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Jesus' Itineraries in the Light of GIS Research: Three Case Studies

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Abstract: This paper discusses select itineraries known from the Gospels using the tools of Geographic Information Systems (GIS) and satellite archaeology. As a result, several conclusions on the geohistorical and sociohistorical context are suggested. First, the Roman imperial road from Jericho to Jerusalem covered an earlier ancient road; given the road's length (29 km) and inclination (6.9 degrees), it entailed a 9-hour travel route unlikely to be undertaken on foot within one day. Second, it appears that travellers between Khirbet Qana and Capernaum had two good options for one-day travel in Early Roman times – a topographic route via the valley of Nahal Tsalmon (28 km/7 hours) or a route via the Arbel Valley (30 km/8 hours). Third, the most probable direct route from the Hajlah ford to Khirbet Qana led via the vicinity of the Nazareth Range. The travel distance between the Hajlah ford and Khirbet Qana amounts to at least 130 km and as such requires five or six full days of travel on foot. Fourth, as for the routes from the northern identifications of the baptism site (Yardenit, Gesher, Makhadet Abara) to Khirbet Qana, travel only from Yardenit may be achieved within one long travel day (40 km).

Keywords: Gospels, Jesus of Nazareth, GIS, satellite archaeology, road archaeology, Jericho, Jerusalem

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The aim of this paper is to discuss select itineraries known from the Gospels using the tools of Geographic Information Systems (hereinafter GIS) and satellite archaeology. In this context, it should be noted that this paper is part of an interdisciplinary research project which aims, among other things, to discover actual roads or suggest potential routes between chosen ancient settlements in the kingdom of Herod the Great.

For a long time, it was widely held in scholarship that no remains of ancient interurban roads older than Roman imperial roads had been preserved, neither in the ancient Near East[1] nor in the southern Levant in particular.[2] However, research in recent decades has brought about fundamental changes to our knowledge in this regard. Through both satellite archaeology and fieldwork, many remains of ancient roads known as hollow ways have been discovered, especially in northeastern Syria and Iraq.[3] The hollow ways (also known as sunken lanes or linear hollows) can be defined as 'broad and shallow linear depressions in the landscape, thought to be formed by the continuous passage of human and animal traffic.'[4] Hollow ways can usually be first detected on satellite imagery as linear concentrations of vegetation or moisture; they can also be verified on the ground, although often with some difficulty. Second, remnants of several pre-Roman roads were revealed in recent decades in the southern Levant (modern Israel, the Palestinian territories, and Jordan), especially the Wadi Zarqa-Main Road, the Callirrhoe–Machaerus Road, the Aroer Ascent, 'Glueck's Road', Naqab Dahal and the Masada–Hebron Road.[5] In this context, a new research project entitled 'Travel and Mobility in Hellenistic and Early Roman Palestine', financed by the National Science Centre in Poland, was launched in 2021. An important

1 B.J. Beitzel, "Roads and Highways (Pre-Roman)," *ABD* V, 776.

2 D.A. Dorsey, *The Roads and Highways of Ancient Israel* (ASOR Library of Biblical and Near Eastern Archaeology; London: John Hopkins University Press 1991) 28.

3 J. Ur, "CORONA Satellite Photography and Ancient Road Networks: A Northern Mesopotamian Case Study," *Antiquity* 77/295 (2003) 102–115; T.J. Wilkinson – C. French – J. Ur, "The Geoarchaeology of Route Systems in Northern Syria," *Geoarchaeology* 25/6 (2010) 745–771;M. de Gruchy – E. Cunliffe, "How the Hollow Ways Got Their Form (and Kept It): 5000 Years of Hollow Ways at Tell al-Hawa," *New Agendas in Remote Sensing and Landscape Archaeology in the Near East: Studies in Honour of Tony J. Wilkinson* (eds. D. Lawrence – M. Altaweel – G. Philip) (Oxford: Archaeopress 2020) 124–143.

4 Ur, "CORONA," 102.

5 A. Strobel, "Ancient Roads in the Roman District of South Peraea: Routes of communication in the Eastern area of the Dead Sea," *Studies* 6 (1997) 271–280; A. Kloner – C. Ben-David, "Mesillot on the Arnon: An Iron Age (pre-Roman) Road in Moab," *Bulletin of the American Society of Overseas Research* 330 (2003) 65–81; C. Ben-David, "Iron Age Roads in Moab and Edom – the Archeological Evidence," *SHAJ* 10 (2009) 723–730; C. Ben-David, "The Ancient Road from Callirhoe on the Dead Sea to Machaerus – a Built Wide Road of the Second Temple Period," *ErIsr* 31 (2015) 20–29; C.C. Ji, "The Ancient Road in Wadi Zarqa – Main, North of Khirbat Ataruz," *SHAJ* 13 (2019) 143–157; S. Bar *et al.*, "An Archaeological Survey and a Test Pit in the Ceremonial Path at the Southern Slope of the Sartaba," *Jordan Valley Research Studies* 6 (2021) 7–17; U. Davidovich – C. Ben-David – R. Porat, "The Roman-period Road Network in Southern Moab: A Geographic and Historical Enquiry," *PEQ* 154/2 (2022) 141–159. Furthermore, leaving the category of the city streets aside, the roads directly ascending the ancient cities could be seen as another category. Some of these roads were also identified in literature, e.g., at Masada (a snake path), Tell Medeyne, and Khirbet Ataruz.

part of the project is a large-scale attempt to discover more ancient pre-Roman roads.[6] This attempt, realised through GIS simulations, satellite archaeology, and fieldwork, is mainly focused on searching for ancient roads between chosen settlements – the toparchies (lowest administrative centres) in the kingdom of Herod the Great at its largest extent (thus, roughly speaking, in the last quarter of the first century BCE). At the same time, another potential source of interest for this project may be the itineraries indicated by ancient written sources. Accordingly, in this paper, we set out to showcase our working methodology for select itineraries mentioned in the Gospels.[7]

Upon a preliminary reading of the geographic data in the Gospels (Mark, Matthew, Luke, and John), the following itineraries have been chosen: (1) from Jericho to Jerusalem; (2) from Cana to Capernaum; (3) from the baptism site to Cana (Fig. 1). Given the well-established tradition of New Testament exegesis, including problems of sources and editorial compilation, dating, and historicity,[8] it should be stressed that we focus on the chosen itineraries as geographical and socio-historical phenomena regardless of historicity or the accuracy of episodes narrated in the Gospels.[9]

1. GIS Sources and Methodology

In the past, scholars sporadically touched on the topic of how the courses of ancient roads could be reconstructed.[10] In short, it has been concluded that the following clues may be indicative of the existence of ancient roads: information in written sources (ancient sources including ancient itineraries or the Madaba Map as well as travelogue literature from the 19th and early 20th centuries and old maps), existence of settlement along the potential route, topography, and later analogies (Roman imperial roads, Ottoman roads,

6 M. Marciak – B. Szypuła – D. Sobczyński, "In Search of Ancient pre-Roman Imperial Roads: State of Research and Some Methodological Recommendations," *Archaeological and Anthropological Sciences* 15/118 (2023) 1–19; M. Marciak *et al.*, "In Search of Ancient Pre-Roman Imperial Roads: A Case Study of the Application of Remote Sensing in Road Archaeology in the Southern Levant," *Remote Sensing* 15/18 (2023), https://doi.org/10.3390/rs15184545.

7 A similar GIS methodology, though much more limited, was used for some of the itineraries of Paul from Tarsus by V. van Altena *et al.*, "GIS as a Heuristic Tool to Interpret Ancient Historiography: A Case Study to Reconstruct What Could Plausibly Have Happened According to the Accounts in New Testaments Texts," *Transactions in GIS* 25/3 (2021) 1193–1212.

8 D.E. Aune, *The Blackwell Companion to the New Testament* (Chichester: Wiley-Blackwell 2010); P. Gray, *The Cambridge Companion to the New Testament* (Cambridge: Cambridge University Press 2021).

9 For geography as a hermeneutical category, see B.J. Beitzel – K.A. Lyle (eds.), *Lexham Geographic Commentary on the Gospels* (Bellingham, WA: Lexham 2017); for 'spatiality' in biblical literature, see V.H. Matthews, "Social Science Models," *The Cambridge Companion to the Hebrew Bible/Old Testament* (eds. S.B. Chapman – M.A. Sweeney) (Cambridge Companions to Religion; Cambridge: Cambridge University Press 2016) 147–162.

10 For instance, Y. Aharoni, *The Land of the Bible: A Historical Geography* (Philadelphia, MA: Westminster Press 1979) 45; Dorsey, *The Roads*, 52; A. Faust – A. Erlich, *The Excavations of Khirbet er-Rasm: The Changing Faces of the Countrysid* (BAR International Series 2187; Oxford: Archaeopress 2011) 225.

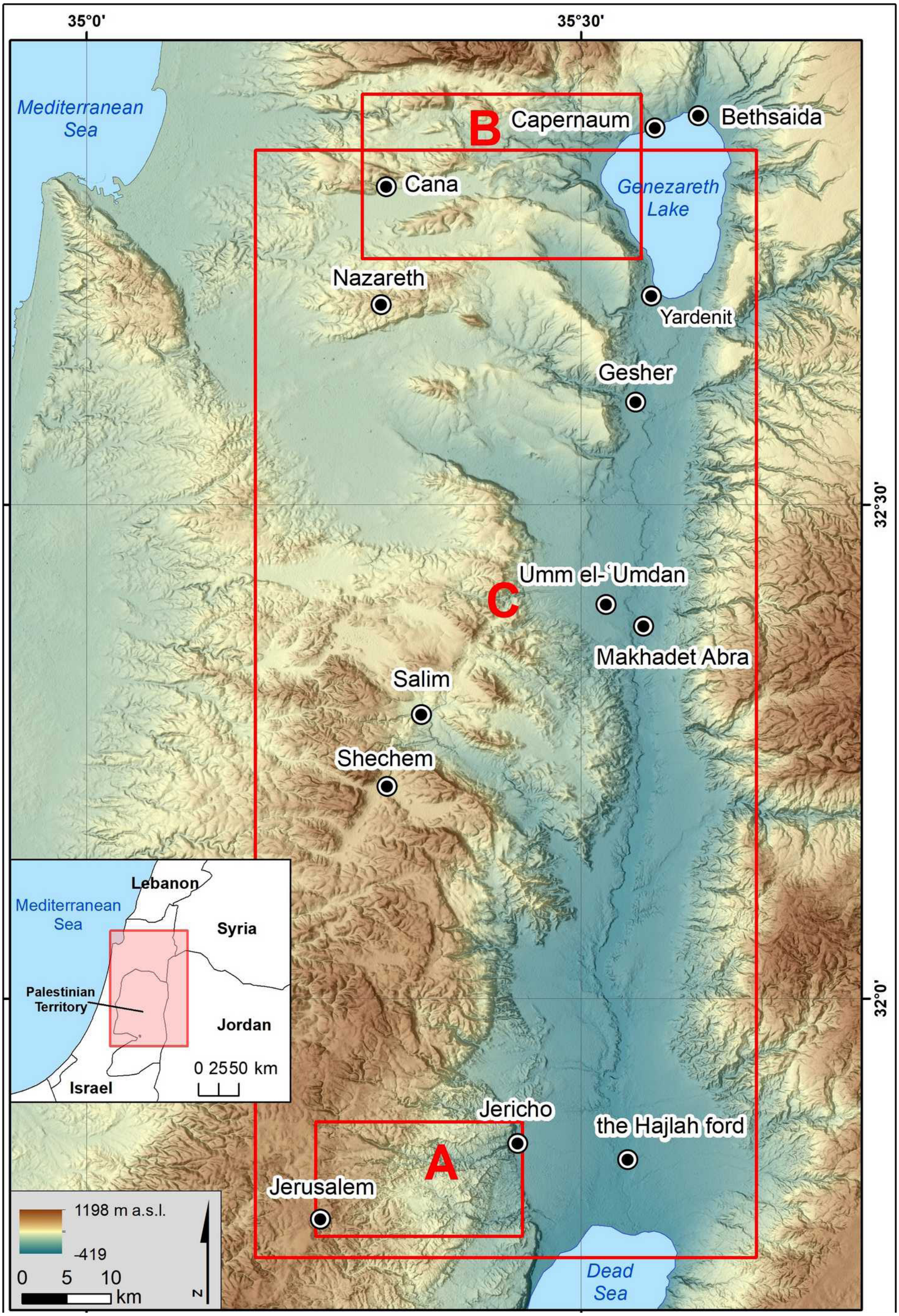

Fig. 1. Geographical extent of the case studies: A – Jericho to Jerusalem; B – Cana to Capernaum; C – baptism site to Cana. Hypsometry and hillshading based on SRTM DEM (2013)

or even modern roads). By translating this past state of research into modern scientific nomenclature and including our own experience from Near Eastern archaeology, our team has identified the following sources and methods: archival cartographic sources; archival aerial imagery; archival satellite imagery; GIS simulations, especially Least Cost Paths (hereinafter LCPs); archaeological data, especially on settlement; recent open-access high-resolution satellite imagery and very high-resolution, multispectral satellite imagery.[11]

The archival sources – that is, old topographic maps, archival aerial photography, and archival satellite imagery – have one significant advantage over newer and usually more detailed sources of knowledge – they document the Near Eastern environment prior to the major 20th-century changes in civilisation that dramatically altered the landscape – especially through industrialised agriculture and urbanisation. Old topographic maps, despite their smaller scales and cartographic imperfections, are particularly valuable because of their content. For instance, maps published by the *Palestine Exploration Quarterly* in 1872–1881 explicitly associate some places with biblical topography. Likewise, the *Karte des Ostjordanlandes* from 1890 by Gottlieb Schumacher identifies some roads as Roman (ger. *Römerstraße*) or old (ger. *Alte Straße*). For the purpose of our project, seven archival topographic maps have been digitalised (see Table 1) and, as a result, shapefiles called 'Ottoman roads', 'Ancient roads', and 'Roman roads' have been created.[12]

Table 1. Archival cartographic sources used in research

Name	Year	Scale	Author
Map of Western Palestine	1880	1:63,360	Palestine Exploration Fund (Claude Conder, Herbert Kitchener)
Survey of Eastern Palestine	1881	1:63,360	Palestine Exploration Fund (Claude Conder)
Karte des Ostjordanlandes	1890	1:63,360	Palestine Exploration Fund (Gottlieb Schumacher)
Arabia Petraea	1906	1:300,000	Alois Musil
Map of Palestine	1918	1:50,000	German Military Service
Map of the Levant	1946	1:50,000	British Military Service
Map of Israel	1956	1:100,000	Survey of Israel

The first category shows the entire road network from Ottoman times, mainly based on the maps of *Palestine Exploration Fund* and Schumacher, thus coming from 1880–1890,

11 Marciak, in search.

12 The shapefiles are stored in the project's repository and can be downloaded at any time in both GIS formats and kml. formats, the latter openable in Google Earth (D. Sobczyński – M. Marciak, "GIS dataset from the NCN project 'Travel and Mobility in Hellenistic and Early Roman Palestine' (grant no. UMO-2020/38/E/HS3/00031)," https://doi.org/10.26106/ynta-ff42).

while the second and third categories contain the digitalised roads from the same sources, but only those explicitly identified by cartographers as ancient or Roman. Another valuable type of data in the scientific quest for ancient roads is archival aerial and satellite imagery. The first aerial photographs of the southern Levant were taken by British and German military aircrafts at the beginning of the 20th century and can obtained from public repositories, especially the Aerial Photographic Archive for Archaeology in the Middle East project (APAAME), the Map Library and Aerial Photograph Archive of the Department of Geography of the Hebrew University[13] and the Digital Media Center of the University of Haifa.[14]

Next, archival satellite images come from aerial and satellite intelligence missions during the Cold War, especially the US missions. Their datasets are regularly declassified and, once declassified, are made available through public repositories. Of great popularity are the datasets of the CORONA satellite imagery from 1959–1972. For our project, a dataset of CORONA images was obtained from the repository of the Corona Atlas & Referencing System hosted by the Center for Advanced Spatial Technologies.[15] However, it should be noted that in practical terms, archival imagery (especial aerial imagery) is used rather selectively: whenever a specific object (an ancient road) is suspected to have existed in a given area because of indications in other sources, archival imagery is additionally checked. In the case of the Jericho–Jerusalem road, CORONA imagery revealed the course of the Roman imperial road as the satellite imagery was taken before the construction of Jerusalem's suburbs and a modern highway completely changed this area forever (Fig. 2).

