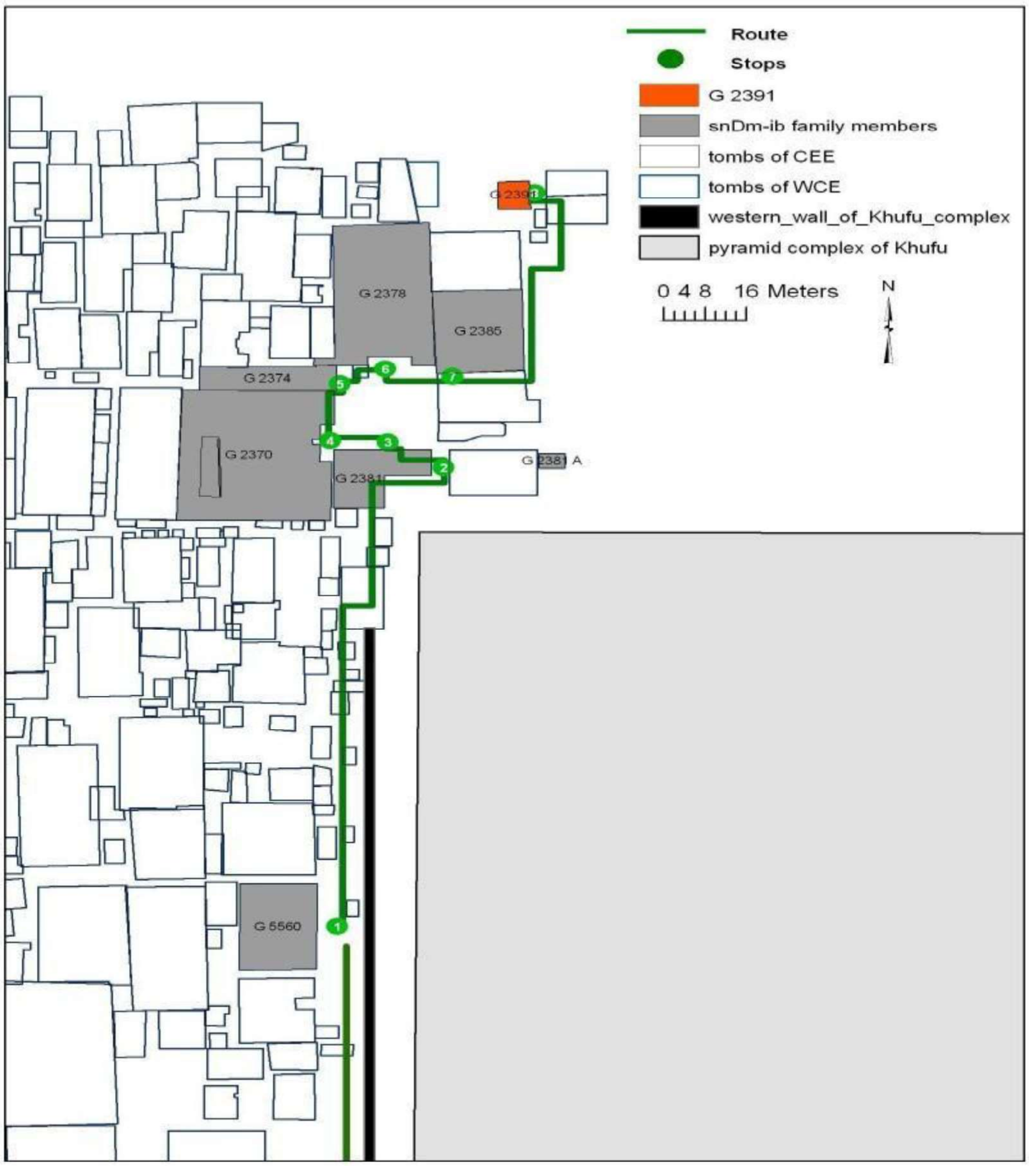


Map 2: Effort estimation for the transportation of stone from 9 quarries to G 5230

