Ancient Transportation Logistics and its Effect on the Shape of Road Networks in Roman Egypt

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Abstract

Road networks were one of the Roman Empire's greatest legacies. They paid much attention to the road system as the Roman Army needed better roads because it had to be able to move quickly to areas of trouble to keep Egypt under control.

The roads were also essential for moving logistics and supplies of food, water and weapons to the soldiers. In times of peace, good and safe roads meant more trade movement and more trade meant more taxes for the Emperor.

The desert trails converge towards crucial points, serving as lifelines for traveller's navigating the arid landscape; these components comprised the logistic activities that formed the backbone of any desert road network.

Importantly, transport was an essential factor in the important questions of how communities within Egypt were supplied? And What were the main logistics that the human activities cluster around in the desert environment? As a consequence, How these resources affected the shape of the roads from simplicity to complexity? These are the major questions that this research aims to investigate.

Keywords: Roman Egypt, Logistics, Transportation, Road Networks, Human Activities.

Introduction

The concept of *'logistics'* derives its origins from the ancient Greek word *'λόγος' 'logos',* meaning *'calculation'*, then turned in French to the word '*logistique'* or '*loger'* which means *'storage'* and finally became '*logistics'* in English as a refer to a system that transports goods and resources[1].

In the Greco-Roman Civilization, logistics was more than just a concept; it was a vital operational function embodied by military officers known as 'λογιστικός' 'Logistikas'. These officers were experts in the art of calculation, responsible for the crucial tasks of managing finances and overseeing the distribution of supplies. The precision and

[1] Ilija Tanackov, Gordan Stojić (2011), Ancient logistics - historical timeline and etymology, Technical Gazette 18, 3 (2011), PP. 379-384, P.379.

efficiency of this system ensured that armies remained well-equipped and financially stable, playing a pivotal role in the success and longevity of these vast empires for many centuries[2].

Contemporary research defines logistics as the process of transporting goods, information, and resources from the point of origin to the final destination according to customer needs, with a focus on effectiveness and efficiency. This modern understanding of logistics, while more comprehensive in scope, it preserves the fundamental principles established by the ancients practices[3].

The concept of logistics can be traced back to the earliest human civilizations, originating from the fundamental need to supply and exchange goods for survival. In ancient Egypt, significant advancements were made in transportation and storage practices to ensure a reliable supply of food and essential commodities[4].

Likewise, ancient Greeks utilized logistics to enhance their military campaigns. This civilization developed advanced transport and storage systems to supply the needs of their cities, armies, and trade routes, using pack animals, carts, warehouses, and strategic routes.

Later, the Roman Empire expanded these logistical practices by establishing an extensive network of roads to efficiently transport and distributes goods needed across the far-reaching corners of its empire. Along these thoroughfares, they erected supply depots to facilitate the smooth flow of resources[5].

During this period, flourishing trade routes facilitated the exchange of valuable knowledge and goods, including metals, textiles, gemstones, and spices, among diverse regions. Among these routes, the Silk Road stood out as the principal commercial artery linking East and West for centuries (Figure 1-2)[6].

Throughout history, logistics services have played a crucial role in advancing human societies, initially by facilitating the transportation of goods, property, and various supplies. Over time, their significance has evolved to encompass intricate management systems, establishing logistics as a cornerstone of the modern business world.

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[2] Jonathan, P., (1999), The Logistics of the Roman Army at War (264 B.C. - A.D. 235), Boston, Köln, PP.7-9.

[3] Turkay Yildiz, (2023), Logistics and Supply Chain Management: Fundamentals and Strategies, Izmir, P. 18.

[4] Ilija Tanackov, Gordan Stojić (2011), P.379.

[5] Joseph Berechman, (2003), Transportation-economic aspects of Roman highway development: The case of Via Appia, Transportation Research Part A 37 (2003) PP. 453–478, P.453.

[6] Lubina Sarwar, (2017), The Old Silk Road and the New Silk Road An Analysis of the Changed Discourse, The Journal Of Central Asian Studies, Vol. XXIV, PP. 13-22, P.14.

I. Transport and Supply in Desert Areas

The eastern and western desert in Egypt served as more than just a trade route, as it was also home to valuable mineral deposits and stone that had been mined since the Pharaonic era[7]. This exploitation of resources not only persisted but likely intensified during the rule of the Ptolemies.

Transporting quarry produce in the desert is a major challenge, as is providing logistical support for both this and the daily needs of the quarry settlements. The state-directed supply systems have varied based on factors like structural changes, availability of animals and food, and seasonal fluctuations[8].

During the Roman period, the trade routes connecting Egypt with the eastern regions grew busier, necessitating the development of road infrastructure to support traders (Figure 1). The region's strategic significance led to the establishment of a limited but constant military presence to deter incursions from nomadic tribes, which in turn required logistical support too[9].

II. Logistics Activities

In the inhospitable desert environment, human activities naturally cluster around vital resources such as water, food, and other essentials resources. Desert trails converge towards these crucial points, serving as lifelines for traveller's navigating the arid landscape, where access to watering points is indispensable.

The following section explores the diverse logistical activities that formed a backbone of the desert road network during Roman rule in Egypt. These essential operations facilitated the movement of people, goods, and resources across the challenging desert landscapes, where desert paths naturally converge and where the vital nodes traverse through with watering points that providing essential lifeline for safe and efficient passage to all who traverse the arid landscape

II.I Watering Stations

The Saharan route considered as a crucial lifeline, between travel two points across the desert, but its viability hinged significantly on the availability of water at regular intervals. Adequate water supply was essential to satisfy the needs of caravans, which

[7]Isabelle, Goncalves, (2022), Exploiting and crossing the Egyptian Eastern Desert during the Pharaonic Era, Networked spaces- The spatiality of networks in the Red Sea and Western Indian Ocean, Accessed July 10, 2024, https://books.openedition.org/momeditions/16431

[8] Peacock, D. P. S. and Maxfield, V. A. (2007) The Roman Imperial Quarries: Survey and excavation at Mons Porphyrites 1994–1998, Volume 2: The Excavations, Egypt Exploration Society, London, P. 112.