It goes without saying that travel, especially over long distances, cannot be considered without the context of settlement. Ancient travellers, much like modern ones, had to rely on settlements in order to rest, replenish food and water resources, and, finally, to find security.[16] When working on a large-scale travel network, it is necessary in practical terms for researchers to use pre-existing electronic datasets of archaeological sites rather than trying to create new ones on the basis of literature. Several valuable datasets currently exist, particularly two official repositories connected with the archaeological authorities of Israel and Jordan, the Archaeological Survey of Israel platform[17] and the MEGA-Jordan database,[18] as well as several academic projects including the Pleiades project,[19] the Digital Atlas of the Roman Empire,[20] the Digital Archaeological Atlas of the Holy Land,[21] and the Geographic

13 *Map Library and Aerial Photograph Archive of the Department of Geography of the Hebrew University*, https://geohub.huji.ac.il/ [access: 10.04.2025].

14 *Digital Media Center of the University of Haifa*, https://lib.haifa.ac.il/departments/yaaz/hadracha/menus/library/digitool/abakhoushy.htm [access: 4.10.2025].

15 *Corona Atlas & Referencing System*, https://corona.cast.uark.edu [access: 4.10.2025].

16 C. Hezser, *Jewish Travel in Antiquity* (TSAJ 144; Tübingen: Mohr Siebeck 2011) 144.

17 *Archaeological Survey of Israel*, http://survey.iaa.org.il/ [access: 10.04.2025].

18 *MEGA-Jordan*, http://megajordan.org/ [access: 10.04.2025].

19 *Pleiades*, https://pleiades.stoa.org/places [access: 10.04.2025].

20 *Digital Atlas of the Roman Empire*, https://imperium.ahlfeldt.se/ [access: 10.04.2025].

21 *Digital Archaeological Atlas of the Holy Land*, https://daahl.ucsd.edu/DAAHL [access: 10.04.2025].

Data for Ancient Near Eastern Archaeological Sites.[22] However, it should be noted that all these repositories have their own issues and present certain challenges. For instance, the Survey of Israel is not complete, while access to MEGA-Jordan is restricted for unknown reasons. Likewise, the global academic projects, though helpful, often only offer information about major sites and tend to lack geographical accuracy.

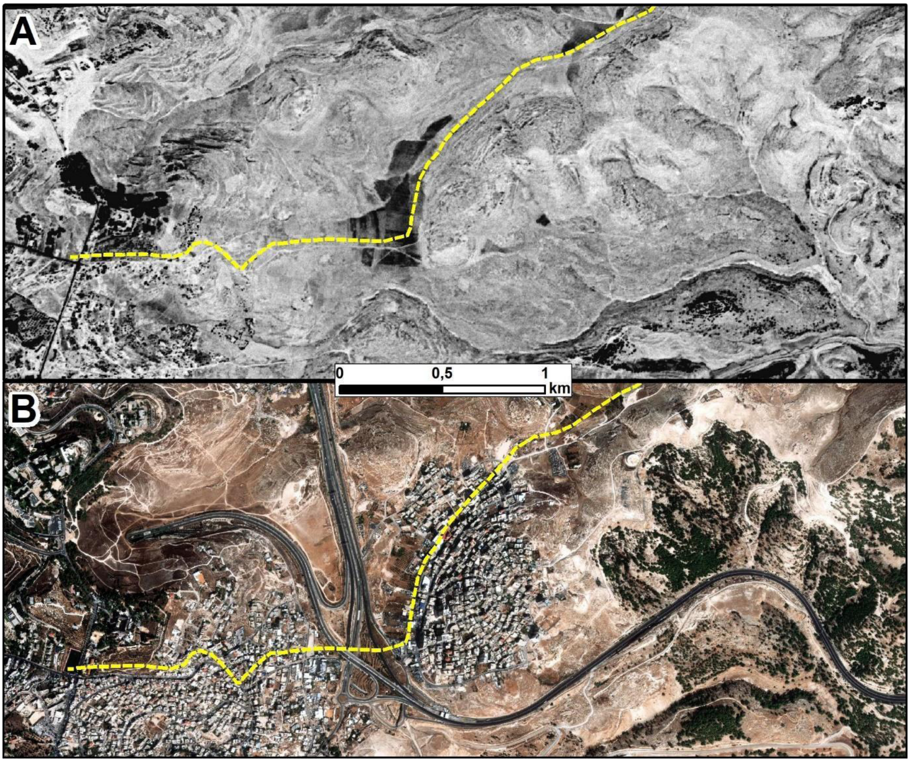

Fig. 2. Comparison of archival and modern satellite imagery near Jerusalem: A – CORONA imagery (2x2 m, 1970), https://isac-idb.uchicago.edu/id/47496939-9f80-45fb-b518-c206b51e251f [access: 26.06.2025]; B – satellite image (5x5 m, 2024, Esri/Maxar/Earthstar Geographics). Yellow dashed line indicates a course of Roman imperial Road

It is often stated that few ancient pre-Roman roads were preserved because they were reused and covered by later roads, especially Roman imperial roads.[23] Thus, at least to some extent, the course of the Roman imperial roads may indicate the course of ancient pre-Roman roads. The earliest professional attempts to comprehensively gather data on Roman

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22 *Geographic Data for Ancient Near Eastern Archaeological Sites*, https://www.uu.se/en/department/archaeology-ancient-history-and-conservation/research/research-projects/geographic-data-near-east [access: 10.04.2025].

23 Ben-David, "Iron Age Roads," 723.

roads in the southern Levant go back to W. Smith,[24] but two modern publications of the cartographic data of the Roman imperial road network in this area are the *Tabula Imperii Romani*[25] and the *Barrington Atlas of the Greek and Roman World*.[26] Surprisingly, it is in fact only the latter publication that has been adapted into a GIS environment by well-known platforms, especially Mapping Past Societies,[27] led by Harvard University, and the Digital Atlas of the Roman Empire,[28] hosted by the University of Gothenburg. For this reason, the relevant maps of the *Tabula Imperii Romani* were also digitalised in our project, as were sketch maps from the publications of Israel Roll.[29] Nevertheless, a great deal of discrepancies between these four resources resulting from cartographic imperfections have been noted in both our digital research and fieldwork. In this context, the latest digital research on the Roman imperial network by the Minerva project must be mentioned. Using mainly methods of satellite archaeology, A. Pažout created the latest digital presentation of Roman imperial roads in the southern Levant in 2024.[30] While its review goes beyond the scope of this project, it appears at first glance to offer a level accuracy that has not been seen in any other cartographic products.

Concerning topography as one of the sources, previous scholars paid attention to the existence of terrain obstacles as one of the aspects determining the course of ancient roads, but they did so mainly in the light of cartographic sources or their own fieldwork experience.[31] However, given recent scientific developments, it is nowadays possible to use more precise and quantitative tools, especially digital elevation models and related GIS simulations, usually known as least cost paths. In short, a digital elevation model is a digital representation of the Earth's surface (with or without overlaying objects such as vegetation or buildings) created from a variety of sources (field surveys, topographic maps, photogrammetric surveys, laser scanning and radar interferometry). The least cost path is a method for determining an optimal route over a surface between two chosen points that has the least accumulative cost along the way. The cost may be defined in various ways (most often as a degree of slopes, but possibly also as other factors such as land cover, settlement, or blockades). In our project, we have decided to simultaneously use two different Digital Elevation Models (hereinafter DEMS) and calculate the least cost paths on each of them using two different definitions of cost. The two DEMs chosen for our analyses are the

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24 W. Smith – G. Grove, *An Atlas of Ancient Geography, Biblical and Classical to Illustrate the Dictionary of the Bible and the Classical Dictionaries* (London: Murray 1874) 51.

25 Y. Tsafrir – L. Di Segni – J. Green, *Tabula Imperii Romani: Iudaea Palestina: Eretz Israel in the Hellenistic, Roman and Byzantine Periods: Maps and Gazetteer* (Jerusalem: Israel Academy of Sciences and Humanities 1994).

26 R. Talbert, *The Barringron Atlas of the Greek and Roman World* (Princeton: Princeton University Press 2000).

27 *Mapping Past Societies*, https://darmc.harvard.edu/ [access: 10.04.2025].

28 *Digital Atlas of the Roman Empire*, https://dh.gu.se/dare [access: 10.04.2025].

29 I. Roll, "Imperial Roads Across and Trade Routes Beyond the Roman Province of 'Judaea-Palestina' and 'Arabia': The State of Research," *TA* 32/1 (2005) 107–118, Fig. 1.

30 *Itiner-e – The Digital Atlas of Ancient Roads*, https://itiner-e.org/ [access: 10.04.2025].

31 Aharoni, *The Land of the Bible*, 45; Dorsey, "The Roads," 52.

latest versions of two DEMs with a long and respected tradition of use in Near Eastern satellite archaeology: ASTER – Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER GDEM 2009), and SRTM – Shuttle Radar Topography Mission (SRTM v3 2013). ASTER is the result of the satellite recording of reflected radiation (14 bands of the electromagnetic spectrum, ranging from visible to thermal infrared light), while SRTM is the outcome of the measurements employing interferometric synthetic aperture radar. Thus, while both DEMs feature a similar resolution of about 30 m, the data was obtained using two different methods leading to slightly different values of individual pixels. In turn, two chosen definitions of travel cost include one based only on the degree of slope and another based on Tobler's Hiking Function, which takes into account both degree of slope and related travel speed. The choice to use two different DEMs and different LCP algorithms results from an obvious desire to diversify scientific methods and reduce the subjectivity of using only one source or method. As LCPs based on Tobler's Hiking Function attempt to find relatively short routes, only avoiding very high slopes, the LCPs based directly on slope degree are looking for alternative routes that avoid even relatively small inclinations at the expense of longer distances to be covered. This approach does not serve to obtain the highest probability of LCP, but allows us to consider different travel options.

Satellite archaeology would not have been possible without the existence of high-resolution satellite imagery. First and foremost, this imagery offers the basic capability to analyse the GIS data on an orthophotograph. In our project, the data source employed for remote sensing analysis was Bing Maps Aerial with aerial Maxar images offering a spatial resolution of 50 cm and declared accuracy of 5 m. The imagery was used in the WGS-84 (EPSG:4326) coordinate system. Additionally, multispectral satellite images (different bands of the electromagnetic spectrum) offer more advanced capabilities, especially to detect signs (in the form of spectral responses) of archaeological artifacts buried under the surface or at least not easily visible to the naked eye. However, it should be noted that the large geographic area of our project and the cost of such commercial imagery only allow for the sporadic and selective use of this imagery once an area of considerable importance is chosen and deemed to be promising for the use of multispectral imagery (e.g., traces of a paved Roman road not visible on the ground due to coverage by the current land use). Such imagery has not been used for the itineraries analysed in this paper.

2. Jesus' Itineraries

2.1. Jericho–Jerusalem

The existence of a direct route between Jerusalem and Jericho is well documented by various ancient sources, including the New Testament (e.g., Luke 10:30–35; John 11:17–18) and Josephus' writings for the Roman period (e.g., *Ant.* 14:5–6/*J.W.* 1:120–122; *Ant.*

14:407–411/*J.W.* 1:299–302; *Ant.* 15:5–56/*J.W.* 1:437; *J.W.* 5:42 and 69).[32] At the same time, the route is believed to have also been used in pre-Roman times as indicated by D. Dorsey in his reconstruction of the Iron Age road network in ancient Israel (route J32).[33] However, the only remains preserved until today are those of a Roman imperial road, sometimes intermingled with Ottoman and British road sections (consisting of repairs, adaptations, and course changes to the Roman road).[34] It should be stressed that the course of the Roman imperial road has been previously studied by many scholars (with two of the most detailed studies by R. Beauvery and J. Wilkinson[35]). Sections of road remains (pavement and four mile-stations including 12 milestones) and remains of related archaeological structures (especially four Roman guard posts [watchtowers] along the Wadi Qelt, Khan Hatrura with some Second Temple remains, a Herodian palatial structure near Khan Hatrura, and Roman road stations including one at Qasr ʿAli) are known to have been identified along the route.[36] This fact suggests a great opportunity for the present study, as our use of various sources (in practical terms, the courses of various shapefiles) may be verified with regard to the extant remains.[37] In this light, this study will focus on select examples of well-preserved remains clearly visible on satellite imagery.

If the Ottoman road network is used as an analogy (see Fig. 3), the journey between Jericho and Jerusalem could take place via Ottoman Road no. 106 (OR 106 hereinafter),[38] Roman Road no. 7 (RR 7 hereinafter), OR 107, RR 26, or OR 110. The course of these roads when joined together (as shapefiles) closely follows the course of a Roman imperial road that once connected Jericho and Jerusalem (see Fig. 4). The cartometric error between the road section on the old map and its real course is on average about 100 m (it is relatively small, especially in the central and eastern part of the road); however, near Jerusalem, the error increases to almost 700 m. The total route of the joined Ottoman roads is 23 km from Jericho to Jerusalem, but this is underestimated due to the generalisation of old maps. The aforementioned spatial analysis suggests that the Roman imperial road was also used in Ottoman times.

