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Is the Inland Waterways System Primed for Mitigating Road Transport in Egypt?

Islam Hassanin[1*], Patrizia Serra[2], Julie Iskander[3], Silvia Gamboa-Zamora[4], Lixin Shen[5], Yiqian Liu[5] and Matjaz Knez[6]

[1] Arab Academy for Science, Technology and Maritime Transport, College of International Transport and Logistics, Alexandria, Egypt.
[2] Department of Civil and Environmental Engineering and Architecture, University of Cagliari, Italy.
3 University of Melbourne, Australia.
[4] Board of Attorneys and Board of Notaries, Sustainable Development Consultant at National Technical Environmental Secretariat, Costa Rica.
[5] School of Maritime Economics and Management, Dalian Maritime University, China.
[6] Faculty of Logistics, University of Maribor, Celje, Slovenia.

Emails: islam.saleh@aast.edu, patrizia.serra10@unica.it, Julie.iskander@unimelb.edu.au, sgamboa@proxcr.com, slx_1106@163.com, matjaz.knez@um.si

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Abstract

***Purpose**: This paper aims to investigate the possibility of using hybrid transportation modes depending on inland waterways transport to reduce the dependency on road transport in Egypt focusing on environmental, economic, and social measures.*

***Design/ methodology/ approach:** The research is considered inductive qualitative research that employs a focus group tool to collect interactive and in-depth insights from experts in the field of transportation within different sectors in Egypt.*

***Findings:** The study reveals that, while Egypt's inland waterways have significant potential to reduce reliance on road transport, significant challenges require being addressed, such as infrastructure improvements, fleet modernization, labor training, and government incentives, all of which have been recognized as significant opportunities for development this mode in Egypt.*

***Research implications/ limitations:** One of the major research limitations encountered in this study was a lack of comprehensive and up-to-date data on inland waterway transport in Egypt. The data accessible from diverse sources, such as government bulletins, reports, and scholarly publications, are often inconsistent.*

***Practical implications/ limitations:** Many practical limitations were involved during the study, including the socioeconomic elements that form perceptions regarding inland waterways transport, which may have influenced participants' perspectives.*

***Originality:** This study fills a significant gap throughout the existed literature by investigating the integration of inland waterways transport with road transport in Egypt. It is a stakeholder-centered approach focused on Egyptian experts' comments about both modes. This study provides practical insights that could improve and promote sustainable transportation in Egypt.*

***Keywords:** Focus Group; Inland Transportation; Inland Waterways; Road Congestion; Road Transport; Transportation; Transport Utilization.*

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Introduction

Transportation is regarded as a milestone in socioeconomic interaction, which is now vital for human activity (Shen et al., 2022). However, developing countries face several transportation issues, including lack of reliable and safe transportation, road congestion, and accidents. Transportation is responsible for high air and noise pollution and generates significant Greenhouse Gas (GHG) emissions (Ahmed and Abd El Monem, 2020). In recent years, the negative impacts on the environment, economy, and society have grown significantly, and all evidence confirms that the situation may deteriorate even more, posing an obvious threat to the quality of urban life (Faheem et al., 2024).

Road transport is the most used for daily activities, whether in terms of the social or economic status of a country. Road transport enables the performance of the initial and final legs for all other modes of transportation, as these modes cannot provide full door-to-door service (Reis and Macário, 2019). However, one of the most essential aspects of road transport is the contradiction with the principles of sustainability, harming the global environment (Afrin and Yodo, 2020, Shah et al., 2021), bringing significant strain on both the government and the social sectors with serious economic and environmental consequences (Hassanin, 2020, Faheem et al., 2024),

Considering the negative impacts of road transport, from an economic perspective, congestion raises travel expenses, lowers local economic growth, lengthens journey times, and increases fuel consumption. From an environmental perspective, it increases noise pollution and air pollution emissions such as particulate matter in the atmosphere, GHG emissions, carbon dioxide (CO_2), nitrogen oxides (NO_x), and sulphur oxides (SO) (Faheem et al., 2024). All of these factors increase energy usage and accidents, which have raised major concerns in the global community (Heidari et al., 2023).