[9] Sidebotham, Steven E., (1995), "Routes Through the Eastern Desert of Egypt." *Expedition Magazine* 37, No.2, Accessed July 13, 2024, https://www.penn.museum/sites/expedition/routes-through-the-eastern-desert-of-egypt/

often included hundreds of people and animals. Thus, ensuring that watering points were spaced no more than eighty kilometres apart was vital. This facilitated reliable access to essential resources, ensuring the sustainability and safety of traveller's navigating through the challenging desert terrain[10].

Regions devoid of water lack show signs of prolonged human habitation; any human presence there was typically transient and sparse. In contrast, the majority of archaeological evidence discovered in Egyptian desert sites is concentrated near water sources, such as wells or springs. For this reason, these sources have played a pivotal role in sustaining human activity, and providing essential resources for settlements and facilitating permanent forms of occupation in these arid regions[11].

Thus, Water-bearing areas represent the fundamental nodes upon which nearly all other desert activities and infrastructure rely. Without local water sources, agriculture becomes impracticable, and endeavour's such as prospecting, trade, and military operations encounter significant logistical and practical challenges. These areas are critical hubs for sustaining human presence and activities in the desert, essential for both survival and economic activities.

Watering stations existed along the Ain Amur and Ghubari routes between the Dakhla and Kharga oases in the western desert; there were also several water stations that were apparently found on the route connecting the Kharga oasis with Farshut and on the route from Girga (Figure 3-4)[12].

II.II. Agricultural Nodes

In the Egyptian desert, plots of land adjacent to water sources were often cultivated, but the success of crops depended significantly on the quality and quantity of available water. This distinction is underscored by the two primary types of water sources in these regions which divided into oases and waterholes.

Oases provide a consistent and abundant water supply throughout the year, making them ideal for sustaining permanent and reliable agriculture. In contrast, waterholes depend on springs that vary in output and water quality across different areas, leading to fluctuations in productivity over time. Consequently, agriculture in these regions faces considerable challenges due to the unpredictable nature of water supply, making it less sustainable compared to oases[13].

[10] Maciej Paprocki, (2019), Roads in the Deserts of Roman Egypt- Analysis, atlas, commentary, Oxford, PP. 45-46.

[11] Figueras, P. (2000), From Gaza to Pelusium: materials for the historical geography of North Sinai and Southwestern Palestine (332 BC – 640 AD), University of the Negev Press, P.207.

[12] Roe, A., (2006) The Old 'Darb al Arbein' Caravan Route and Kharga Oasis in Antiquity. Journal of the American Research Center in Egypt 42, PP. 119–129, P.128.

[13] Maciej Paprocki, (2019), PP. 47-48.

Recent researches have illuminated that many Egyptian waterholes were indeed populated during the Greco-Roman period. One notable discovery along the route from El Dakhla to Farafra is the Abu Minqar waterholes, where archaeologist's discovered two ruined brick buildings believed to date back to the Roman era (Figure 2). Given that a single well would have provided ample water for both the site's residents and passing caravans, the excess water was probably utilized for irrigating local fields, although evidence of such cultivation has regrettably not been found[14].

Surveys along the road from Bahariya to Farafra, specifically in the Ain al-Wadi area, have revealed remnants of small yet flourishing Roman agricultural settlements. These communities cultivated the land surrounding local springs that had previously remained unexplored.

II.III Mining Nodes

The geological contrasts between Egypt's Eastern and Western Deserts have resulted in distinct mineral resources available for exploitation in each region. The Eastern Desert is renowned for its rich and varied minerals and abundant in mountainous terrain (Figure 1). While the Western Desert has fewer overall resources, it hosts minerals of exceptionally high value concentrated primarily around its oases (Figure 2)[15].

Since the Eastern Desert is craggy and composed of mineral-rich igneous and metamorphic rocks, it became a focal point for extensive quarrying and mining activities during the Roman period. The geological richness of this region, with its abundant mineral resources found in mountainous areas, attracted Roman prospectors who meticulously surveyed numerous sites in search of valuable stones and metals[16].

Key Roman quarry sites included Mons Porphyrites, Mons Claudianus, Umm Huyut, Domitiane, Tiberiane, Mons Ophiates, Wadi Maghrabiya, and Gebel Rokham was strategically located to exploit various precious stones and building materials[17]. This exploitation of mineral resources in the Eastern Desert was a direct consequence of its

[14] Maciej Paprocki, (2019), P. 47.
[15] Maciej, Paprocki, (2019), P.48.
[16] Riemer, H. and Förster, F. (2013) Ancient desert roads: Towards establishing a new field of archaeological research. In Desert Road Archaeology in Ancient Egypt and Beyond, Africa Praehistorica 27, Heinrich-Barth-Institut, Köln, PP. 19–60, P.47.
[17] Sidebotham, S. E., (2011), Berenike and the Ancient Maritime Spice Route, University of California Press, Berkeley, P.167.

geological composition that was contributes significantly to the Roman economy and infrastructure development in the region[18].

In contrast to the extensive quarrying and mining of different minerals in the Eastern Desert during the Roman era, the region's gold deposits were not as actively exploited. While gold mining sites existed during the Ptolemaic and early Roman periods, by the late first century AD, these mines had largely declined in significance[19].

Many of them were partially abandoned, reflecting the dispersed nature of the gold deposits and the high costs associated with guarding them. This shift in mining activity underscored a strategic and economic change in the region, where the focus shifted away from gold to other more accessible and economically viable mineral resources like precious stones and building materials[20].

The mining and quarrying nodes in the Egyptian deserts formed a distinct class of sites that didn't strictly depend on local food and water resources, allowing them to appear independently from local food and water resources. Despite their autonomy, these mineral-rich areas still demanded the provision of essential supplies for the workers, including food, water, and shelter[21].