32 J. Flavius, *The Jewish War*. I. *Books I–III* (trans. H.S.J. Thackeray) (LCL 203; Cambridge, MA – London: Harvard University Press 1927); J. Flavius, *The Jewish War*. III. *Books IV–VII* (trans. H.S.J. Thackeray) (LCL 210; Cambridge, MA – London: Harvard University Press 1928); J. Flavius, *Jewish Antiquities*. VI. *Books XIV–XV* (trans. R. Marcus – A. Wikgren) (LCL 489; Cambridge, MA – London: Harvard University Press 1943).

33 Dorsey, "The Roads".

34 J. Wilkinson, "The Way from Jerusalem to Jericho," *BibAr* 38/1 (1975) 10–24.

35 R. Beauvery, "La route romaine de Jérusalem à Jéricho," *RB* 64/1 (1957) 72–101; Wilkinson, "The Way".

36 For a recent overview, see A.D. Riddle, "The Passover Pilgrimage from Jericho to Jerusalem. Jesus's Triumphal Entry. Matt 21:1–9; Mark 11:1–10; Luke 19:28–40; John 12:12–19," *Lexham Geographic Commentary on the Gospels* (eds. B.J. Beitzel – K.A. Lyle) (Bellingham, WA: Lexham Press 2017) 395–407.

37 According to Wilkinson ("The Way") who was working about 20 years after Beauvery (but was himself working around half a century ago!), some structures noticed by Beauvery did not survive until his times.

38 The numbers reflect the order of digitalizing and can be consulted in the original file downloadable from the repository of the project: https://ruj.uj.edu.pl/xmlui/handle/item/307393 [access: 10.04.2025]. It should be noted that Ottoman roads in Palestine did not possess any numbers in historical times.

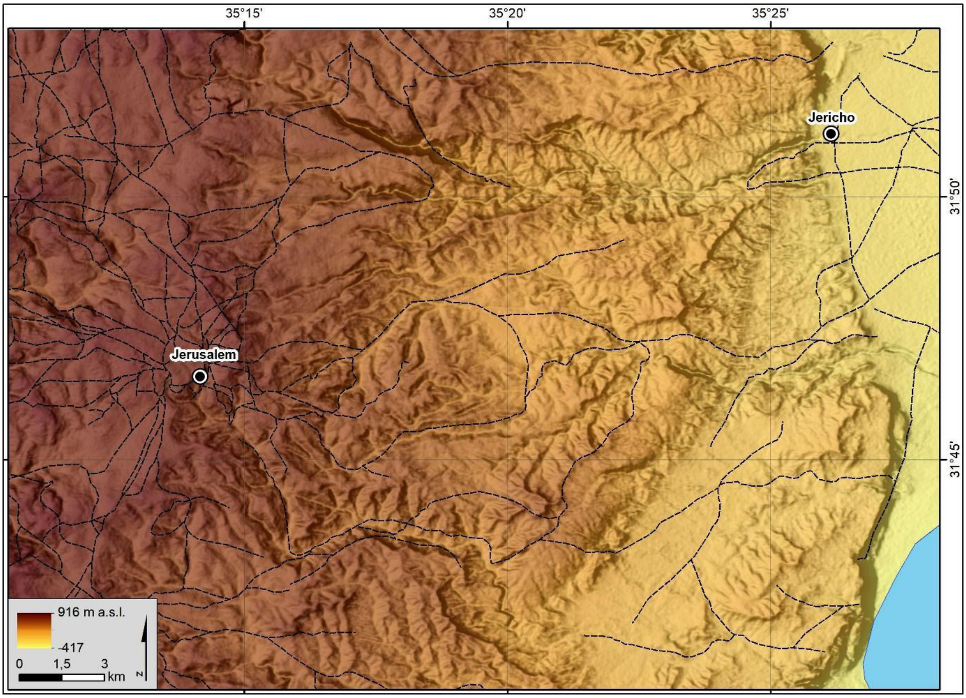

Fig. 3. The entire Ottoman road network between Jerusalem and Jericho.
Hypsometry and hillshading based on SRTM DEM (2013)

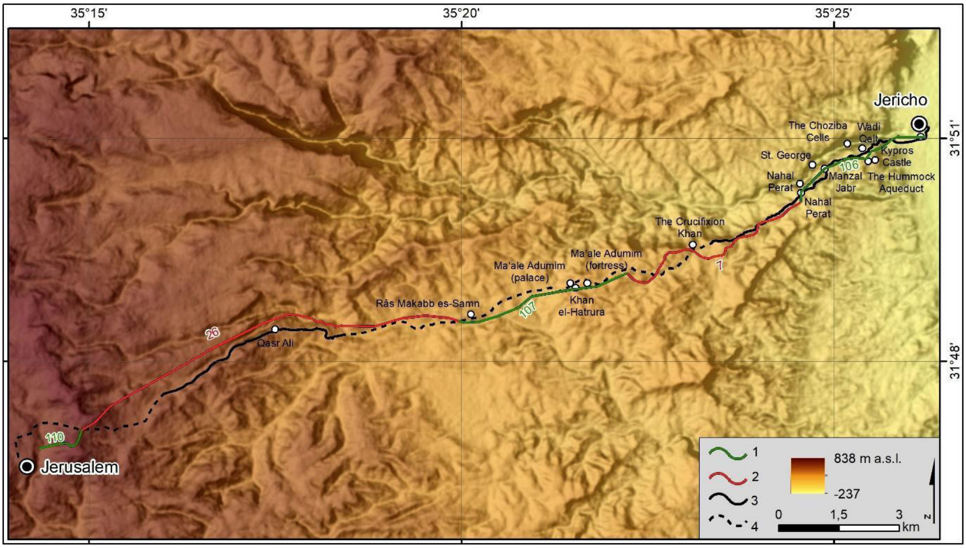

Fig. 4. From Jericho to Jerusalem using the Ottoman road network:
1 – 'Ottoman' roads; 2 – 'Roman' road (used in Ottoman times); 3 – Roman imperial road identified on satellite imagery; 4 – uncertain course of the Roman imperial road.
Hypsometry and hillshading based on SRTM DEM (2013)

In the case of the Roman imperial road network, travel between Jericho and Jerusalem could be accomplished via ID 2162[39] (see Fig. 5). The course of this road closely follows the course of the Jericho–Jerusalem Roman imperial road as identified on satellite imagery (the route has a real length of 29 km), but exact sections of the road cannot be derived from the Harvard dataset[40] due to its generalisation. This type of data only indicates a general area for more detailed research performed using high-resolution satellite imagery (according to this data, the route is only 21 km) or fieldwork. A much more detailed dataset on the course of Roman imperial roads will be published in the near future as the result of the Itiner-e project (https://itiner-e.org/). This pioneering project marked out the courses of Roman imperial roads on a large scale using satellite images, offering an incredible increase in the detail of the data (see Fig. 5). Only in a few cases, at the most controversial points of the road's course, is there a slight discrepancy between the course suggested by the Itiner-e project and our remote sensing research.

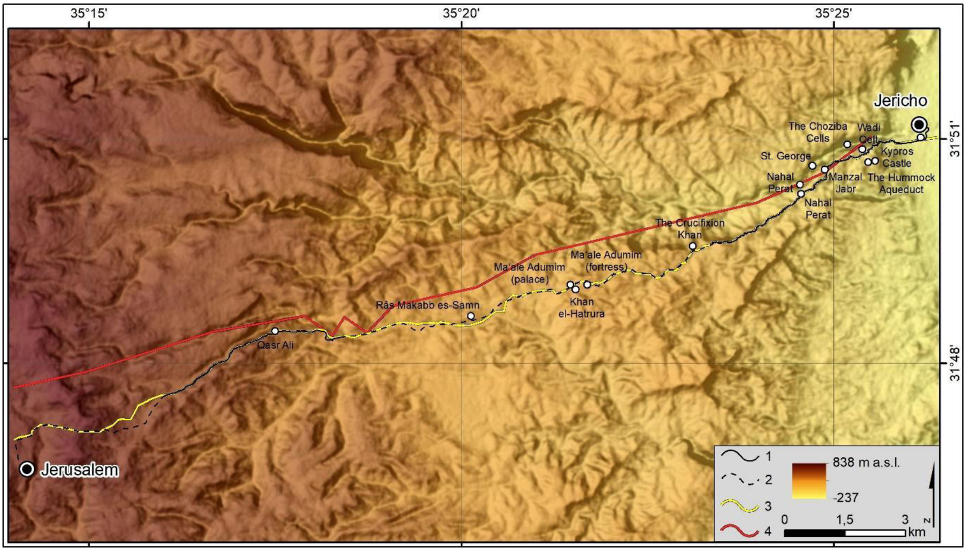

Fig. 5. From Jericho to Jerusalem using the Roman imperial road network:
1 – the course derived from satellite imagery; 2 – uncertain course derived from satellite imagery;
3 – the course from the Itiner-e project (Adam Pažout, Jerusalem-Jericho, https://itiner-e.org/route-segment/22162 [access: 25.06.2025]); 4 – the course from Harvard Dataverse/Barrington Atlas.
Hypsometry and hillshading based on SRTM DEM (2013)

39 ID number comes from the original dataset. See M. McCormick *et al.*, "Roman Road Network (version 2008)," Harvard Dataverse V1 (2013), https://doi.org/10.7910/DVN/TI0KAU.

40 The source of this data in the Harvard dataset is the R. Talbert, *The Barringron Atlas* in a scale of 1:500,000.

In the case of the Least Cost Path simulations (LCPs) (see Fig. 6), three of four variants successfully predicted the course of the Roman imperial road. The main pattern of ancient roads following and traversing the ridge is preserved. Three LCPs in the central and eastern section of the route follow the ridge along the Roman imperial road. In the western section of the route, the LCPs follow the riverbed of Wadi Qelt instead of ascending the ridge through Qasr Ali, which is a fairly common feature of LCPs favouring a slight road gradient.

The most southern LCP suggests an alternative route (see Fig. 6), and although it is quite favourable in terms of the terrain gradient, it is difficult to consider it probable due to the longer distance (47 km) and navigation difficulties on the route, which repeatedly crosses many valleys. The length of the LCP most similar to the road remains derived from satellite imagery is 27 km.

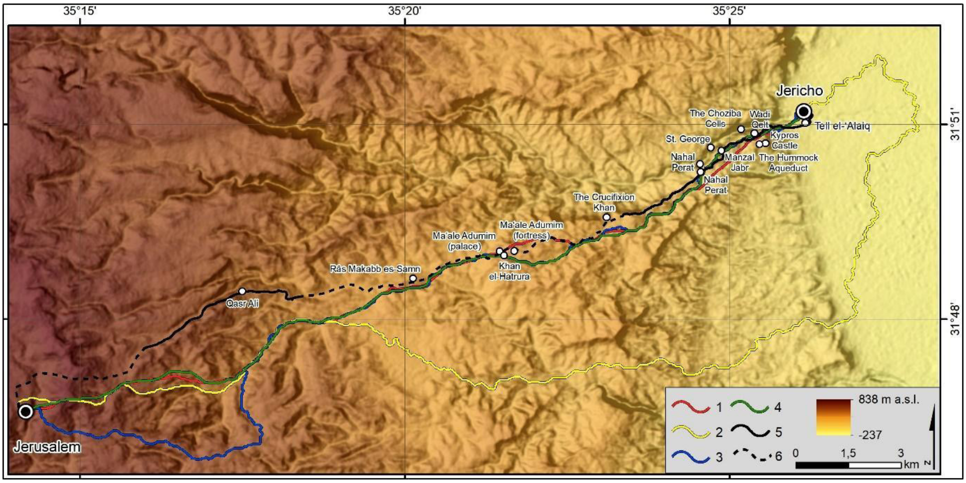

Fig. 6. Least cost path simulation for Jericho to Jerusalem: 1 – srtm/tobler; 2 – srtm/slope; 3 – aster/slope; 4 – aster/tobler; 5 – the course derived from satellite imagery; 6 – uncertain course derived from satellite imagery.
Hypsometry and hillshading based on SRTM DEM (2013)

A partially preserved road from Jericho to Jerusalem starts with the elevation of 229 m below sea level up to 793 m above sea level with an average inclination of 6.9 degrees (see Fig. 7). Total ascent along the route is 1,594 m and, as the route is 29 km, it is estimated that the continuous march from Jericho to Jerusalem could take 9 hours.[41] This in turn means that it was very difficult to reach Jerusalem from Jericho on foot within one day of

41 Add the topographic distance in km with the sum of all 100 m of ascent and then divide by 5 to obtain the number of hours of continuous walking. In this case, we add 29 and 16 to get 45, which, when divided by 5, gives 9 hours.

travel; all travellers who were not at the prime age or strength or were not very experienced travellers must have needed overnight accommodation on their travel.[42] Due to the context of the archaeological sites discovered along the route, it seems likely that the resting places along the route were the Crucifixion Khan, Khan el-Hatrura, or Qasr Ali – 8 km, 12 km and 20 km distant from Jericho, respectively.

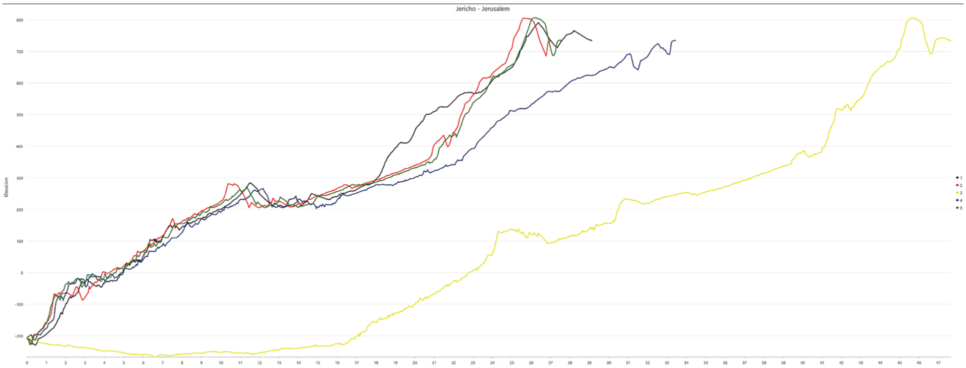

Fig. 7. Least Cost simulation profiles for Jericho to Jerusalem.
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In the case of Roman and pre-Roman roads, it is quite common that the roads, despite having a slightly greater inclination, led along ridges to avoid the need to build the many bridges and retaining walls associated with building a road along a valley. This is also apparently related to the fact that the erosive power of water is greatest at the bottom of a valley, so road builders marked the road out along ridges, where the roads would have a greater chance of surviving. This example shows that when considering ancient routes, it is best to take into account archaeological sites as intermediate points for determining LCP for longer distances, as the least inclined route was not always chosen by Roman road engineers for building roads.