As a result, the expansion of the transportation system should be carefully organized for global sustainability (Shah et al., 2021), with a focus on responsible resource management for future generations. In this context, sustainability is defined as the ability to reduce negative impacts through socially inclusive working conditions, economic performance, and ecologically friendly transportation services. Inland Waterway Transportation (IWT) contributes significantly to the transformation of the transportation sector by offering large transport capacities, lower costs, energy efficiency, and, as a result, fewer GHG emissions than other modes of transportation, particularly road transport (Specht et al., 2022).

In such a context, this study proposes enhancing the utilization of IWT in the combination transportation system, reducing the share of road transport. Regarding the Egyptian case, the absolute rapid growth of the population is reflected in traffic increases, resulting in traffic jams and increasingly frequent and serious accidents (Hassanin et al., 2021, Faheem et al., 2024). Consequently, new approaches to optimizing and managing traffic congestion and its repercussions are required (Hassanin et al., 2021). Hence, in Egypt, IWT provides numerous environmental, economic, and social advantages and numerous studies have recently been done to improve the infrastructure of the Nile River to increase the total volume of shipped cargo via inland waterways that connect most Egyptian cities (Moustafa et al., 2022).

This study examines the possibility of raising the share of IWT in the transportation sector to mitigate the negative impact of road transport with consideration of the environmental, economic, and social perspectives because they represent the most critical dimensions of sustainability (Kristensen and Mosgaard, 2020). The framework of this paper is as follows: the second section goes over the background information related to the main aspects of the study, and the third section discusses the road transport sector in Egypt and its implications. The fourth section concentrates on the need for alternative transport options based on IWT, then section five represents the study methodology. In section six, a presentation of the results and discussions, then section seven specifies the conclusion and recommendations, and finally, the limitations and future scopes are emphasized in section eight.

Background Information

The style and form of a city road network help shape its morphological identity (Shen et al., 2022). Nevertheless, Road transport, in particular, is seen as vital in all freight and transportation legs, with significant environmental consequences on the one side and social and economic impacts on the other side.

Environmental Consequences of Road Transport

Currently, the global transportation sector is responsible for around 24% of energy emissions worldwide; by 2050, it is predicted that this percentage will rise to 60% (Thomas and Serrenho, 2024). As a result, in the modern era, there is a growing understanding of the negative consequences of the transportation industry on global warming and climate change (Samaras and Vouitsis, 2013). Compared to all other modes, road transport energy consumption, CO_2 emissions, and other pollutants are increasing at a greater rate. For instance, the main source of GHG emissions from road transport is fossil fuel-powered vehicles. They account for 19% of energy consumption, approximately 50% of particulate matter, 25% of CO_2, and 30% of NO_x emissions (Wojewódzka-Król and Rolbiecki, 2019). Thus, the environmental consequences of road transport directly affect environmental sustainability, and addressing these issues through sustainable practices is crucial for achieving long-term ecological balance and growth in environmentally sustainable development (Ekram et al., 2023).

Social and Economic Effects of Road Transport

The challenges of road transport caught substantial attention from scholars in recent times, primarily because of the swift growth of urban areas and transportation infrastructure. Lately, sophisticated traffic management and control strategies have proven to be successful in reducing traffic congestion and improving the overall effectiveness of urban transportation (Faheem et al., 2024). As a result, it is possible to ensure that there is agreement among urban transportation experts that social sustainability is an important factor in evaluating sustainable transportation. Furthermore, historical study on social sustainability as a concept differs from the other two sustainability dimensions, namely environmental and economic aspects (Grande-Ayala et al., 2024).

On the other hand, some research suggests that since a developed transportation network stimulates economic growth in a nation, there is a critical relationship between productivity and transportation (Vencataya et al., 2018). The economic consequences of transportation challenges, especially road transport, such as congestion, high fuel costs, and infrastructure degradation, can hinder productivity and growth (Weisbrod and Fitzroy, 2011). To address these challenges, fostering economic sustainability through investments in efficient and sustainable transportation systems is essential as economic growth and sustainable development rely significantly on the condition of the transportation sector (Nawazish Ali et al., 2024).

Hence, in light of the negative effects that road transport has on the environment as well as on the economic and social domains, Thomas and Serrenho (2024) propose a way to mitigate these effects through the modal shift, whereas, less emissions-intensive modes of transportation are employed instead of more emissions-intensive modes. For example, Egypt's primary mode of transportation is the road and it is receiving more attention than IWT, although, the latter can move commodities more effectively and with less of an impact on the environment. Egypt's goal of attaining sustainable development and encouraging environmentally friendly transportation is sharply at odds with these tendencies (Sulaiman et al., 2023).