At Mons Porphyrites, Roman quarrymen hewed columns and blocks of greatly coveted imperial porphyry, whereas works at Umm Huyut and Mons Claudianus provided blocks of grano-diorite and tonalite gneiss[22].

Neighbouring quarries at Domitiane and Tiberiane yielded quartz diorite[23]. Further south, in Wadi Maghrabiya and at Mons Ophiates, one finds Roman gabbro quarries. In Wadi Hammamat quarried different varieties of sandstone[24]. Finally, at Gebel Rokham, quarrymen tapped into a thin marble vein, a mineral rare in the borders of Egypt.[25]

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[18] Colin, Adams, (2007), Land Transport in Roman Egypt-A Study of Economics and Administration in a Roman Province, Oxford University press, NewYork, P. 36.

[19] Klemm, R., Klemm, D., (2013), Gold and Gold Mining in Ancient Egypt and Nubia: Geoarchaeology of the ancient gold mining sites in the Egyptian and Sudanese eastern deserts, Springer, New York, PP.13-16.

[20] Van der Veen, M., Hamilton-Dyer, S. (1998) A Life of Luxury in the Desert? The food and fodder supply to Mons Claudianus. Journal of Roman Archaeology 11, PP. 101–116, P. 101.

[21] Peacock, D. P. S. and Maxfield, V. A. (2007), P. 112.

[22]Sidebotham, S. E. (1996) Newly Discovered Sites in the Eastern Desert. The Journal of Egyptian Archaeology 82, 181–192., PP. 186–189.

[23] Sidebotham S. E. (2011), P. 167.

[24] Sidebotham, S. E. (1996), P.169.

[25] Sidebotham S. E. (2011), P. 167.

The inhospitable nature of these sites made extensive on-site farming impractical, necessitating the regular importation of supplies from other regions. This logistical challenge highlighted the advanced organizational capabilities required to sustain mining operations in such harsh desert environments, reflecting the broader infrastructure and support networks that were essential for their success.

II.IV. Trade Nodes

Pivotal trade hubs considered another important category of nodes in the desert landscape where goods traversed from producers to consumers. Recent studies reveal that ancient Saharan trade networks formed intricate webs of connections, spanning short, medium, and long distances between local trade centres. Along these routes, minor communities and rest stations along the routes to facilitate trade flows[26].

At their core, these trade networks played an essential role in enabling the crucial movement of agricultural surpluses across the variable productivity zones of the desert oases. Due to the uneven yields in local agriculture, prosperity in one region often coincided with famine in another. The trade of foodstuffs served to mitigate these disparities by transporting surpluses to less prosperous communities, thereby balancing and sustaining economic stability across different regions of the desert landscape[27].

Key features of the ancient desert foodstuff trade included the emphasis on high-bulk, low-value commodities, the perishability of the transported goods, and the resulting high volume and frequency of caravans moving these provisions. The rapid agricultural development in the Western Desert oases during Roman times underscores the critical role of this trade in distributing food surpluses within the desert economy[28].

A significant portion of the agricultural output from places like Kharga and Dakhla was exported to the Nile Valley, illustrating how these trade networks were essential for sustaining both local desert communities and broader regional economies[29].

In contrast, Eastern Desert communities like Berenike didn't grow their own crops and relied on food supplies imported from the Nile Valley[30]. For this reason, the dependency

[26] Maciej Paprocki, (2019), P. 50.
[27] Colin, Adams, (2007), PP. 6-9.
[28] Sidebotham, Steven E., (1995), "Routes Through the Eastern Desert of Egypt." *Expedition Magazine* 37, No. 2, Accessed July 13, 2024, https://www.penn.museum/sites/expedition/routes-through-the-eastern-desert-of-egypt/
[29] Colin, Adams, (2007), P. 160.
[30] Sidebotham, S. E., (2011), PP.78-80.

on food transport was pivotal in shaping the extensive caravan networks that traversed both the Eastern and Western Deserts[31].

These caravans played a crucial role in ensuring the flow of essential provisions to desert communities and in facilitating trade between regions with varying agricultural capacities. Thus, the transport of foodstuffs became a vital component of desert economies, linking distant communities and sustaining their livelihoods amidst diverse environmental challenges.

In addition to the transport of foodstuffs, the roads of the Eastern Desert also facilitated two-way trade in luxury goods. Roman commodities were traded for African and Indian goods at Red Sea ports and in the Indian Ocean. These luxury items and mineral resources, characterized by their non-perishable nature, medium bulk, and high value, were vulnerable to theft by desert nomads. The necessity to safeguard these valuable cargoes led to the emergence of another category of nodes called military installations[32].

II.V. Military Nodes

The emergence of military nodes in the Egyptian deserts was a direct consequence of the establishment of mineral, food, and trade nodes. These military complexes were strategically designed to safeguard civilians from desert-based assailants. While the regional food trade system relied on peaceful cooperation, it also had its darker side[33].

Military nodes were strategically positioned along trade routes to protect caravans from raiders and ensure the safe passage of goods. These installations not only defended against threats but also provided essential support services, such as shelter, water, and supplies, to travelers and traders moving through the harsh desert environment. Thus, military nodes played a crucial role in facilitating trade and maintaining the security of trade routes in the Eastern Desert, contributing to the broader economic and strategic goals of the Roman Empire in the region.

Some individuals, unsatisfied with what they could acquire through trade, resorted to attacking other communities to ensure their survival in the harsh desert environment. This dynamic created a need for fortified military installations to protect against such threats, forming an interconnected system of security and trade in the desert regions[34].

[31] Maciej Paprocki, (2019), P. 51.
[32] Roe, A., (2006), P. 129.
[33] Maciej Paprocki, (2019), P. 51.
[34] Wright, J., (2007), The Trans-Saharan Slave Trade, Routledge, New York, P.12.

As the remote agricultural areas of the Egyptian desert experienced rapid progress under the Romans, their newfound wealth attracted the attention of many desert nomads. Consequently, military installations were established to protect the oases from raids[35]. This expansion led to the establishment of fortified outposts strategically placed around the oases, serving as defensive bastions against nomadic raids and ensuring the security and stability of the agricultural communities[36].