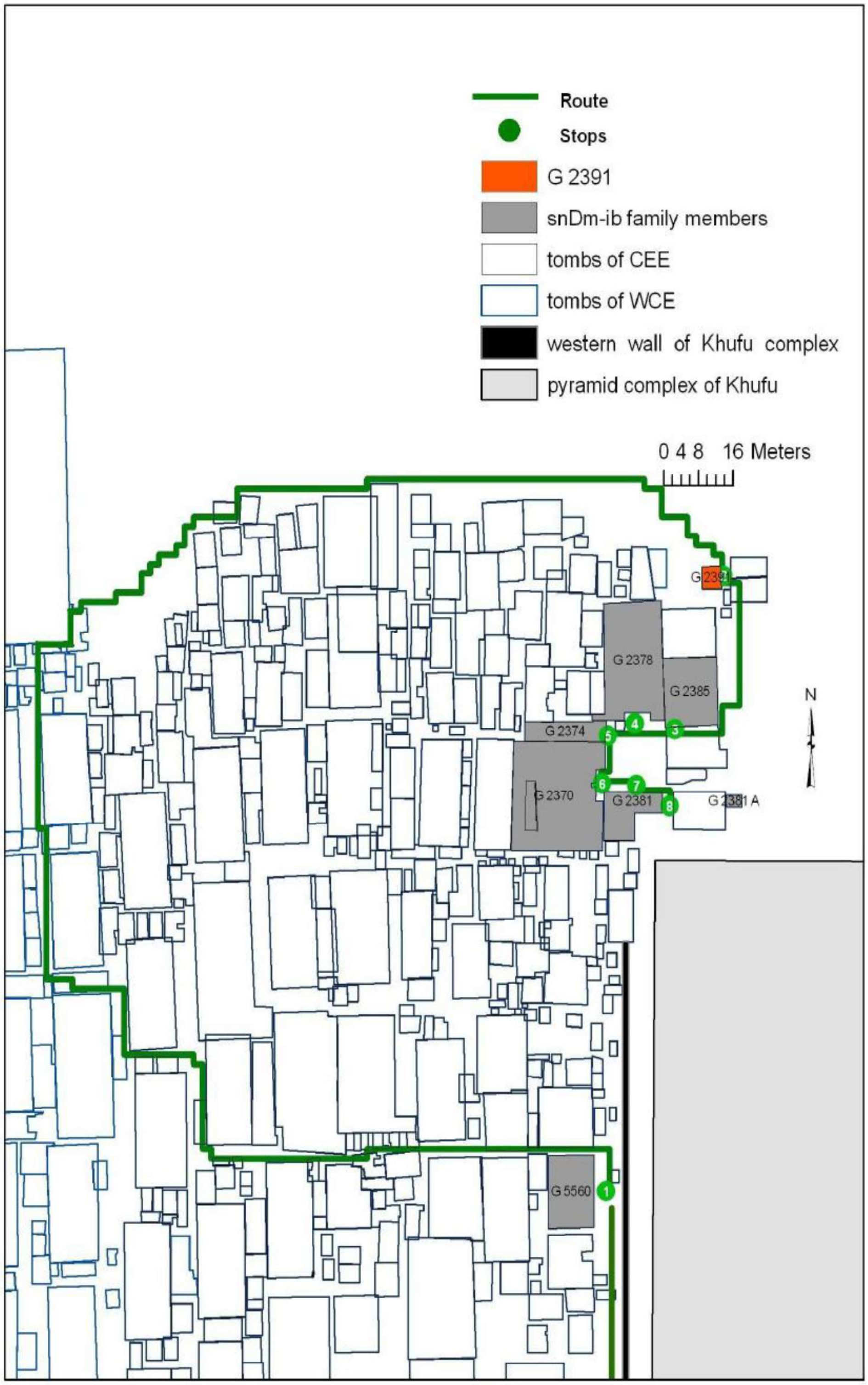
Map 3: Real route described by Reisner and the suggested route by network solver



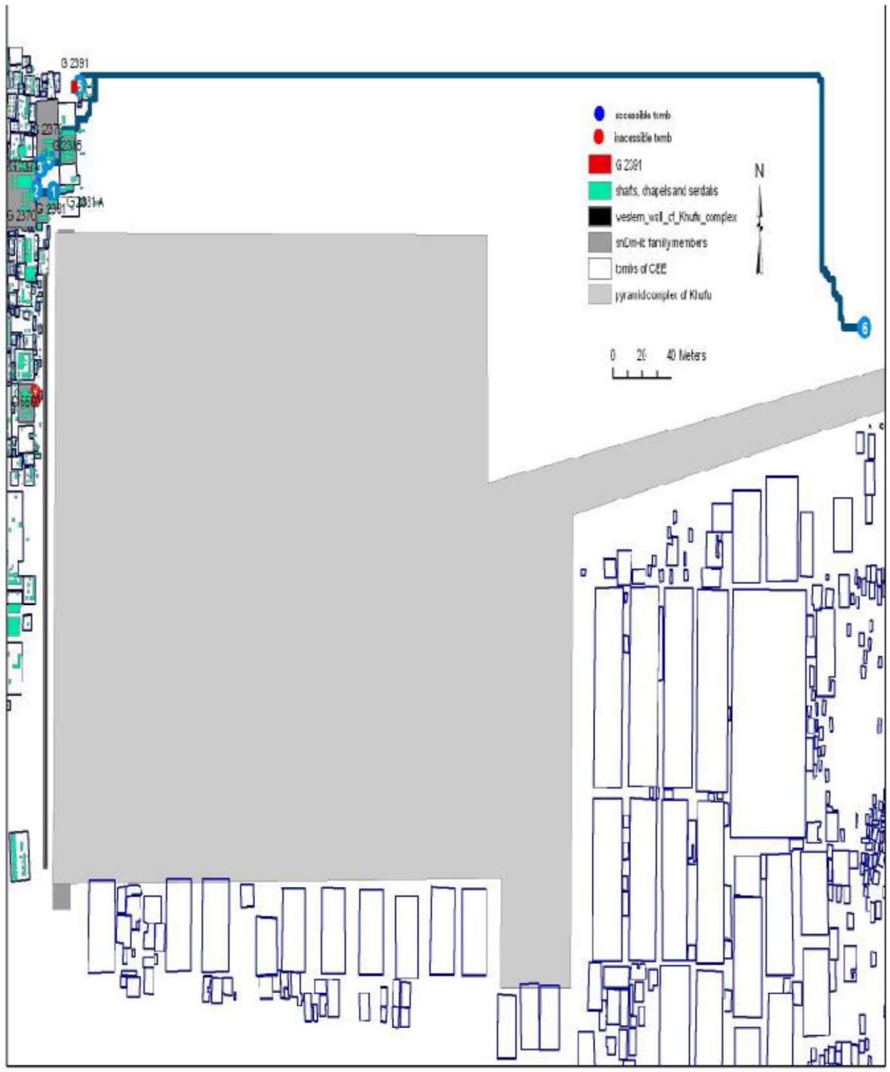
Map 4: Accessible and inaccessible points in CEE



Map 5: Suggested itinerary for nfr-mHi with dating class 9



Map 6: suggested itinerary for nfr-mHi dating class 10



Map 7: suggested itinerary for nfr-mHi with dating class 11

Map 8: suggested itinerary for nfr-Htp with dating classes 5-10

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