IWT Effectiveness

The European Union's transport strategy aims to reduce traffic congestion, promote traffic safety, employ ecologically friendly means of transportation, and use alternative fuels (Erceg, 2019, Wojewódzka-Król and Rolbiecki, 2019). Thus, developing IWT is vital for guaranteeing the long-term viability of these aims (Wehrle et al., 2024). Thus, IWT plays an important role in the logistics and supply chains of various European countries, with a core network connecting the Netherlands, Belgium, Luxembourg, France, Germany, and Austria. The principal waterways include enormous rivers like the Rhine and Danube that connect major cities, but many smaller towns and industrial sites are also easily accessible by numerous tributaries and canals (Erceg, 2019).

European inland waterways transport around 500 million tons of freight each year, with Germany, the Netherlands, Belgium, and France leading the way (Kotowska et al., 2018). Germany is the major player, accounting for 44%, while the Netherlands comes in second with roughly 39% (Sys et al., 2020). Following are examples of the most successful European countries where IWT is particularly well developed, with its significant implications for ports and trade flows:

Germany

Germany has one of the most extensive inland waterway networks in Europe, IWT in Germany transports roughly 230 million tons of freight yearly along a 7300-km infrastructure network (Wehrle et al., 2024), with rivers including the Rhine, Elbe, and Danube. The containers are mostly transported along the Rhine route and to/from Hamburg's seaport, which serves as the connection to the Elbe River corridor and connected canals. Furthermore, the Hamburg port is located 130 km inland from the open sea on the Elbe

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River, with the middle section of the river and the Elbe Lateral Canal connecting it to German business areas such as Hanover, Braunschweig, Salzgitter, Wolfsburg, and the Ruhr district (Kotowska et al., 2018).

Also, the Port of Duisburg is located on the Rhine, which is considered the largest inland port in Europe. It serves as a hub for both domestic and international freight, connecting Germany to the Netherlands, Belgium, and beyond via the Rhine-Main-Danube Canal (Pascha, 2021). Freight flows are heavily focused on bulk commodities like coal, chemicals, and agricultural products, as well as containers. This indicates that there is a growing interest in improving all business solutions over the long term. The basic idea is to address problems with infrastructure, traffic, and goods flows by integrating ecological and economic considerations (Kapkaeva et al., 2021)

Netherlands

In addition to being connected to inland ports in the Netherlands, Germany, Belgium, France, Switzerland, and Austria through the Rhine-Main-Danube canal, the Port of Rotterdam is situated in the estuary of the Rhine and Meuse rivers. In addition, a vast system of canals and the Rhine, Meuse, and Scheldt rivers are particularly significant (Engström and Anna, 2019). The expansion of container shipping in the ports of Rotterdam and Antwerp is also linked to the robust growth. Furthermore, in Belgium and the Netherlands, the majority of containers are shipped by inland canal routes, mostly to and from the seaports in Rotterdam and Antwerp (Kotowska et al., 2018, Sys et al., 2020).

Belgium

With a share of about 8%, Belgium ranks third in Europe for inland navigation. Belgium has extensive inland waterway networks, with major rivers such as the Scheldt, Meuse, and the Sambre, as well as a vast system of canals (Sys et al., 2020). The main port of Belgium is the Port of Antwerp, which lies on the Northern Sea and is regarded as one of the largest ports in Europe. Because of its advantageous location in the Scheldt-Meuse-Rhine delta, it has access to more than 75 inland ports throughout Europe as well as 1500 km of the European network of inland waterways. Over 915 interior barges are handled each week, with 190 of those being regular links with Belgian inland ports (Kotowska et al., 2018).

Road Transport Problems in Egypt

Egypt's population is estimated to be approximately 107 million in November 2024 by the Egyptian Central Agency for Public Mobilization and Statistics (CAPMAS). By 2027, more than 24 million people would have lodged available. This rapid increase is directly correlated with the mounting strain on the infrastructure systems now in place, primarily the road networks. It is anticipated that daily average vehicle speeds in the town will be less than 10 km/h, which will have a substantial detrimental impact on both the economy and the standard of living (Soliman et al., 2016).