In the Eastern Desert, military installations were strategically positioned at regular intervals along the wadi beds. These installations served to protect state transports and civilian travelers, offering essential provisions such as food, water, and shelter[37]. This network of defenses ensured safe passage through the challenging terrain of the Eastern Desert, supporting both trade and travel routes.

Similarly, in the Western Desert, military fortifications were important for protect the oases from both internal and external threats. Outermost garrisons were strategically placed near the passes that provided access to the oases, serving as the first line of defense against potential invaders or raiders. This defensive strategy not only protected the agricultural communities and their resources but also facilitated trade and communication across the Western Desert region.

An important feature of Roman forts was their strategic placement near secure water sources. Unlike linear deployments, they followed water sources instead of stretching ahead in straight lines, resembling the leapfrogging pattern of desert caravans moving from one water source to another.

These military nodes played a dual role including protecting valuable trade routes and prosperous agricultural communities from nomadic raids, and offering vital support to civilian travellers and caravans navigating through the desert. This approach not only ensured the protection of resources and people but also facilitated the sustained economic and strategic interests of the Roman Empire in these remote areas.

II.VI. Settlement Nodes

Settlement nodes stand as the most important and developed forms among the diverse categories of desert nodes. These settlements typically have access to water sources, the ability for agricultural production, engage in both local and regional trade, and occasionally host defensive military installations. Consequently, they naturally evolve into vital entry and exit points within the extensive desert road networks[38].

[35] Colin, Adams, (2007), P. 29.

[36] Wagner, G., (1987), Les oasis d'E´gypte a` l'e´poque grecque, romaine et byzantine d'apre`s les documents grecs, Recherches de papyrologie et d'e´pigraphie grecques, Cairo, P.117.

[37] Maxfield, V., (1996), The Eastern Desert forts and the army in Egypt during the participate, Journal of Roman Archaeology, Ann Arbor, MI, PP. 9-19, P.13-15.

[38] Maciej Paprocki, (2019), P. 52.

Of particular interest are the rarest types of settlement nodes - permanent human communities that lacked access to water sources or farmland. Among the rarest types of settlement nodes were the Roman colonies of Gerrha, Casium, Pentaschoenum, and Ostracine, situated on the exposed Sirbonitic Spit between Lake Bardawil and the Mediterranean Sea. These settlements were strategically positioned to control the coastal road along the Mediterranean and served as crucial way stations, providing shelter and essential water supplies to travellers passing through the area[39].

The existence of these four settlements along this inhospitable stretch of the desert highlights the Roman administration's capability to successfully enhance road infrastructure in a region that was extremely conducive to desert transport[40]. This underscores Roman engineering prowess and their dedication to developing transportation networks in such challenging environments, and highlighting their historical adeptness in navigating and improving complex landscapes[41].

These settlement nodes served a variety of critical functions, acting as centres for water, food, trade, and military protection. Their strategic locations along desert road networks made them crucial entry and exit points for travellers and caravans navigating desert landscapes. The development of these settlements was a testament to the resourcefulness and administrative prowess of the inhabitants and administration Roman, demonstrating their ability to overcome challenges inherent in the desert environment.

III. Shapes of Desert Trail Networks

The conceptualization of desert trails often takes two primary forms - a direct simple line between two points or a chain of interconnected stations. In the desert context, these roads or track are often seen as straightforward routes connecting two points, starting at point A and ending at point B. when travellers traverse the desert, they encounter various stopping points along the way, each serving different functions and attracting diverse forms of traffic.

However, study of desert trail networks reveals a more complex reality. These trails often connect not just discrete points, but also hospitable zones rich in water and food - a landscape where distinctions between one node and another become blurred. This nuanced perspective suggests that these trails serve to link broader, resource-abundant areas rather than just individual locations. They facilitate movement across hospitable stretches of land, shaping the patterns of travel and settlement in desert environments.

[39] Figueras, P. (2000), P.11, P.207.
[40] Maciej Paprocki, (2019), P. 52.
[41] Figueras, P. (2000), P.207

III.I. Single Track Trails

The desert landscape is characterized by single-line trails that connect isolated settlements, following to the standard linear A-B road model (Figure 5). This pattern is notably evident in Egypt's sparse road network, with prime examples seen in the inter-oasis routes linking various desert agricultural hubs.

For instance, one can observe trails linking Farafra to Bahariya and Siwa[42]. Given the small size of these oases, it's understandable why their access roads remain branched upon approach. The close proximity between oasis villages ensures that any location within an oasis can be conveniently reached from the administrative centre, typically accessed via inter-oasis routes. This setup underscores the efficiency and directness of single-track trails in facilitating movement and connectivity across these arid landscapes[43].

III.II. Single Track with Fan Shaped Ends

Desert trail networks connecting oasis settlements are more complex than the simple linear A-B road model (Figure 5). The elongated shapes of the oasis zones, along with their multiple settlement nodes, often result in numerous trails criss-crossing the desert directly between the zones (Figure 6). Specifically, minor roads created at the population centers within an oasis zone often merge into a single trail that cuts through the high desert.

As this trail nears the next terminal zone, it fans out again into multiple branches, connecting the main hub road to the minor communities within that zone. This design ensures not only efficient travel through the challenging desert terrain but also provides essential links between the central route and various settlements, facilitating trade, communication, and resource distribution across the region.

This type of desert road network typically develops in terrains that are rough, perilous, arid, or otherwise challenging to navigate. For personal safety, travelers avoid venturing directly through the desert.

Instead, they follow established trails that have been used before, offering the assurance of encountering other caravans that can provide aid in case of emergencies. This approach not only enhances safety but also promotes a sense of community and cooperation among travelers, ensuring a more secure and efficient passage through the harsh desert landscape[44].