42 Various estimates of the maximal distance that could possibly be covered during daily travel in ancient times can be found in literature. For an overview, see J.W. Hanson, *An Urban Geography of the Roman World, 100 BC to AD 300* (Archaeopress Roman Archaeology 18; Oxford: Archaeopress 2016) 81. Obviously, the distance could vary depending first on the mode of travel, next on the condition and experience of the traveller, and finally on seasonal conditions (rain or snow and less daylight in winter/rainy seasons versus extremely high temperatures and sun exposure in hotter months). As for the most widespread mode of travel in ancient times, i.e. on foot, it is most often suggested that an individual of average health and fitness (not a trained soldier) could travel between 30 and 40 km in eight hours, a full day's worth of travel. However, the present authors consider 40 km a day as a possible distance only for shorter travels and opt for 30 km a day as the norm for two reasons. First, it is unlikely that travellers would keep the same pace for several consecutive days of travel due to fatigue. Second, the calculation of 40 km a day ('about 5 km could be travelled in an hour and about 40 km in a full day of eight hours'; according to Hanson [*Urban Geography*, 81]) apparently does not take into account the necessary breaks during travel.

2.2. Cana–Capernaum

The Cana–Capernaum itinerary is explicitly mentioned twice in the Gospel of John (John 2:12: Jesus, his mother, and disciples traveling to Capernaum; John 4:46: a royal official from Capernaum traveling to Cana to have his son healed). In this context, it should, however, be noted that the identification of the New Testament village of Cana is not self-evident. Over the course of the research, four main identifications were suggested: Ain Kana (2.4 km southeast of Nazareth),[43] Kefr Kenna (4.8 km northeast of Nazareth),[44] Karm er-Ras (1 km northwest of Kefr Kenna)[45] and finally Khirbet Qana (13.7 km north of Nazareth).[46] While the traditional Christian identification of Cana is Kefr Kenna,[47] the latest archaeological research seems to favour Khirbet Qana thanks to the discovery of substantial remains of a thriving rural site from the Early Roman period.[48] Therefore, the site of the NT Cana chosen for our analysis is placed at Khirbet Qana.[49]

If the Ottoman road network is used as an analogy, travel from Cana to Capernaum[50] takes 39 km (see Fig. 8). The route leads east for the first 3 km via OR 1051 and then turns

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43 Starting with C.R. Conder, *Tent Work in Palestine: A Record of Discovery and Adventure* (London: Bentley 1879) I, 154–155. This identification is based mainly on the toponymic similarity and the presence of the perennial water source.

44 A turning point in the modern evaluations of ancient traditions over New Testament Qana in favour of Kefr Kenna came with Franciscus Quaresmius (1583–1650). See P. Richardson, *Building Jewish in the Roman East* (Leiden: Brill 2005). The presence of Christian sites commemorating the Gospel's events has always been the most important argument in favour of Kefr Kenna. Recent archaeological research has begun to reveal ancient remains at the site, although not necessarily from the Early Roman period or in large quantities.

45 Y. Alexandre, "The Archaeological Evidence of the Great Revolt at Karm er-Ras (Kfar Kanna) in the Lower Galilee," *The Great Revolt in the Galilee* (ed. O. Guri-Rimon) (Haifa: Hecht Museum – University of Haifa 2008) 73–79; Y. Alexandre, "Karm er-Ras near Kafr Kanna," *Galilee in the Late Second Temple and Mishnaic Periods* (eds. D.A. Fiensy – J.R. Strange) (Minneapolis, MN: Fortress 2015) II, 146–157. The discovery of remains from the Early Roman period may support this identification. However, the toponymic connection is weak.

46 Beginning with E. Robinson – E. Smith, *Biblical Researches in Palestine, Mount Sinai and Arabia Petraea: A Journal of Travels in the Year 1838* (Boston, MA: Crocker & Brewster 1841) III, 204–208. Next to the toponymic similarity and the presence of substantial Early Roman remains recently unearthed, the site is located in the Beit Netofa Valley, matching well Josephus' description of Cana of Galilee (Josephus, *Life* 207).

47 See J.C. Laney, "The Identification of Cana of Galilee," *Selective Geographical Problems in the Life of Christ* (Diss. Dallas Theological Seminary; 1977) 90–107 and E.J. Thomassen, "Jesus' Ministry at Cana in Galilee. John 2:1: 4:46–54: 21:2," *Lexham Geographic Commentary on the Gospels* (eds. B.J. Beitzel – K.A. Lyle) (Bellingham, WA: Lexham Press 2017) 74–83.

48 C.T. McCollough, "City and Village in Lower Galilee: The Import of the Archaeological Excavations at Sepphoris and Khirbet Qana (Cana) for Framing the Economic Context of Jesus," *The Galilean Economy in the Time of Jesus* (eds. D.A. Fiensy – R.K. Hawkins) (ECL; Atlanta, GA: SBL 2013) 56–72.

49 It may also be speculated that given the recent considerable increase in archaeological research in Galilee, the current state of research is far from the final word on the matter.

50 The NT Capernaum is nowadays widely identified with the site known in the 19th century as Tell Hum. Archaeological excavations run by Franciscan archaeologists, especially Virgilio Corbo and Stanislao Loffreda, revealed substantial remains of an Early Roman village. For an overview, see S. Loffreda, "Capernaum," *The Oxford Encyclopedia of Archaeology in the Near East* (ed. E.M. Meyers) (New York – Oxford: Oxford University Press 1997) I, 416–419. In the 19th century, a site called Khirbet Minyeh (or Minnim) was also identified with Capernaum by E. Robinson, who was followed by some of the earliest explorers. However, this identification

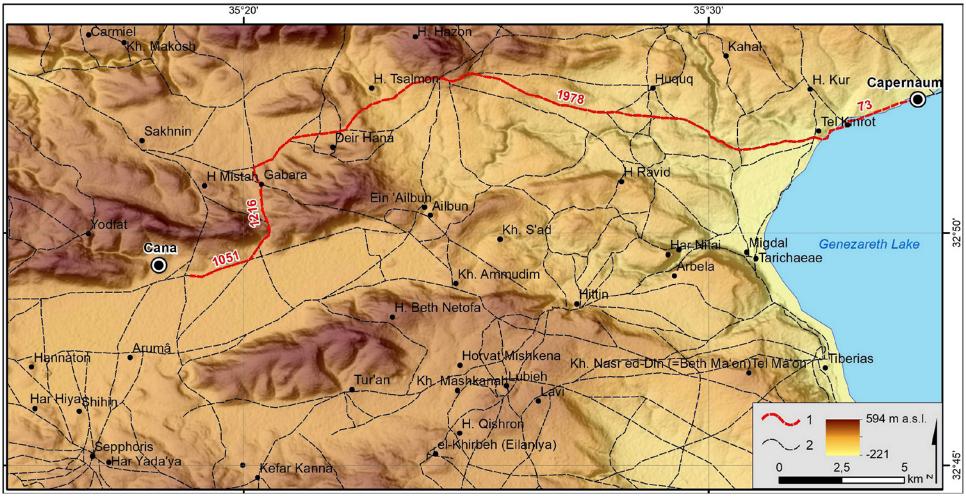

Fig. 8. From Cana to Capernaum using the Ottoman road network:
1 – 'Ottoman' roads, 2 – other 'Ottoman' roads.
Hypsometry and hillshading based on SRTM DEM (2013)

north via OR 1216 and 3163 through Gabara. From there, the route leads northeast via OR 1978 through Horvat Tsalmon and, after passing this site, turns southeast, descending into Nahal Amud near Huquq. Following the wadi, the route uses the narrow passage near Amud Cave to descend to Lake Galilee, which it finally reaches near Tel Kinrot. The route next continues along the shores of Lake Galilee for around a one-hour walk via OR 73 to reach Capernaum. Potential resting places on this route include Horvat Tsalmon (14 km from Cana) and Huquq (23 km from Cana).

In contrast, the Roman imperial road network (see Fig. 9) passes around 5 km south of Cana and would have to be reached via a local road, e.g. OR 1207. The main corridor of movement marked by the Sepphoris–Tiberias road passes to the southeast and northeast for approximately 45 km. The route through Tiberias could be accomplished via ID 2745, 7096 (Harvard Dataverse). Altogether, the route from Cana to Capernaum using the Roman imperial network (including a local road near Cana) is approximately 45 km. Potential places for overnight stays on this route are Horvat Mishkenah (18 km from Cana) and Tiberias (30 km from Cana),[51] as the Roman imperial road crossed these important sites.

In the case of the Least Cost Path simulations (see Fig. 10), all lead directly through the eastern part of the Beit Netofa Valley and the valley of Nahal Tsalmon in the direction of

quickly gave way to Tell Hum. See C.R. Conder – H.H. Kitchener, *The Survey of Western Palestine: Memoirs of the Topography, Orography, Hydrography and Archaeology*. I. *Sheets I–VI: Galilee* (London: Committee of the Palestine Exploration Fund 1881) 404. The site of Khirbet Minyeh features remains of a palatial structure dated to the Early Muslim period. See H.P. Kuhnen – M. Pines – O. Tal, "Horbat Minnim. Preliminary Report," *Hadashot Arkheologiyot* 130 (2018), https://www.jstor.org/stable/26691685.

51 Although it should be noted that pious Jews would avoid Tiberias since it was considered to be unclean as it was partly located on the territory of an old cemetery.

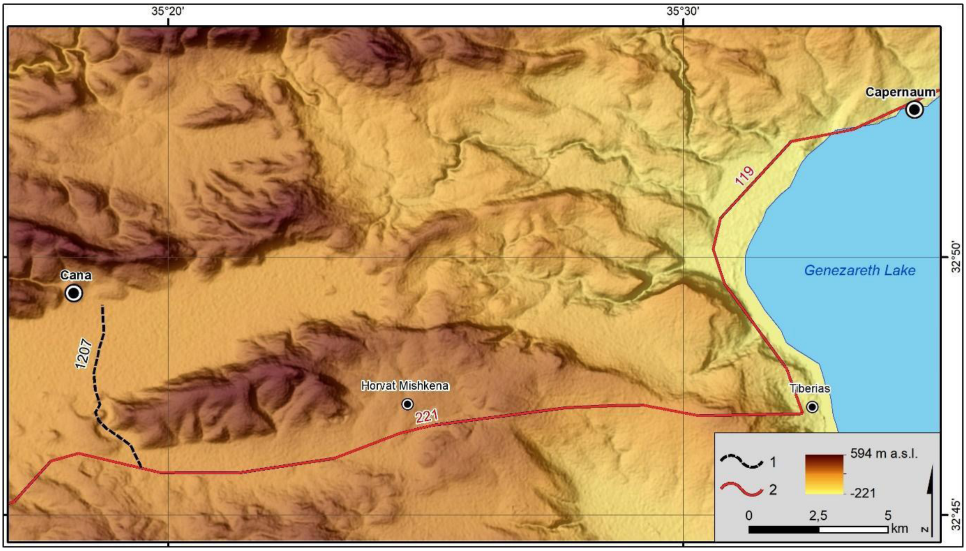

Fig. 9. From Cana to Capernaum using the Roman imperial road network:
1 – Roman imperial roads (Harvard Dataverse/Barrington Atlas),
2 – 'Ottoman' road as a connector.
Hypsometry and hillshading based on SRTM DEM (2013)

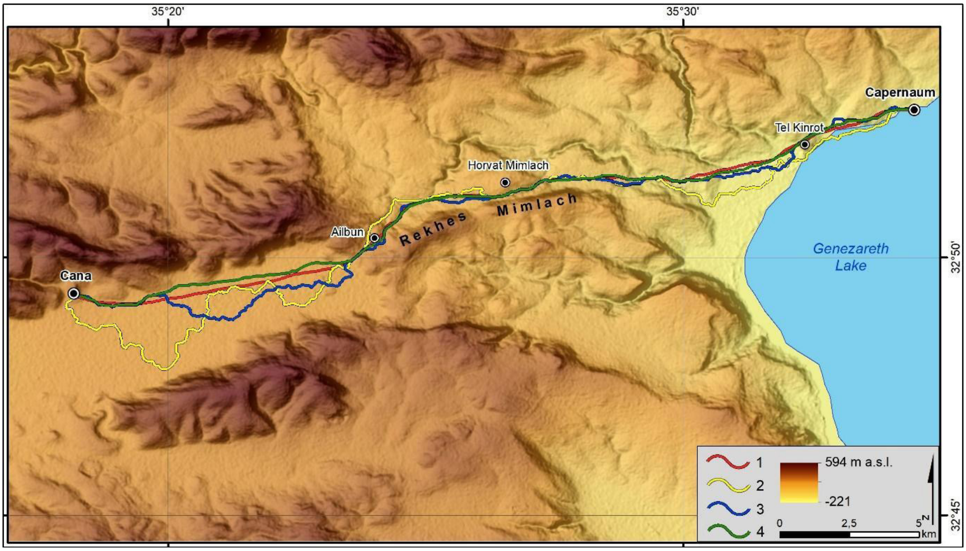

Fig. 10. Least cost path simulation for Cana to Capernaum: 1 – srtm/tobler;
2 – srtm/slope; 3 – aster/slope; 4 – aster/Tobler.
Hypsometry and hillshading based on SRTM DEM (2013)

Lake Galilee. The route slowly descends along Rekhes Mimlah and continues along Nahal Tsalmon until it reaches Capernaum from the west. The total length of this route is 28 km. Potential places to rest on this route are Ailbun (12 km from Cana) and Horvat Mimlach (18 km from Cana), where travellers could stock up on water from nearby springs. It should also be noted that on the same corridor of movement, several Ottoman roads can be identified between Cana and Capernaum (OR 1051 to Ailbun, OR 1985, 1986, 1987, 1988, 1990, 1989,1977 to Tell Kinrot, and OR 73 to Capernaum).

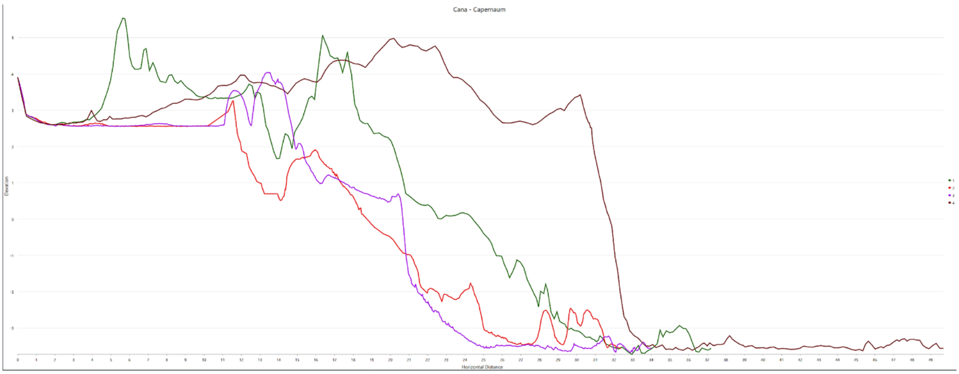

Fig. 11. Profiles of all routes for Cana to Capernaum (green line – Ottoman road, red line – LCP simulation [SRTM/Tobler], purple line – route indicated by archaeological sites, brown line – Roman imperial road). © Travel and Mobility in Hellenistic and Early Roman Palestine Project

All in all (see Fig. 11 and 13), the results of our remote sensing research suggest that the fastest travel between Cana and Capernaum in Early Roman times would have been via the valley of Nahal Tsalmon, as indicated by the analogy of the GIS simulations (and several Ottoman roads). No archaeological remains of roads or road infrastructure directly related to the route along the valley of Nahal Tsalmon are known. In the case of future fieldwork in search of such archaeological remains, the most promising section of this route is a descent to the shores of Lake Galilee from the eastern part of the Beit Netofa Valley and the valley of Nahal Tsalmon, since this area is not urbanised. In contrast, a route following the Roman imperial road network and a route using the Ottoman road via Khirbet Tsalmon would have implied detours and would have been considerably longer by about 15 and 11 km, respectively. These two routes would have required two days of travel on foot.