Regarding the Egyptian economy, Fig. 1 displays the recent expansion of trade size in Egypt by illustrating the rise in demand for more trade as a result of population growth. Furthermore, road transport is still the preferred means of transportation for domestic trade within the country (Elshahawany et al., 2022). This is corroborated by the World Economic Forum, which found that there is an imbalance in Egypt's various forms of transportation, with roads carrying 95% of the country's freight, railways moving 4%, and the IWT carrying less than 1%. Road transport in Egypt thus has a significant share and contribution that adversely influences the environmental, economic, and social dimensions, which is reflected through the three main indicators, i.e., air pollution, traffic congestion, and road accidents (Vencataya et al., 2018).

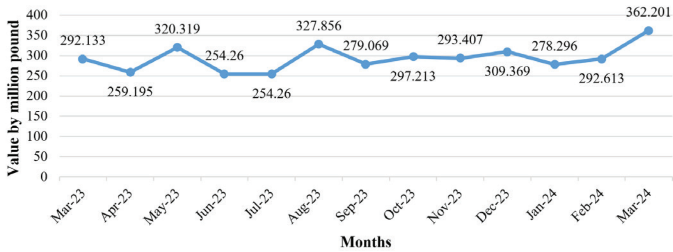

Figure 1. Trade size in Egypt
Source: Egyptian Ministry of Transport (2024)

Air pollution

As illustrated in Fig. 2, generally, the transportation sector consumes gas and petroleum products in second place after the electricity sector, accordingly, it becomes the second generator of CO_2 emissions. Since there has been a greater need for road transport for moving commodities between Egyptian cities rather than IWT or railways, this is a concerning development that has resulted in excessive emissions from the road transport sector (Sulaiman et al., 2023). Approximately 13% of all licensed vehicles in Egypt are transport vehicles (lorries) moving on the country road network. These vehicles include gas, diesel, and gasoline-powered vehicles (Ramadan et al., 2022).

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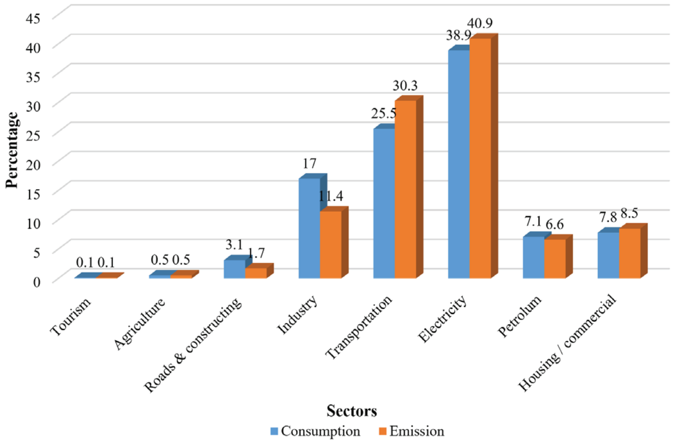

Figure 2. Sectoral consumption of petroleum products, gas, and resulting CO2 (2021/2022)

Source: Egyptian Ministry of Petroleum and Mineral Resources (2024)

Traffic Congestion

The problem of traffic congestion, particularly in Egypt, has a negative impact on the well-being of the country population and its economic stability. In this context, Fig. 3 displays CAPMAS statistics showing that the total number of licensed vehicles ascended from 6.6 million in 2012 to 9.9 million in 2022, with 1.3 million licensed transport vehicles and trailers included in the same year, as shown in Fig. 4. The primary source of urban traffic congestion is expected to be an overall increase in the total number of vehicles on the road (Faheem et al., 2024).