[42] Cassandra, Vivian, (2000), The western desert of Egypt, The American University Press, Cairo, P. 153.
[43] Maciej Paprocki, (2019), P. 279.
[44] Maciej Paprocki, (2019), P. 280.

A prime example of this fan-shaped desert road network is the Darb al-Tawil road, which connects the Dakhla Oasis to Asyut (Figure 4). At the Dakhla end, the road starts as several feeder trails that converge near the Naqb Shusina pass in the Abu Gerara escarpment area. From there, the
road continues northeast as a single track until it reaches Beni Adi near Asyut, where it branches out again into multiple feeder trails descending into the Nile Valley (Figure 2)[45].

This intricate network ensures efficient connectivity and accessibility between the oasis and the Nile Valley, illustrating the sophisticated logistical planning required navigating the challenging desert terrain.

III.III. Criss-Crossing Interzonal Webs

In regions where two parallel areas accommodate numerous settlements, travelers between the two regions often choose to cross direct routes through the desert rather than following single-track roads. These choices lead to the formation of a complex network of Criss-crossing interzonal webs through the desert strip that separates the two regions (Figure 7).

If two parallel zones are separated by a relatively flat and narrow desert strip, it can be reasonably expected that travelers will strike directly across the desert from one community to another, instead of taking detours along single-track roads. This preference for direct routes results in a complex network of interconnected trails linking various settlements in both zones[46].

For instance, an example of such a webbed road network can be found in the area between Kharga Oasis and Qena, the elongated Kharga hollow roughly parallels the Nile Valley, with the two agricultural zones separated by a desert strip averaging around 150 kilometers in width[47]. In this situation, travelers are likely to prefer direct routes through the desert, resulting in a complex network of interconnected trails that connect the settlements in both zones.

III.IV. Trails that Fan-Out

When a desert trail connects a singular endpoint to a broader terminal area, it must diverge as it approaches the zone, branching into smaller paths that connect all settlements within the area to the main trans-desert highway.

[45] Cassandra, Vivian, (2000), P. 115
[46] Maciej Paprocki, (2019), P. 280.
[47] Sidebotham, S. E., (2011), PP.78-80.

From the perspective of the endpoint, these smaller paths converge, terminating at the same destination. This network design ensures that the starting point is intricately linked to all settlements within the terminal area, creating multiple pathways and enhancing overall accessibility and connectivity (Figure 8)[48].
A notable example of this type of road system can be found in the Eastern Desert of Egypt, where routes from the Roman imperial quarries at Mons Claudianus and Mons Porphyrites ultimately lead to the town of Qena[49].

As these roads approach Qena, they branch out into a network of feeder trails, effectively linking various settlements in the region to the main trans-desert route. This design not only ensures seamless connectivity but also facilitates efficient movement of resources and people across the challenging desert landscape.

This network structure ensures comprehensive connectivity between the terminal and all settlements within the terminal zone, providing multiple access points and improving overall accessibility and connectivity.

Conclusion

From the previous, the following points can be concluded:

1. Logistics played a vital role in the humanity's progress and development throughout history.
2. The eastern desert is craggy and composed of mineral-rich igneous and metamorphic rocks, it became a focal point for extensive quarrying and mining activities during the Roman period.
3. The western desert has fewer overall resources, it hosts minerals of exceptionally high value concentrated primarily around its oases, and all these resources were contribute significantly to the Roman economy and infrastructure development in the region.
4. The desert trails gravitate towards such sites with watering points or Military Nodes which comprised the logistic activities and providing essential lifeline for safe and efficient passage to all who traverse the arid landscape.
5. These logistic activities affected the shape of the roads from simplicity in single track trails, to complexity in criss-crossing interzonal webs.

[48] Maciej Paprocki, (2019), P. 281.
[49] Colin, Adams, (2007), P. 34.

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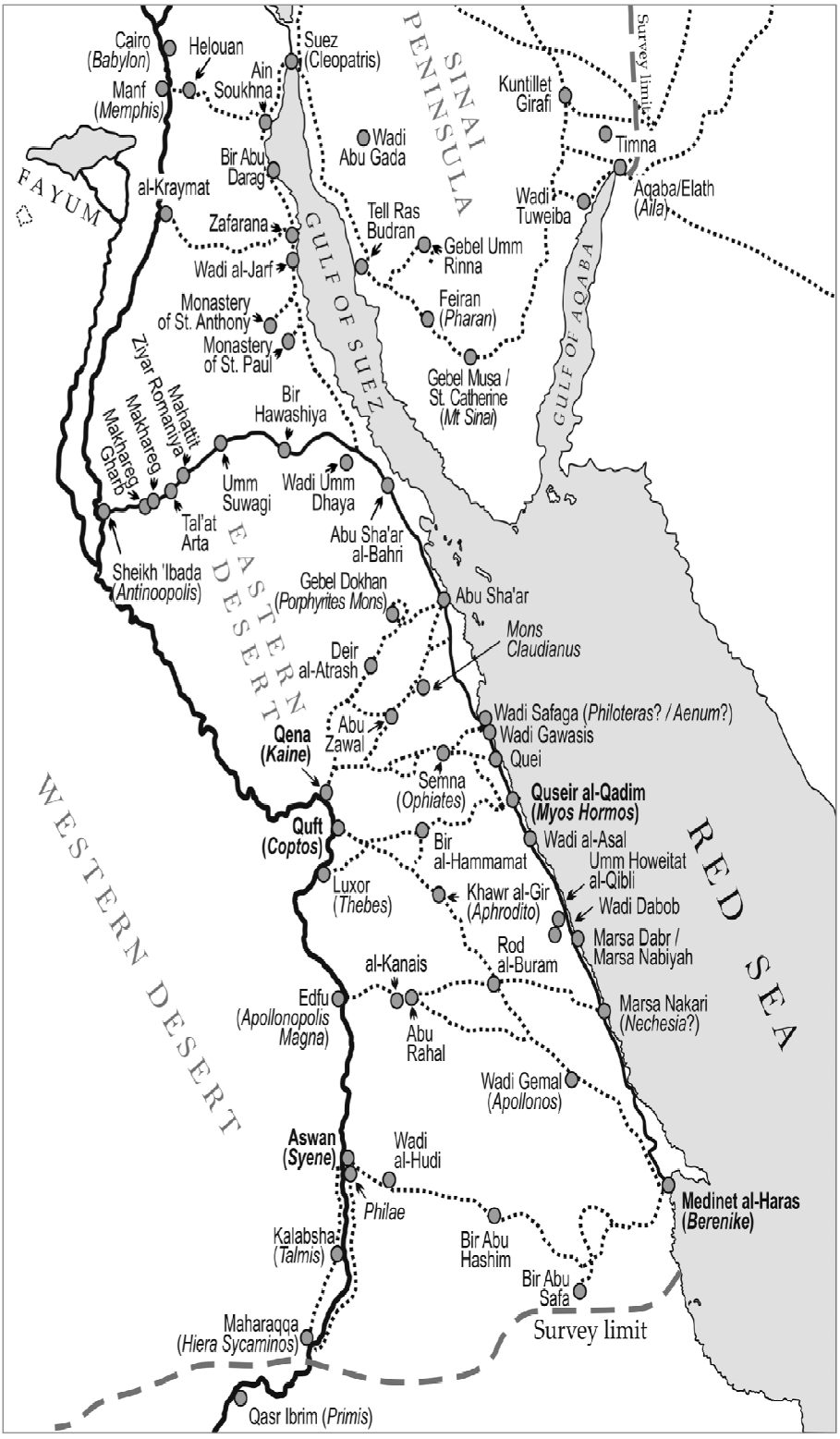