At the same time, it should be noted that the pattern of archaeological settlement may also suggest an alternative. Namely, if we take account of archaeological settlement and its administrative role, another route may still be recommended (Fig. 12). First, southeast of Ailbun, there existed a number of important sites, including Khirbet Ammudim, Hittin, Arbela and Tarichaeae. These sites, especially Arbela and Tarichaeae, which functioned as

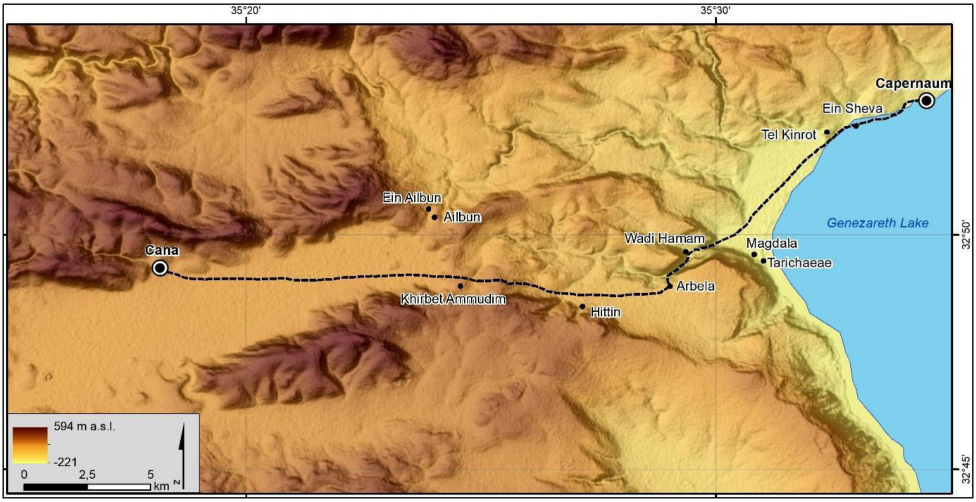

Fig. 12. Least cost path simulation for Cana to Capernaum route through Arbela.
Hypsometry and hillshading based on SRTM DEM (2013)

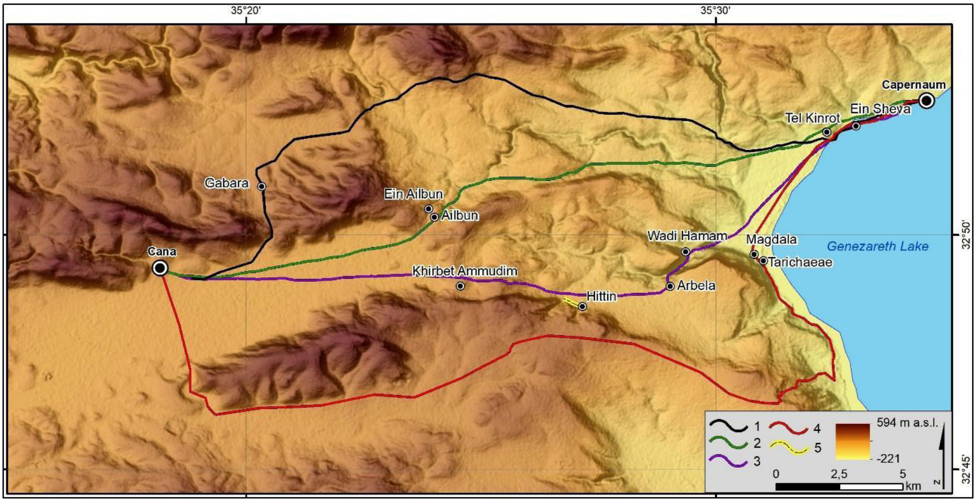

Fig. 13. Situation map – Ailbun, Khirbet Ammudim, Hittin, Arbela and Tarichaeae.
The four lines indicate different routes: 1 – Ottoman road; 2 – LCP simulation (srtm/tobler);
3 – LCP through Arbela; 4 – Roman imperial road (Harvard Dataverse/Barrington Atlas);
5 – pre-Roman road near Hittin.
Hypsometry and hillshading based on SRTM DEM (2013)

administrative centres (*toparchiai*), must have been connected with other administrative centres, especially with Sepphoris and Gabara in the west, in the vicinity of which Khirbet Qana was located. Reconstructed connections between Gabara and Arbela led via Kh. Ammudim, while the connection between Sepphoris and Tarichaeae went via Hittin, Arbela, and Wadi Hammam.[52] It follows that the area of Arbela and Tarichaeae functioned as an important travel hub. Although the route from Cana to Capernaum via Arbela is slightly longer (30 km) than the route via the valley of Nahal Tsalmon, it may have been preferable if, for instance, a stopover was necessary on the way. Larger sites may have offered more options in this regard than small villages. Despite the relatively short distance, which could be covered during a one-day trip, the necessity of a stopover could have arisen if the journey began late in the day or during the shorter days of winter.

Fig. 14. Tepper and Tepper's rock-cut steps near Arbela.

52 A route via Wadi Hammam is also discussed by U. Leibner, *Settlement and History in Hellenistic, Roman, and Byzantine Galilee. An Archaeological Survey of the Eastern Galilee* (TSAJ 127; Tübingen: Mohr Siebeck 2009) 14–15, Map 3.

What is more, tentative archaeological data may suggest the existence of road remains along this route. First, one of the series of rock-cut steps identified by Yotam and Yigal Tepper is located north of Arbela.[53] The steps are located on a very steep hillside (see Fig. 14) and apparently served the travel between the hilltop on which the settlement of Arbela was located and the bottom of Wadi Hammam, along which an ancient route most likely led towards the western plain of the Sea of Galilee. Furthermore, to the west from Hittin, there is a modern dirt road which leads in the direction of Khirbet Ammudim (see Fig. 15). However, at some sections, the course of an old road parallel to the course of the modern dirt road can be observed (Fig. 15). What is more, ancient burial caves are located along this modern dirt road (Fig. 16), and these caves must have been accessible from a road in ancient times. Thus, it appears that the modern dirt road partly covers the ancient road, although sections of the ancient road are still preserved roughly parallel to the course of the modern dirt road (see Fig. 15).

Fig. 15. Probable section of pre-Roman road near Hittin.
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53 For a popular summary of Tepper and Tepper's research, see Y. Tepper – Y. Tepper, "Archaeological Views: Walking Roads," *BAR* 42/1 (2016) 20, 62.

Fig. 16. One of the cave tombs near Hittin (to the west).
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2.3. From the Baptism Site to Cana

Much ink has been spilled on the location of the baptising activity of John the Baptist and Jesus' own baptism.[54] In fact, the synoptic Gospels do not provide us with precise geographic or topographical data, at least not to any extent that would comply with modern geographical standards. In fact, the Synoptic Gospels suggest only a general geographical setting. For example, Mark 1:4 places John in the 'wilderness', with 'the whole Judean countryside and

54 For an overview, see M. Piccirillo, "The Sanctuaries of the Baptism on the East Bank of the Jordan River," *Jesus and Archaeology* (ed. J.H. Charlesworth) (Grand Rapids, MI: Eerdmans 2006) 433–444; B.A. Foreman, "Locating the Baptism of Jesus. John 1:19–2:1," *Lexham Geographic Commentary on the Gospels* (eds. B.J. Beitzel – K.A. Lyle) (Bellingham, WA: Lexham Press 2017) 65–73; A.L. Taylor, "Ministry in the Wilderness. Matt 3:13–4:11, Luke 3:21–4:15," *Lexham Geographic Commentary on the Gospels* (eds. B.J. Beitzel – K.A. Lyle) (Bellingham, WA: Lexham Press 2017) 42–52; A.L. Taylor, "Wilderness Events: The Baptism and Temptation of Jesus. Matt 3:13–4:11, Luke 3:21–4:15," *Lexham Geographic Commentary on the Gospels* (eds. B.J. Beitzel – K.A. Lyle) (Bellingham, WA: Lexham Press 2017) 53–64; J. Knust, "Where Did John Baptize? From Bethany to Bethabara and Back Again," *JAC* 63 (2020) 217–239.

all the people of Jerusalem' coming to him. Matt 3:1–6 locates John's activity in the 'wilderness of Judea' and along the Jordan River and mentions people coming to John from 'Jerusalem and all Judea and the whole region of the Jordan'. Luke 3:2–3 enigmatically states that John may be found both in the 'wilderness' and in 'all the country around the Jordan'. At the same time, the Gospel of John (John 3:22) employs two toponyms to locate John the Baptist's activity: Aenon near Salim and Bethany beyond the Jordan.

Many topographic identifications have been suggested over the centuries on the basis of the aforementioned textual evidence.[55] However, building on a recent consensus, it may be stated that the main identifications of Aenon near Salim are the Arab village of Salim near Shechem and, more likely, Umm el-ʿUmdan, south of Scythopolis.[56] In turn, Bethany has long been widely identified with the vicinity of the Hajlah ford near Jericho.[57] However, in a recent and important study building on previous scholarship going back to as late as 1706, R. Riesner revived and substantiated the other alternative – a northern location if Bethany is emendated to Bathanea.[58] However, within this general identification, several distinctive sites have been postulated: from north to south, Yardenit (a ford south of the Jordan's outlet from Gennesaret); Gesher (a ford near the confluence of the Jarmuk and Jordan rivers); and Makhadet Abara (a ford northeast of Scythopolis). It should be stressed that the two general identifications, the Hajlah ford, and all the other fords in the north lie far apart.[59] Several arguments have been raised over the course of the discussion of these two general identifications, some of which may be discussed in the light of GIS methods. First, following the time sequence in John 1:19–2:1,[60] it has been stated that after the meeting with John at Bethany, Jesus travelled to Cana (John 2:1), and that it took him two or three days to cover this distance.[61] Second, still following the time sequence in John 1:19–2:1, the meeting of Jesus with Philipp of Bethsaida (John 1:43–44) has been interpreted as an indication that Jesus' journey following his meeting with John the Baptist and on his way to Galilee (John 1:43) ran through Bethsaida.[62] Third, it has been stressed that the distance from the Hajlah ford to Cana is too large to be covered within one or two days.[63]

55 For an overview, see R. Riesner, "Bethany Beyond the Jordan (John 1:28): Topography, Theology and History in the Fourth Gospel," *TynBul* 38 (1986) 29–63.

56 Taylor, "Ministry in the Wilderness," 44.

57 Taylor, "Wilderness Events," 54, n. 2.

58 Riesner was criticized by J.M. Hutton ("Bethany Beyond the Jordan in Text, Tradition and Historical Geography," *Bib* 89 [2008] 315–316), but followed by others, apparently particularly in American scholarship, e.g. by Foreman, "Locating the Baptism of Jesus," 65–73, and Taylor, "Wilderness Events," 53–64.

59 Riesner, "Bethany Beyond the Jordan," 45–47; Forman, "Locating," 72.

60 This time sequence may of course also be interpreted symbolically and not chronologically. See J.M. Hutton, "Bethany Beyond the Jordan," 315–316.

61 Riesner, "Bethany Beyond the Jordan"; Forman, "Locating," 72.

62 Foreman, "Locating the Baptism of Jesus," 72.

63 Riesner, "Bethany Beyond the Jordan," 47; Foreman, "Locating the Baptism of Jesus," 72.

2.3.1. The Hajlah Ford

2.3.1.1. The Hajlah Ford–Cana

If the Ottoman road network is used as an analogy for an Early Roman route from the Hajlah ford to Cana (see Fig. 17), the total travel distance is 138 km. The route leads west via OR 1948 and OR 1947 to Jericho and then turns north via RR 9 and RR 40 to Scythopolis (87 km from the Hajlah ford). From Scythopolis, it turns west via ancient road no. 69 (AR 69 hereinafter) and continues via OR 1833 and 1029 to Tel Yizreel. From Tel Yizreel via OR 208 and 191, the route passes through Nazareth to Sepphoris. From Sepphoris, Cana could be reached via OR 998 and 1211 (51 km from Scythopolis).

Next, if the Roman imperial road network is used as an analogy (see Fig. 18), the main corridor of movement passes through the Jordan Valley until Scythopolis: first, turning west via a short section of the Livias–Jericho road (ID 2212, Harvard Dataverse), and next, near Jericho, turning north using the Jericho–Archelais and Archelais–Scythopolis roads (ID 2166, 2170, 2714, Harvard Dataverse). From Scythopolis onwards, the route has two different options. The first option is to turn west towards Legio via the Legio–Scythopolis road (ID 2743, Harvard Dataverse), and next turn north near Legio towards Sepphoris via the Legio–Sepphoris road (ID 7095, Harvard Dataverse). This route requires getting off the Roman road at Sepphoris (ID 7096, Harvard Dataverse). The route from the Hajlah ford to Scythopolis is 88 km, and the continuation to Sepphoris via the Legio road takes another 49 km and 10 km by a local road, while via the Tiberias route it takes 56 km and 5 km by a local road. Thus, the total distance to be covered from the Hajlah ford to Cana using the Roman imperial road network is 147–149 km.

In the case of the Least Cost Path simulations (see Fig. 19), all LCP routes run northwards until Aenon near Salim (Umm el-ʿUmdan) and the immediate vicinity of Scythopolis, where they turn northwest to pass via the Jezreel Valley. However, the LCPs differ in their further course depending on the algorithm (surface cost) – LCPs based on slope pass around the Nazareth Range from the west, while LCPs based on Tobler's Hiking Function pass directly through the range, 6 km to the east from Nazareth. This situation is the result of methodological differences between widely used LCPs based on Tobler's Hiking Function (which favours shorter distances even at the expense of sections with a greater slope) and alternative LCPs based on slope (which favours a small degree of inclination, often at the expense of much greater distances). Both routes pass near Sepphoris and, as this route covers a long distance, it is very likely that the road ran through this important urban centre. The total length of this route is about 139–140 km for LCPs based on Tobler's Hiking Function and 206–217 km for LCPs based on slope.

It should be mentioned that no archaeological remains of a possibly pre-Roman imperial road have been found thus far for this route. In the case of future fieldwork, the most promising section of this route appears to be an ascent located to the east from Nazareth. It is noteworthy that this route passes through Umm el-ʿUmdan, which could prove its importance.