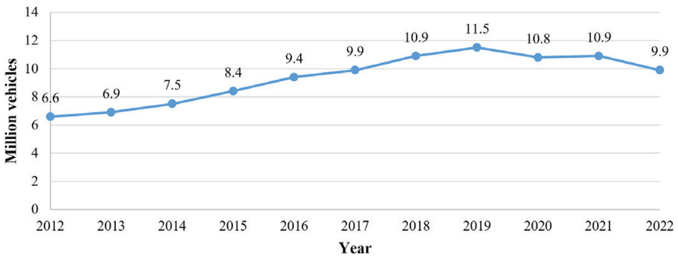

Figure 3. The total number of licensed vehicles in 2022

Source: CAPMAS Statistical Yearbook (2023)

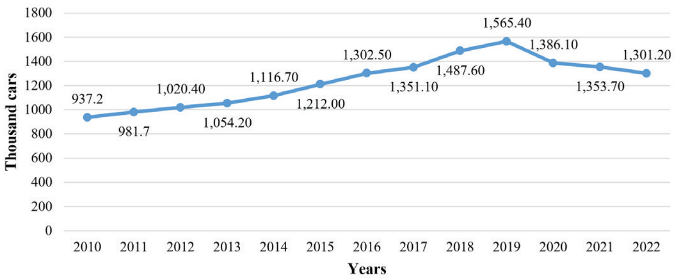

Figure 4. Licensed transport vehicle and trailer

Source: CAPMAS Statistical Yearbook (2023)

Road Accidents

Considering Egyptian road accidents, an increase in accidents and fatalities is correlated with both population growth and the number of registered vehicles in metropolitan areas (Onyeneke et al., 2018), as well as Egypt's Vision 2030 which prioritizes road network expansion. Nevertheless, there is not a specific road safety program; hence, the number of traffic fatalities and incidents is rising rather than declining as seen by the following data from CAPMAS 2023:

- The number of road accident injuries reached 55991 in 2022, compared to 51511 in 2021, an increase of 8.7%.
- The rate of injury per 100 thousand vehicles was 563.2 in 2022, compared to 472.2 in 2021, an increase of 19.3%.
- 7762 persons lost their lives in traffic accidents in 2022 as opposed to 7326 in 2021, a 6 % increase.

A Necessity for Sustainable Transport

The idea of sustainable transport development states that using more environmentally friendly solutions and improving the integration of different transport modes are necessary (Wojewódzka-Król and Rolbiecki, 2019), modifying the transportation system, which contributes significantly to both emissions and traffic, is one of the primary solutions. This will be accomplished by moving cargo transportation from the road to more environmentally friendly sectors, a process known as the "mode shift" (Niedzielski et al., 2021). IWT uses less energy and emits less dangerous substances, and many cities that are close to waterways can use this mode for both freight and passenger traffic (Wojewódzka-Król and Rolbiecki, 2019). Moreover, IWT logistics expenses account for 7% of the total cost of road transport (El-deasty et al., 2024). Since IWT is thought to be seven times more sustainable than other modes of transportation, it is the most environmentally friendly mode of transportation in logistics (Vilarinho et al., 2019).

Concerning Egypt's case, the Nile River has long been significant because it is the primary route used by the ancient Egyptians for transportation (Farag, 2024). The world's longest river stretches from its sources at Lake Victoria in Northeast Africa to the Mediterranean Sea (Bunbury et al., 2023). The Nile River in Egypt is roughly 1530 km long, mainly intended to be a two-way channel (El-deasty et al., 2024). Furthermore, Egypt's internal waterways contain roughly 47 river ports; but as of right now, the Nile River accounts for about 0.6% of Egypt's freight traffic (World Bank Group, 2018).

Consequently, the Egyptian Ministry of Transport top aim at the moment is to greatly increase freight traffic across the Nile River (Moustafa et al., 2022), developing the Nile River navigation path along four major axes (El-deasty et al., 2024), which are as follows:

- 205 kilometers along the Alexandria-Cairo axis. It begins at the Foum El-Riyah El-Beheiry lock, west of the Rosetta Branch, and continues west to the Bolin Lock. From there, it shifts left and meets the Noubaria Canal, which goes north to the Great Maleh, and Small Maleh locks in the Alexandria Seaport.
- The Damietta-Cairo axis stretches 241 kilometers from the start of the Damietta Branch of the Nile River to the Damietta Seaport.
- The Cairo-Aswan axis spans 980 kilometers from the Delta Barrage to Aswan and Wadi Halfa.
- The Aswan-Wadi Halfa axis spans 350 kilometers.