Figure 1: Map of the Eastern Desert (Maciej Paprocki, (2019), P. 184)

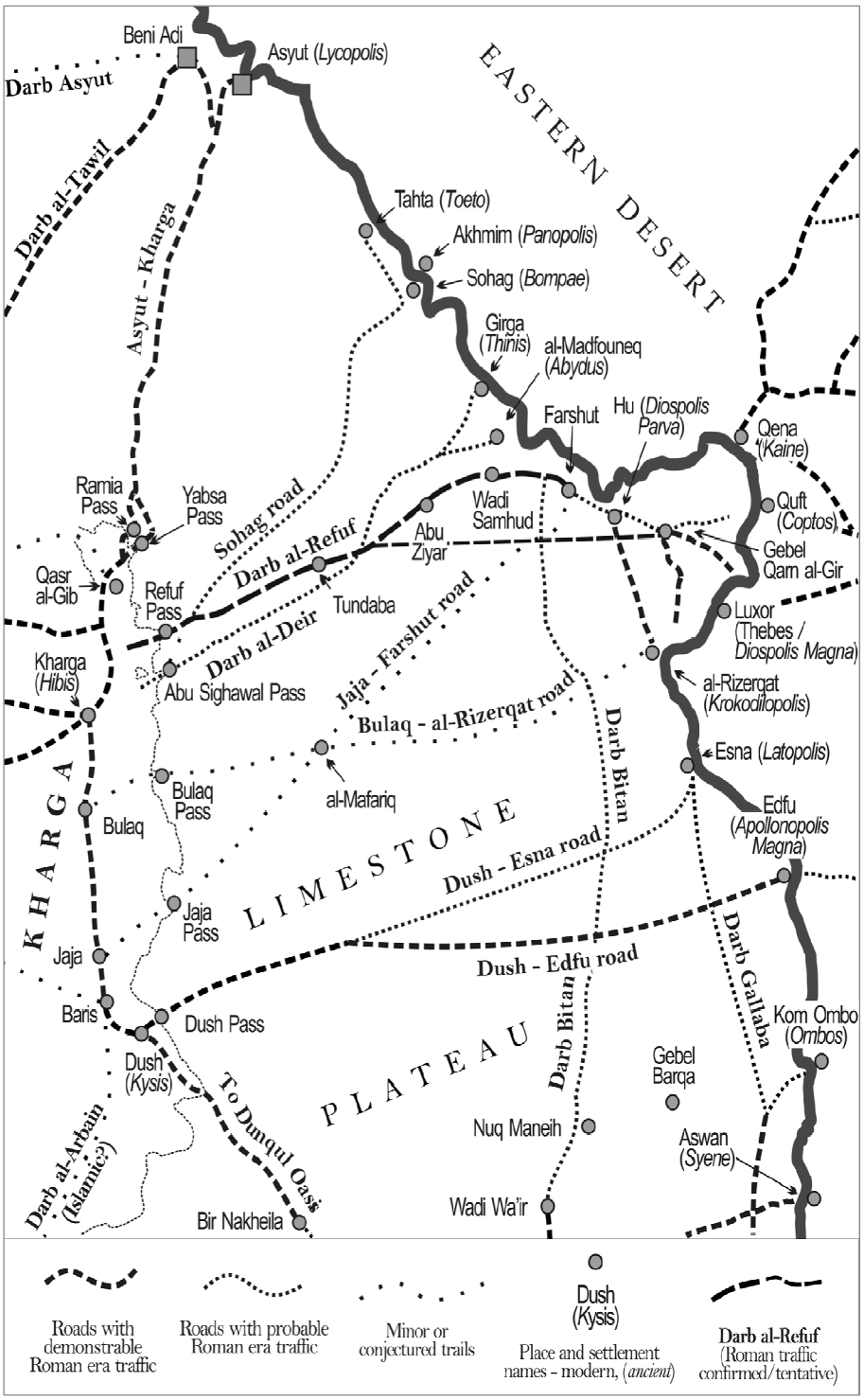

Figure 2: Trails from Kharga Oasis to the Nile Valley (Maciej Paprocki, (2019), P. 230)