The results of our reconstruction of potential routes from the Hajlah ford to Cana are mixed. On the one hand, the Ottoman road network and the LCP simulations based on

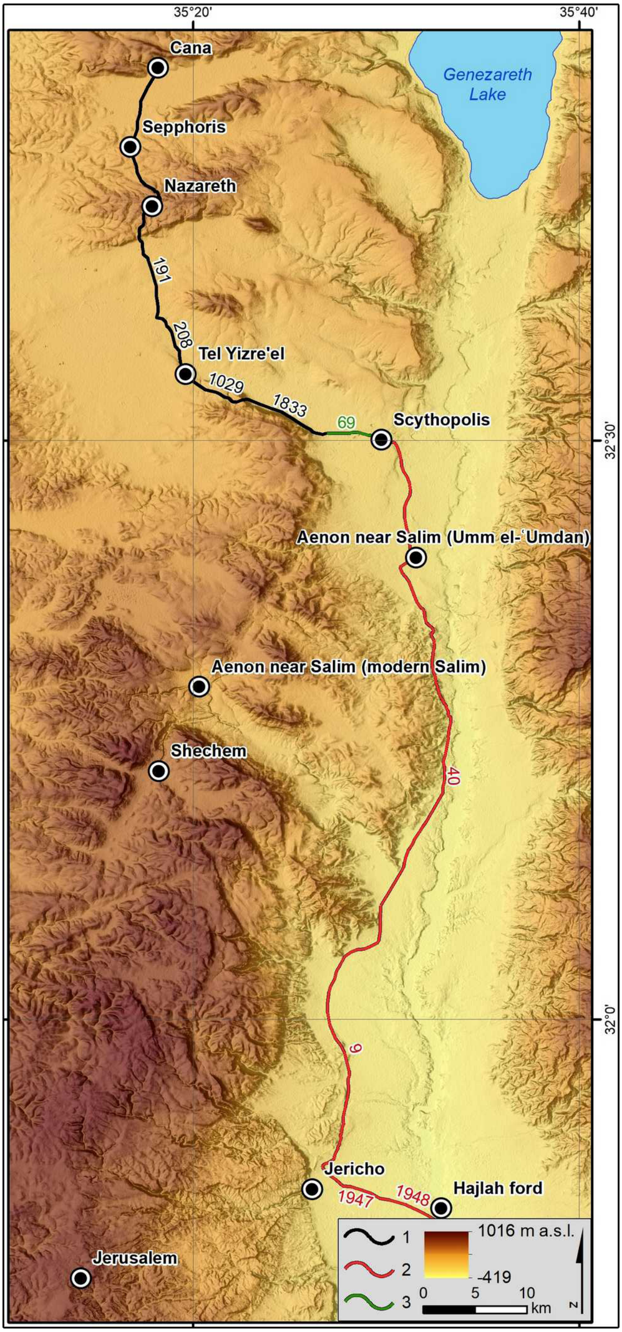

Fig. 17. From the Hajlah ford to Cana using the Ottoman road network: 1 – 'Ottoman' roads; 2 – 'Ancient' roads; 3 – 'Roman' roads. Hypsometry and hillshading based on SRTM DEM (2013)

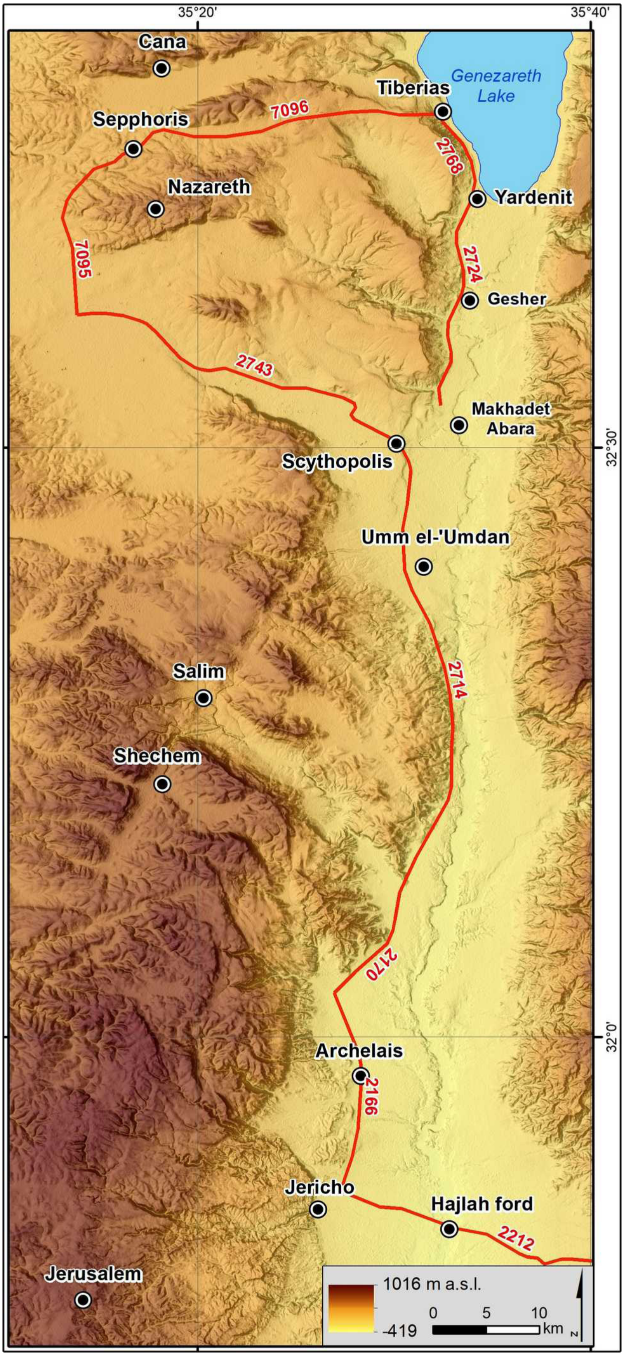

Fig. 18. From the Hajlah ford to Cana using the Roman imperial road network (Harvard Dataverse/Barrington Atlas). Hypsometry and hillshading based on SRTM DEM (2013)

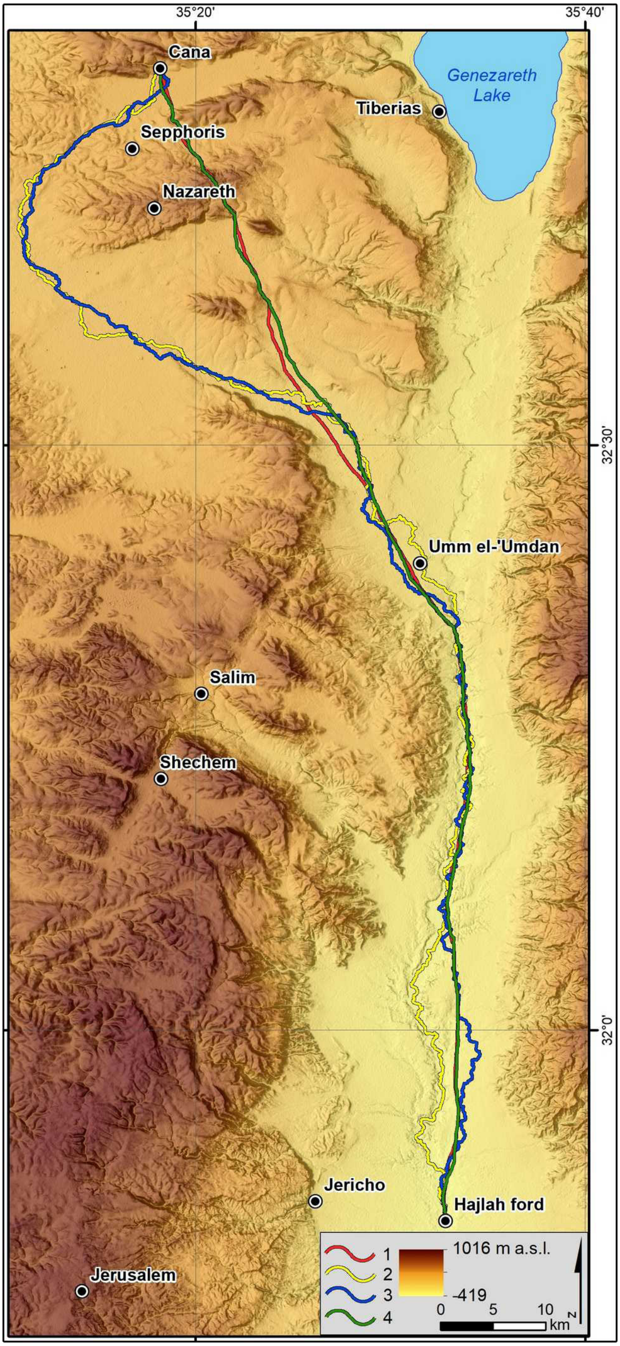

Fig. 19. Least cost path simulation for the Hajlah ford to Cana: 1 – srtm/tobler; 2 – srtm/slope; 3 – aster/slope; 4 – aster/Tobler. Hypsometry and hillshading based on SRTM DEM (2013)

Tobler's Hiking Function indicate a shorter route through the Nazareth Range (138 km using the Ottoman roads and 139–140 km indicated by LCP). On the other hand, the Roman imperial road network and the LCP simulations based on slope hint at the possibility that the route may pass around the Nazareth Range through Simonias and nearby Sepphoris, but this route covers at least 159–165 km. At any rate, the journey from the Hajlah ford to Cana is at least 138 km, which requires around 5 days of travel on foot.

2.3.1.2. The Hajlah Ford–Bethsaida–Cana

If the Ottoman road network is used as an analogy for an Early Roman route from the Hajlah ford to Cana through Bethsaida (see Fig. 20), the journey takes 178 km. The route leads west via OR 1948 and OR 1947 to Jericho and then turns north via RR 9 and RR 40 to Scythopolis. From Scythopolis, it continues to the north via RR 41 and turns northeast near Gesher via OR 2369, 2370 and 74. Then, the route follows the eastern shores of Lake Galilee via OR 73 and, after passing Bethsaida, continues via OR 1977. The direction of the route OR 1978 is firstly northwest, following Nahal Amud and ascending to the west near Huquq. From Horvat Tsalmon, the route leads southwest via OR 1978. Finally, via OR 1216 and 3163, the route leads south through Gabara and, after descending to Beit Netofa Valley, turns west for the last 3 km via OR 1051.

Next, if the Roman imperial road network is used as an analogy (see Fig. 21), the main corridor of movement passes through the Jordan Valley until Scythopolis for 88 km: first turning west via a short section of the Livias–Jericho road (ID 2212, Harvard Dataverse), and next turning north near Jericho using the Jericho–Archelais and Archelais–Scythopolis roads (ID 2166, 2170, 2714, Harvard Dataverse). From Scythopolis onwards, the route continues northeast via ID 2742, 2723 (Harvard Dataverse). Then it continues to the north via ID 2730, 2727 (Harvard Dataverse). After reaching the shores of Lake Galilee, the route continues via ID 2753, 2746, 2747 (Harvard Dataverse) until Bethsaida. From there via ID 2744, 2745, 7096 (Harvard Dataverse), the route finally reaches Cana after 192 km.

In the case of the Least Cost Path simulations (see Fig. 22), all LCP routes (based on Tobler's Hiking Function and slope) indicate nearly the same route along the Jordan River, around Lake Galilee, and directly to the valley of Nahal Tsalmon and the Beit Netofa Valley through Ailbun for 181 km.

In summary, all our sources point to the same corridor of movement for an itinerary from the Hajlah ford to Cana via Bethsaida: first along the Jordan River, and next along the eastern and northern shore of the Lake of Galilee. Only at the northwestern corner of the Lake of Galilee near Tel Kinrot do our routes divide into two groups: the Ottoman network and the LCPs suggest travel via the valley of Nahal Tsalmon, while the Roman imperial network leads first south to Tiberias and next east to Sepphoris – that is, it runs about 10 km south of the Beit Netofa Valley. As for the distance, the travel between the Hajlah ford and Cana amounts to between 178–192 km if directed towards Bethsaida as an intended stop. This is a longer distance than the 138 km to Cana as a direct destination, without the detour to Bethsaida (travel to Bethsaida first requires at least 143 km). Thus,

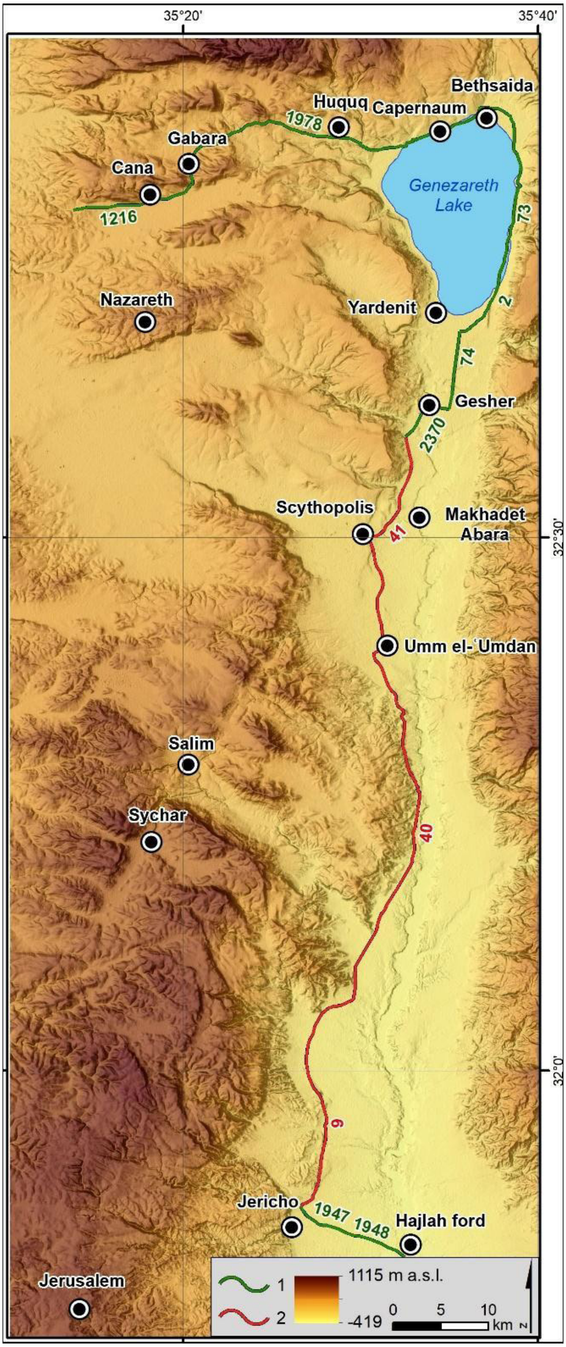

Fig. 20. From the Hajlah ford to Cana through Bethsaida using the Ottoman road network:
1 – 'Ottoman' roads; 2 – 'Roman' roads.
Hypsometry and hillshading based on SRTM DEM (2013)

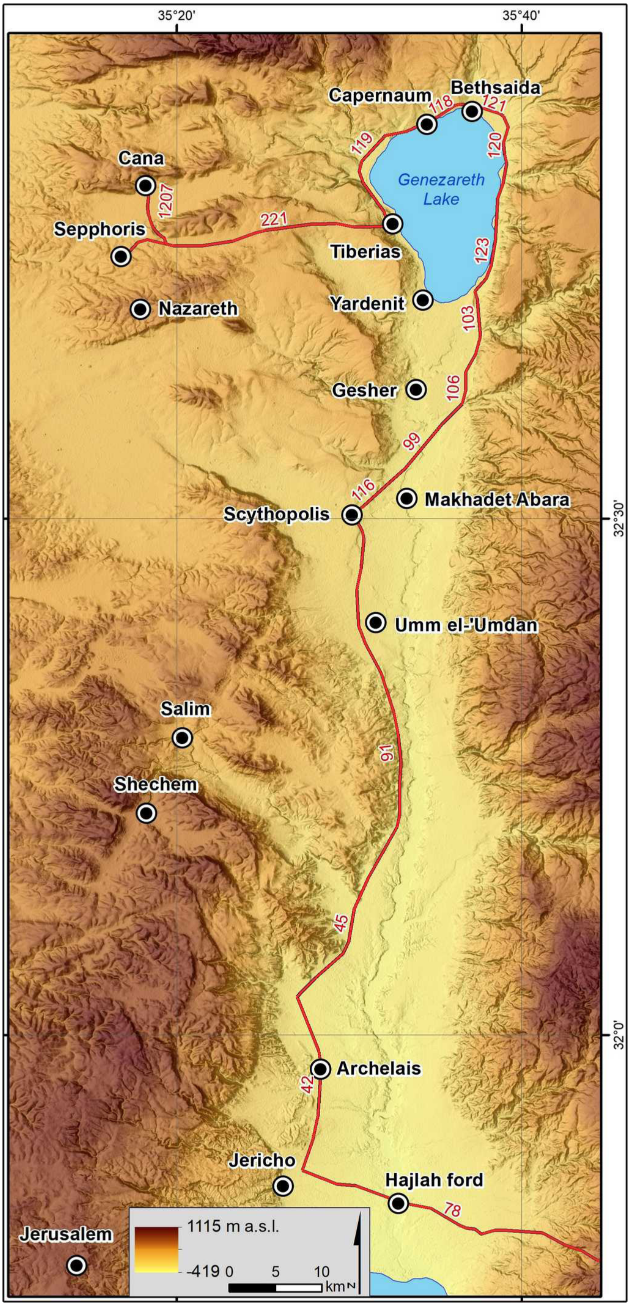

Fig. 21. From the Hajlah ford to Cana through Bethsaida
using the Roman imperial road network (Harvard Dataverse/Barrington Atlas).
Hypsometry and hillshading based on SRTM DEM (2013)

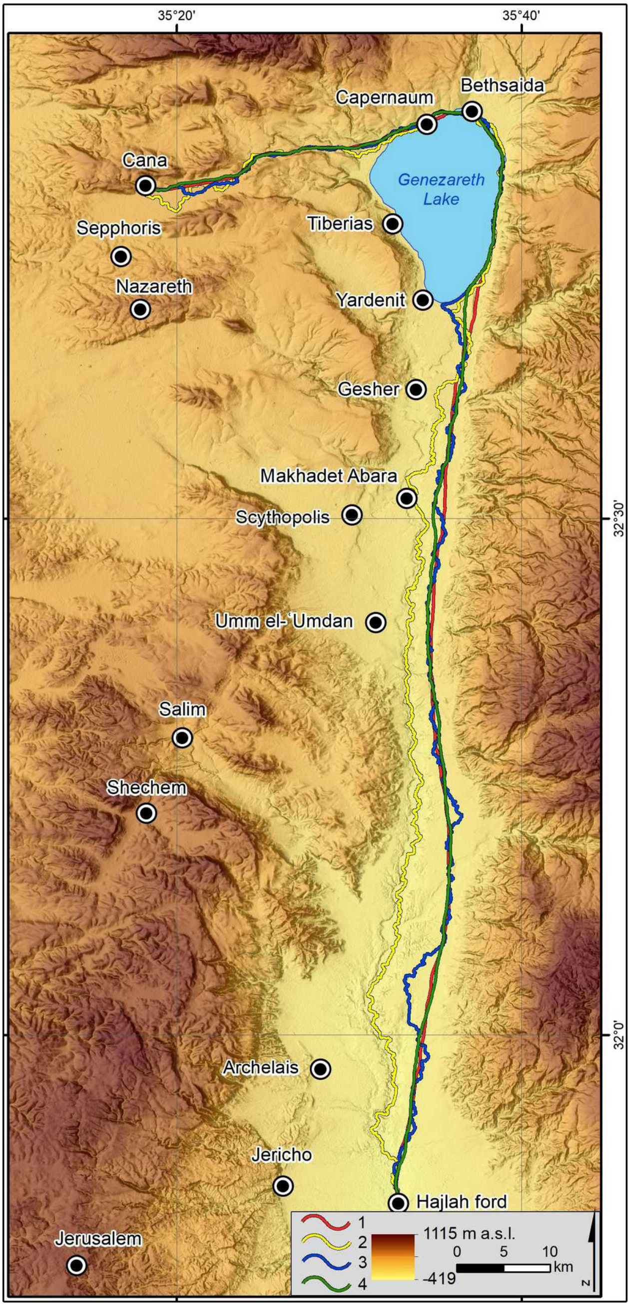

Fig. 22. Least cost path simulation for the Hajlah ford to Cana through Bethsaida:
1 – srtm/tobler; 2 – srtm/slope; 3 – aster/slope; 4 – aster/Tobler.
Hypsometry and hillshading based on SRTM DEM (2013)

not only can the distance not be covered within one or two days, but it requires 5 days of travel via the vicinity of the Nazareth Range and 6–7 days via Bethsaida.

2.3.2. Yardenit/Gesher/Makhadet Abara

2.3.2.1. Yardenit/Gesher/Makhadet Abara–Cana

If the Ottoman road network is used as an analogy for an Early Roman route from the northern identification of Bethany beyond Jordan to Cana, the journey takes 38 km (Yardenit), 44 km (Gesher) or 56 km (Makhadet Abara) (see Fig. 23). On the way, it was possible to stop at el-Khirbeh (Eilaniya), which was 18 km from the destination point. The route leads along the Jordan Valley via RR 41 and ascends to the Lower Galilee plateau via OR 1050, then continues by RR 47 from where OR 1211 provides a connection to Cana.

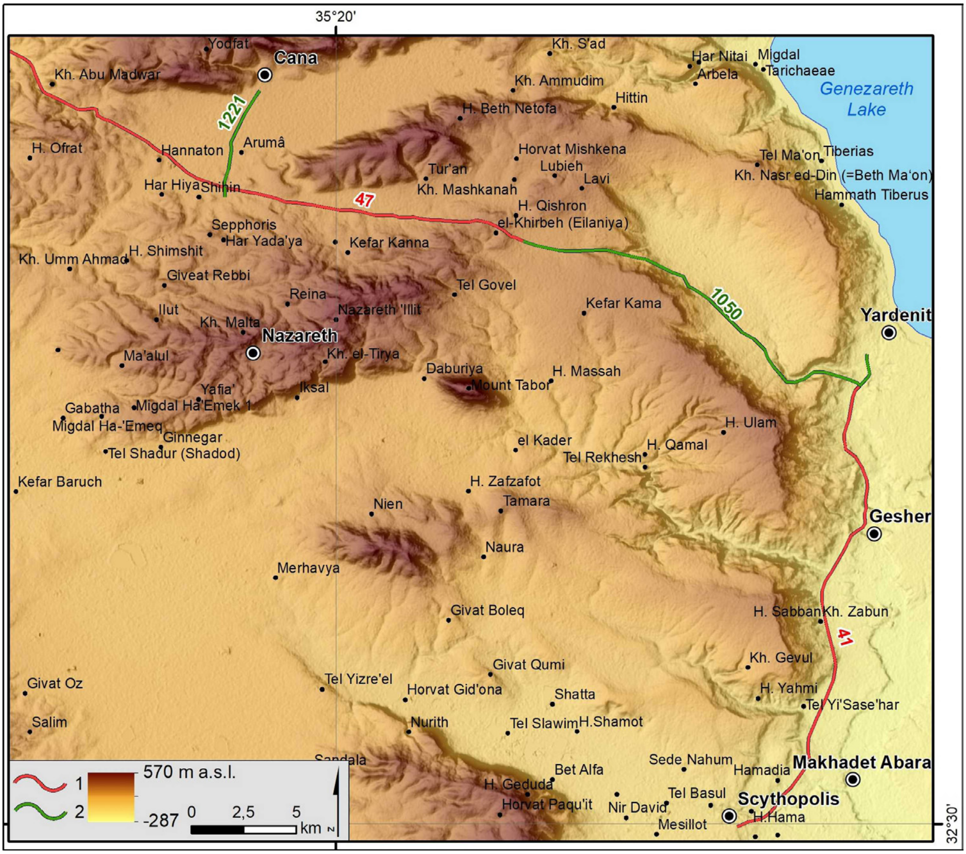

Fig. 23. From Yardenit/Gesher/Makhadet Abara to Cana using the Ottoman road network: 1 – 'Roman' roads; 2 – 'Ottoman' roads. Hypsometry and hillshading based on SRTM DEM (2013)

Next, if the Roman imperial road network is used as an analogy, the main corridor of movement passes to the north through the Jordan Valley via the Scythopolis–Tiberias road (ID 2742, 2724, 2768, Harvard Dataverse). From Tiberias, the road turns west and ascends up to Sepphoris via ID 7096 (Harvard Dataverse). The journey takes 43 km (Yardenit), 50 km (Gesher) or 58 km (Makhadet Abara) (see Fig. 24). In the case of Makhadet Abara, Tiberias could be a preferable stop (32 km from the destination point). At the same time, it could be possible to reach Cana from Makhadet Abara by first going west through the Yezreel Valley and next via Tel Yizreel and Simonias (63 km in total).

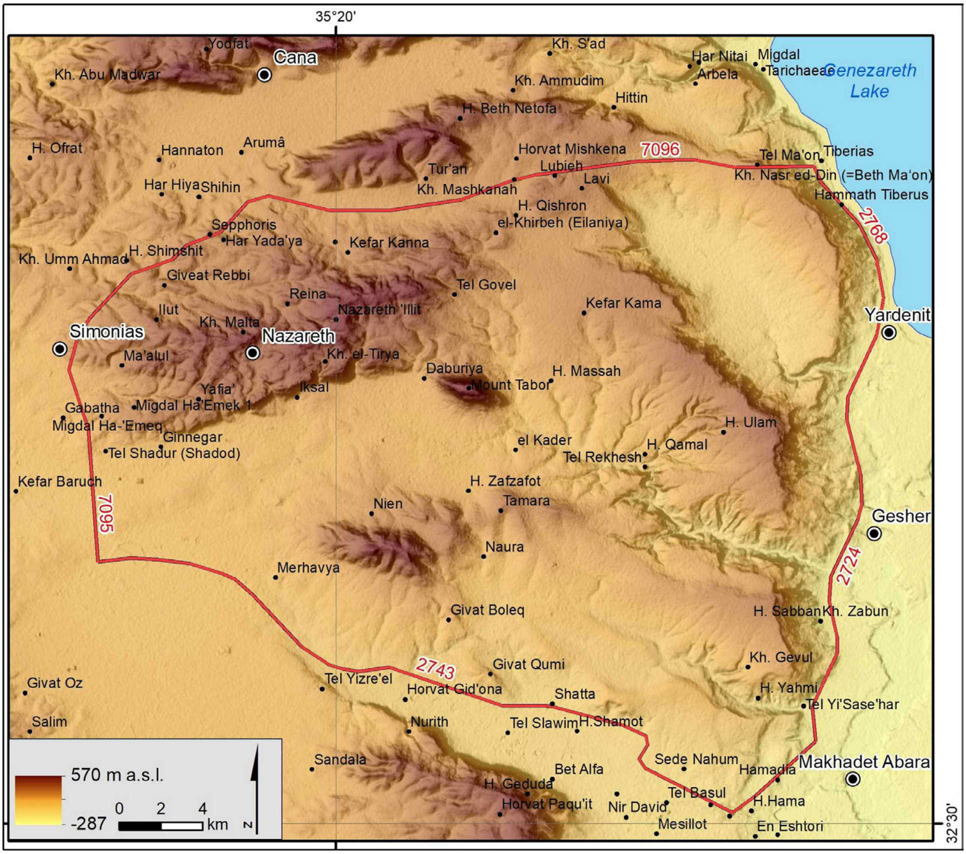

Fig. 24. From Yardenit/Gesher/Makhadet Abara to Cana
using the Roman imperial road network (Harvard Dataverse/Barrington Atlas).
Hypsometry and hillshading based on SRTM DEM (2013)

In the case of the Least Cost Path simulations, all LCP routes based on Tobler's Hiking Function indicate routes which minimise distance (Yardenit: 35 km; Gesher: 43 km; Makhadet Abara: 52 km) (see Fig. 25). At the same time, LCPs based on slope indicate two different routes. The first group (both ASTER and SRTM from Makhadet Abara, as well as SRTM from Gesher and Yardenit) goes via the Jezreel Valley, avoiding any hills on its way and providing cost-efficient travel (75 km long through only flat terrain), following a very similar route as the Roman imperial road from Scythopolis to Sepphoris. The second group includes routes from Gesher and Yardenit, based on ASTER, which pass through the hills like the LCPs based on Tobler's Hiking Function (45–55 km), partially overlapping with a Roman imperial road from Khirbet Mishkena to Sepphoris (Tiberias–Sepphoris).