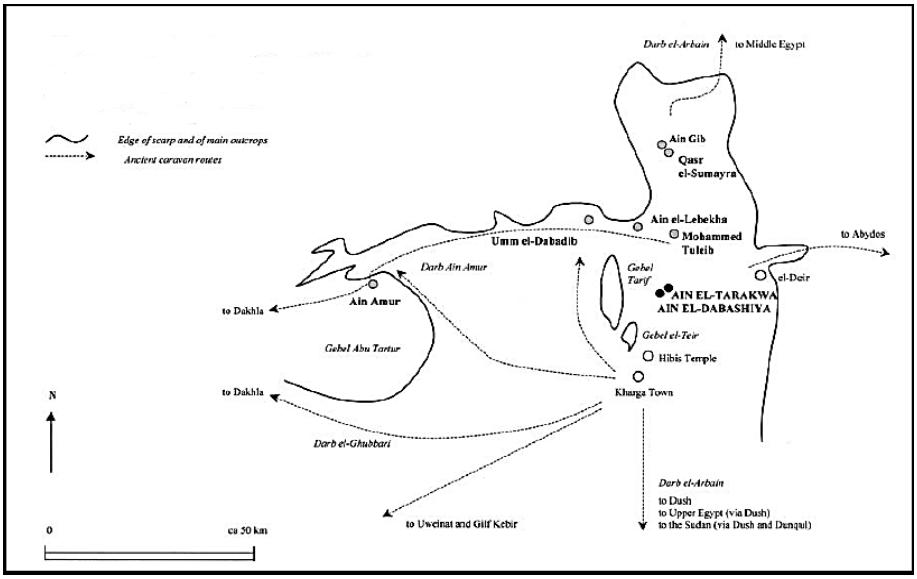

Figure 3: Caravan routes, settlements and roman fortified sites in the western desert (Ikram & Rossi, (2004), North Kharga Oasis Survey Report, IFAO 45, P.166)

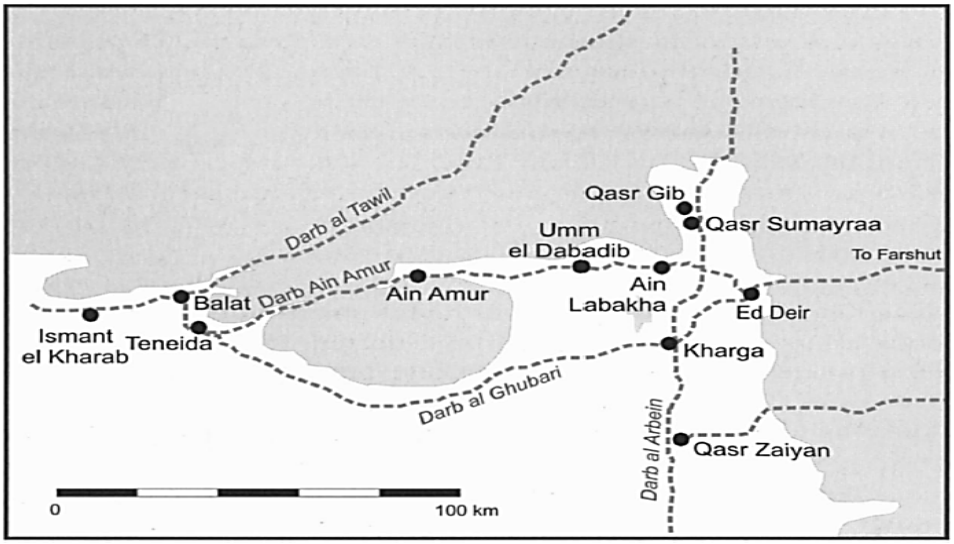

Figure 4: Caravan routes, settlements, and Roman fortified sites in the area of Kharga oasis (Roe, A., (2006) PP. 119-129)

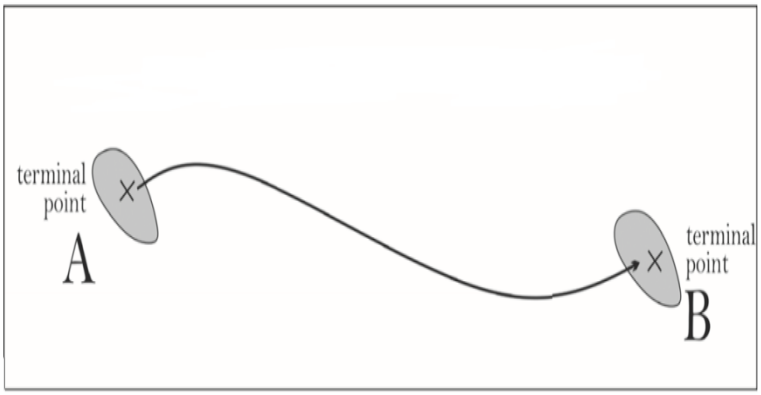

Figure 5: Single-track trails (Maciej Paprocki, (2019), P. 279)

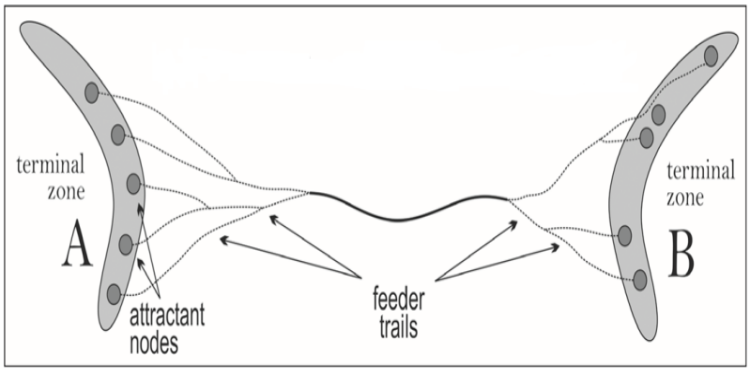

Figure 6: Single-track with fan-shaped ends (Maciej Paprocki, (2019), P. 279)