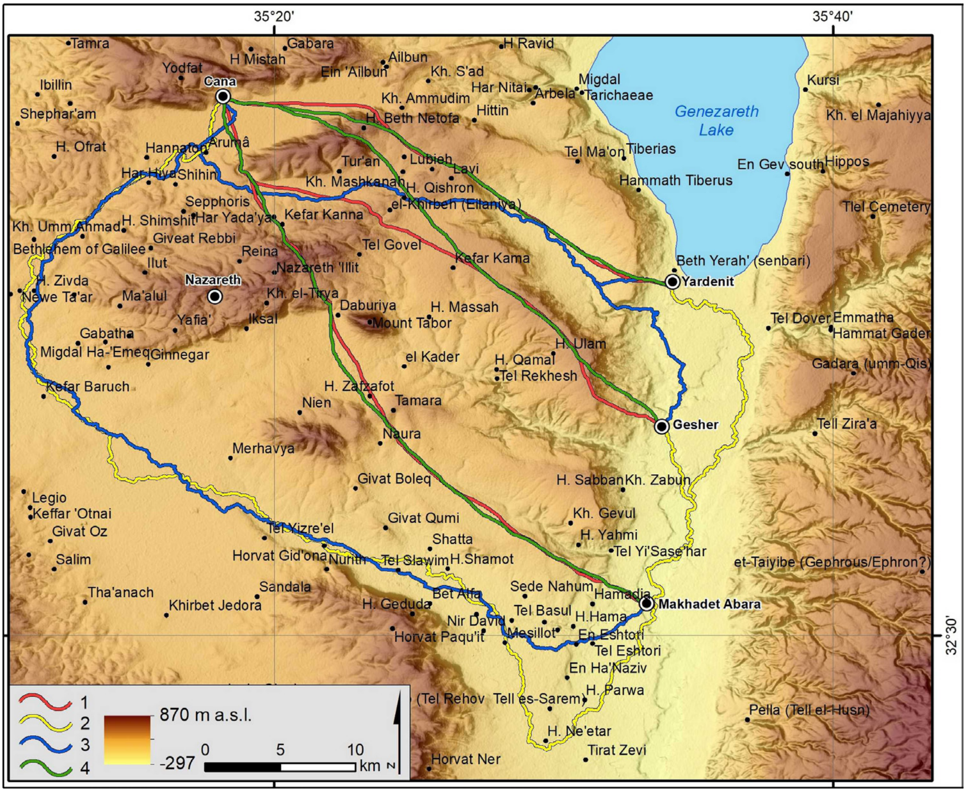

Fig. 25. Least cost path simulation for Yardenit/Gesher/Makhadet Abara to Cana:
1 – srtm/tobler; 2 – srtm/slope; 3 – aster/slope; 4 – aster/Tobler.
Hypsometry and hillshading based on SRTM DEM (2013)

2.3.2.2. Yardenit/Gesher/Makhadet Abara–Bethsaida–Cana

If the Ottoman road network is used as an analogy for an Early Roman route from the northern identification of Bethany beyond Jordan to Cana through Bethsaida, the journey takes 107 km (Yardenit), 114 km (Gesher) or 126 km (Makhadet Abara) (see Fig. 26). From Makhadet Abara, the route leads to the north via RR 41 and turns northeast near Gesher via OR 2369, 2370 and 74. Then, the route follows the eastern shores of Lake Galilee via OR 73 and, after passing Bethsaida, continues via OR 1977. The direction of the route of OR 1978 is firstly northwest following Nahal Amud and ascends to the west near Huquq. From Horvat Tsalmon, the route leads southwest via OR 1978. Finally, via OR 1216 and 3163, the route leads south through Gabara and, after descending to the Beit Netofa Valley, turns west for the last 3 km via OR 1051.

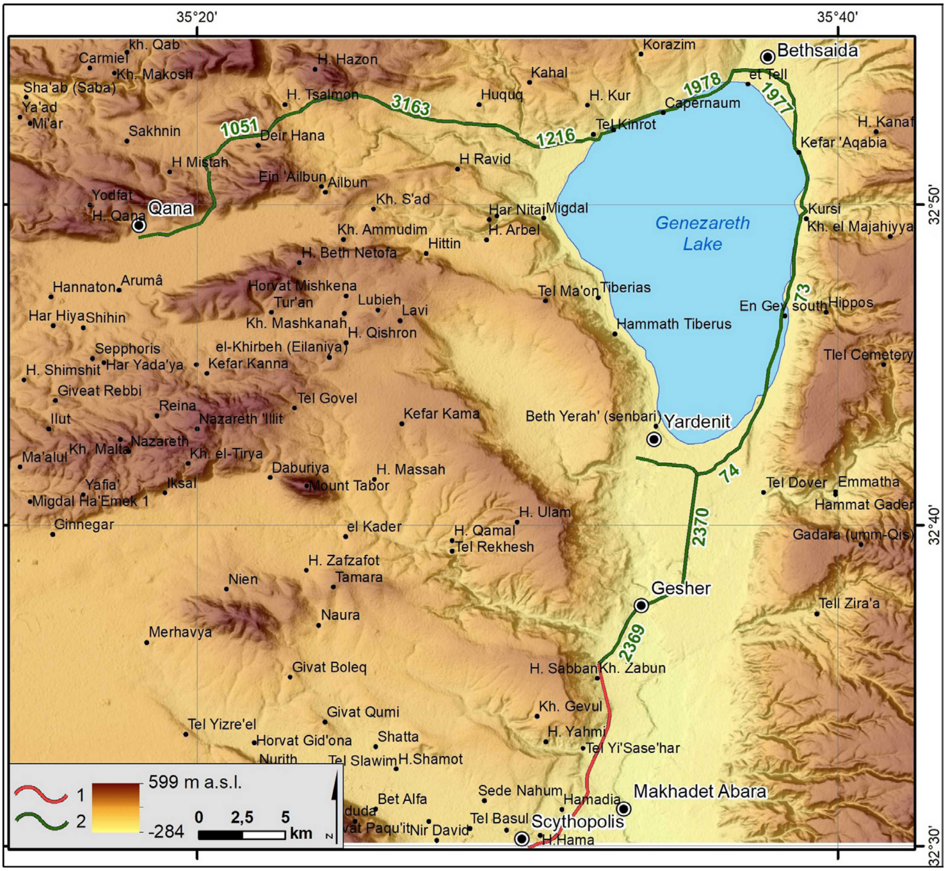

Fig. 26. From Yardenit/Gesher/Makhadet Abara to Cana through Bethsaida using the Ottoman road network: 1 – 'Roman' roads; 2 – 'Ottoman' roads. Hypsometry and hillshading based on SRTM DEM (2013)

Next, if the Roman imperial road network is used as an analogy, the main corridor of movement passes to the north through the Jordan Valley and then along the eastern shores of Lake Galilee via ID 2724, 2725, 2726, 2753, 2746, 2747, 2744, 2745, 7096 (Harvard Dataverse). The total length of this route is 92 km (Yardenit), 101 km (Gesher) or 116 km (Makhadet Abara) (see Fig. 27).

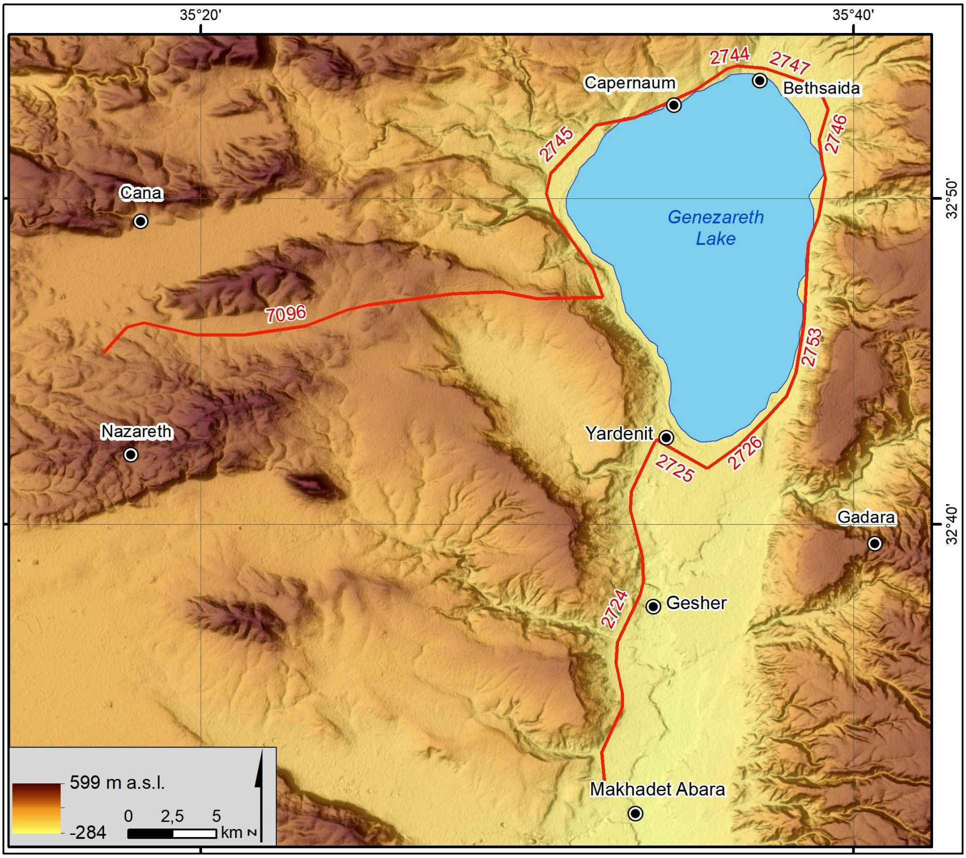

Fig. 27. From Yardenit/Gesher/Makhadet Abara to Cana through Bethsaida using the Roman imperial road network (Harvard Dataverse/Barrington Atlas). Hypsometry and hillshading based on SRTM DEM (2013)

In the case of the Least Cost Path simulations, all LCP routes (based on Tobler's Hiking Function and slope) indicate almost the same route along the Jordan River, around Lake Galilee and the valley of Nahal Tsalmon, and directly to the Beit Netofa Valley through Ailbun for 69 km (Yardenit), 78 km (Gesher) and 92 km (Makhadet Abara) (see Fig. 28).

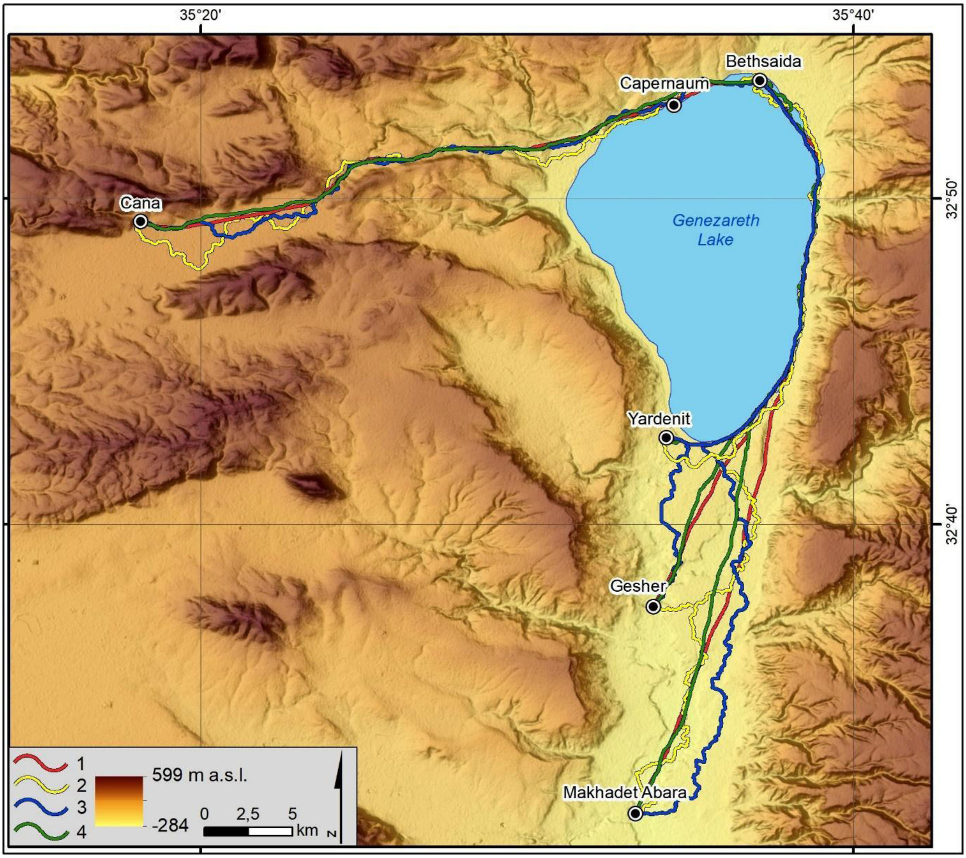

Fig. 28. Least cost path simulation for Yardenit/Gesher/Makhadet Abara to Cana through Bethsaida: 1 – srtm/tobler; 2 – srtm/slope; 3 – aster/slope; 4 – aster/Tobler. Hypsometry and hillshading based on SRTM DEM (2013)

Conclusions

Although a direct route between Jericho and Jerusalem existed both in the Iron Age and Greco-Roman times, the only extant remains are of a Roman imperial road that was used until Ottoman times. This road is about 29 km long and has an average inclination of 6.9 degrees. This means that travel between Jericho and Jerusalem on foot could have required 9 hours[64] of continuous marching and as such is very unlikely to have been completed in one day by most travellers.

It appears that travellers between Cana (Khirbet Qana) and Capernaum had two serious options for travel – a topographic route via the valley of Nahal Tsalmon or a tour via the Arbel Valley. The Nahal Tsalmon route was slightly shorter (28 km), while the Arbela Valley route was a bit longer (30 km), but at the same time it offered more convenient options for overnight accommodation. As both routes could take around 7–8 hours, the choice between them, including the decision to travel for one or two days, may have depended on the season (weather and amount of daylight) and the journey's start time. Longer routes between Cana and Capernaum, including a route via Horvat Tsalmon and Wadi Amud (39 km) and a route following the Roman imperial road from Sepphoris via Tiberias (45 km), are less likely for Early Roman times.

The most probable direct route from the Hajlah ford to Cana (Khirbet Qana) led via the vicinity of the Nazareth Range (on the analogy of Ottoman roads and LCP) and not via Tiberias. The travel distance between the Hajlah ford and Khirbet Qana could amount to 138 km/30 hours and as such would require 4 days of travel on foot.

As for the routes from the northern identifications of the baptism site (Yardenit, Gesher, Makhadet Abara) to Khirbet Qana, their length amounts to 35 km/8 hours (Yardenit), 43 km/10 hours (Gesher), and 52 km/12 hours (Makhadet Abara). In this context, it should be stressed that only from the closest destination, Yardenit, could Khirbet Qana be reached within one long travel day; from Gesher and Makhadet Abara, the journey would likely have taken 2 days.

The use of LCPs, although not an ideal solution, appears to predict general corridors of movement with a high probability. The LCPs typically agree with the courses of the Ottoman roads. Furthermore, they can also provide an accurate prediction of the course of the Roman imperial roads (as indicated by the Jericho–Jerusalem route), although they differ in one important detail – the LCPs may follow riverbeds instead of ascending ridges as they prefer a slight road gradient, while the Roman road engineers led their roads along ridges to avoid building bridges and retaining walls and evade the erosive power of water at the bottom of the valley. The use of DEMs such as SRTM and ASTER do not bring about any substantial differences. In turn, the unclassified use of slope as a cost surface may lead to striking differences in route projections. The LCP simulations based on unclassified slopes prefer routes avoiding even relatively small inclinations at the expense of longer (or even much longer) distances to be covered.

64 For the methodology of the transition from the travel distance (km) to the travel time (hours), see footnote 41.

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