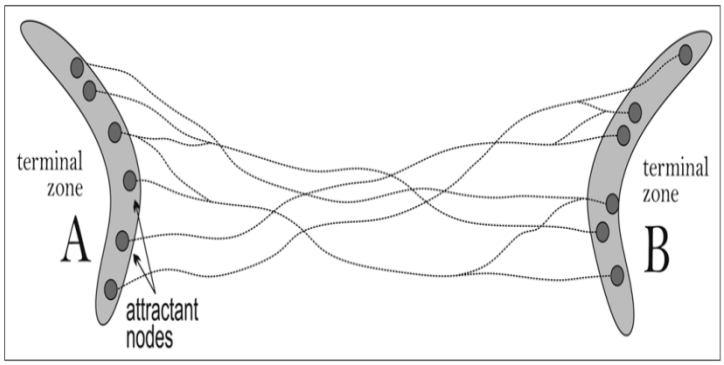

Figure 7: Criss-crossing interzonal webs (Maciej Paprocki, (2019), P. 280)

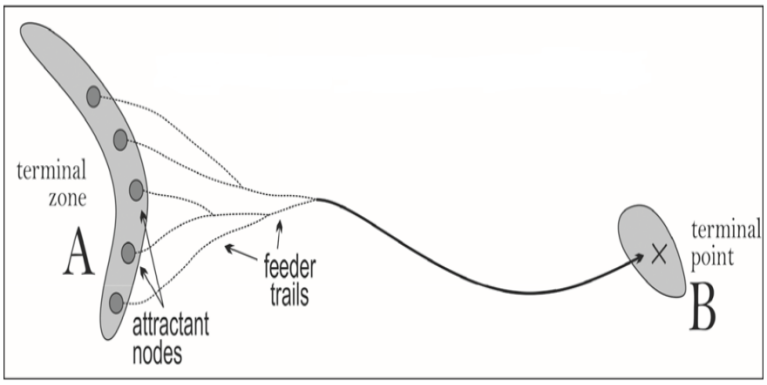

Plate 8: Trails that fan out (Maciej Paprocki, (2019), P. 281)

Road Station	Purpose / Activity	Linking ---- Road
Ain Amur	Watering Stations	Routes between Dakhla and Kharga oases in the western desert
Ain Umm Dabadib Ain Gib Sumayra	Watering Stations	Routes linking Kharga oasis with Farshut
Abu Minqar	Waterholes Agricultural Settlements	Along the route from Dakhla to Farafra oasis
Ain Al-Wadi	Agricultural Settlements	Along the road from Bahariya to Farafra oasis
Mons Porphyrites	Roman Quarry Porphyry	Abu Shara – Coptos Road
Umm Huyut	Roman Quarry Grano-Diorite	Bernike – Antinoöpolis Road

Mons Claudianus	Roman Quarry Tonalite Gneiss	Abu Shara – Kaine Road
Domitiane	Roman Quarry Quartz Diorite	Bernike – Antinoöpolis Road
Tiberiane	Roman Quarry Quartz Diorite	Bernike – Antinoöpolis Road
Mons Ophiates	Roman Quarry Sandstone	Bernike – Antinoöpolis Road
Kharga Dakhla	Trade Nodes	Darb al-Tawil Road, which connects the Dakhla Oasis to Asyut
Berenike	Trade Node	Berenike-Nile valley Road
The Fort of El-Deir Fortress of El-Labeka	Military Node	Darb Al-Arbain Road
Bi'r Samut	Military Node	Bernike – Apollonopolis Road
Fort of Krokodilô	Military Node	Mayos Hormos – Coptos Road
Wâdi al-Hammâmât	Military Node	Mayos Hormos – Coptos Road
Gerrha	Roman Settlement	On the exposed Sirbonitic Spit between Lake Bardawil and the Mediterranean Sea

Casium	Roman Settlement	On the exposed Sirbonitic Spit between Lake Bardawil and the Mediterranean Sea
Pentaschoenum	Roman Settlement	On the exposed Sirbonitic Spit between Lake Bardawil and the Mediterranean Sea
Ostracine	Roman Settlement	On the exposed Sirbonitic Spit between Lake Bardawil and the Mediterranean Sea

Table Shows the Road stations in the roman period and its Activity on the Roadways

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لوجستيات النقل القديم وتأثيره علي شكل شبكات الطرق في مصر الرومانية

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الملخص العربي

كانت شبكات الطرق واحدة من أعظم تراث الإمبراطورية الرومانية. فلقد أولي الأباطرة الرومان اهتماماً كبيراً ببناء وتطوير شبكات الطرق وذلك لحاجة الجيش الروماني إلى أفضل طرق وذلك حتي يكون قادرًا على التحرك بسرعة إلى المناطق المضطربة ولإبقاء مصر تحت السيطرة.

لقد كانت شبكات الطرق ضرورية أيضًا لنقل الخدمات اللوجستية وإمدادات الغذاء والماء والأسلحة للجنود وذلك في وقت الحرب، أما في أوقات السلم فالطرق الجيدة والآمنة كانت تعني المزيد من حركة التجارة والمزيد من التجارة تعني المزيد من الضرائب للإمبراطور وكذلك انتعاش الحالة الاقتصادية.

تتلاقى مسارات الصحراء نحو النقاط بعض النقاط الهامة لتكون بمثابة شريان الحياة للمسافر أثناء التنقل في الطبيعية القاحلة. وتشكل هذه النقاط الأنشطة اللوجستية التي تشكل العمود الفقري لأي شبكة طرق صحراوية .

والجدير بالذكر أن النقل كان عاملاً أساسيًا في الأسئلة المتعلقة بكيفية إمداد المجتمعات داخل مصر؟ وما هي أهم اللوجستيات التي تتجمع حولها الأنشطة البشرية في البيئة الصحراوية؟ ونتيجة لذلك، كيف أثرت هذه الموارد على شكل الطرق من البساطة إلى التعقيد؟ هذه هي الأسئلة الرئيسية التي يهدف هذا البحث إلى التحقيق فيها.

الكلمات الدالة: مصر الرومانية – اللوجستيات – المواصلات – شبكات الطرق – الانشطة البشرية.