The Egyptian Ministry of Transport has prepared a comprehensive plan to develop the river transport sector and implemented some mechanisms to ensure a strong start to maximize transport across the Nile River. As a result, the government works on proposing some draft legislation and plans that restructure this sector, including its facilities. Some of these are presented by the State Information Service, including:

- **The development of a comprehensive network of river ports along the Nile River:** This initiative will facilitate the efficient receiving and shipping of diverse goods and containers to various river terminals distributed across multiple governorates. Each port will be strategically located to optimize accessibility and connectivity, with many focusing on specific categories of cargo, such as agricultural products, construction materials, or consumer goods.
- **The navigational infrastructure enhancements:** Coordination with the Egyptian Ministry of Irrigation to ensure the effective maintenance and continuous improvement of navigational locks. This initiative includes the construction of new locks that meet modern engineering standards, significantly increasing system capacity and reducing wait times for vessels. These enhancements include:
  - **Cairo/Alexandria Navigational Waterway:** Including the Noubaria Canal, which spans 120 km from the Noubaria lock to the Maleh lock. This project includes a 100 km lock designed to facilitate safe navigation. The navigation link to the Noubaria Canal is also being expanded to accommodate two new 200 m berths. Concurrently, efforts are underway to enhance the km 100 lock and to protect its banks, alongside dredging the Noubaria Canal from km 0 to km 100. Additionally, the efficiency of the km 61 Al-Khatahtbeh lock is being improved.
  - **Cairo to Aswan Navigational Waterway**: Work is being conducted to establish a continuous navigational route between Cairo and Aswan by removing obstacles along the stretch from km 8 to km 885.
  - **Cairo/Damietta Navigation Channel**: Efforts have been made to clear bottlenecks between km 953 and km 1195 (spanning Al-Qanater al-Khairiyah, Mit Ghamr, and Damietta Port) to ensure smooth navigation.
  - **Cairo/Ismailia Navigation Waterway**: The construction of this waterway is complete, with obstructions to navigation in the Ismailia Canal cleared between km 0 and km 50 (from Al-Mazalat to Belbeis).
- **The development of River Information Services (RIS):** Implementing an advanced information infrastructure system for the Nile River. The RIS aims to enhance navigational safety through electronic mapping services that identify the river safest routes. Additionally, RIS facilitates real-time information exchange with the River Transport Authority (RTA) regarding river units within the navigational course, thereby improving safety for all vessels.
- **Encouraging private sector participation:** By contributing and investing in IWT, leveraging private expertise and resources, ultimately enhancing the efficiency and effectiveness of river transport in Egypt.

Furthermore, to achieve the necessary balance between environmental, economic, and social requirements, the Egyptian Ministry of Transport has adopted a philosophy that goes beyond the movement of people and goods. To this end, a flexible and advanced comprehensive policy has been followed, which includes the expansion of transportation options to connect Egypt with its surrounding countries and regions. Subsequently, considering all elements mentioned before, this study recommends increasing the utilization of IWT in the transportation system, preparing to gain from the Nile River employment as a vital component in transportation strategies.

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Methodology

The purpose of this study is to investigate important logistics management choices that increase the use of IWT while decreasing dependency on road transport. The study follows the inductive qualitative research method using a focus group approach for this investigation to collect interactive and in-depth insights from a panel of industry experts, who have been invited to evaluate the feasibility of increasing reliance on IWT as a substitute for road transport. This method makes it possible to gather qualitative data that might clarify the possible benefits and drawbacks of making such a shift. Key decision-making factors, such as environmental sustainability, cost-effectiveness, time effectiveness, and safety concerns will form the foundation of this examination.

A focus group is commonly defined as a gathering of six to twelve people when a moderator or interviewer asks questions regarding a specific subject. Although the data collected using this method contain aspects of both group interviews and "natural" discussions of pertinent topics. Finding out respondents' impressions, interpretations, and opinions is the objective of arranging focus groups. It is anticipated that the unstructured and spontaneous comments will represent the members' true thoughts, feelings, and opinions regarding the issue at the discussion. To prevent a single individual from becoming the group dominant figure, to support each other equally, and to make sure that everyone is aware of the contributions made by others, the participants should have comparable backgrounds and work experiences (Chacko, 2018).

Focus Group Procedures

Using a less structured focus group methodology to acquire a thorough understanding of the perspectives of shifting from road transport toward IWT. The arguments for each of the two modes are examined closely during discussions. Focus groups, which generate qualitative data through concentrated talks among a small group of members, offer a useful platform for investigating the subject.

Planning

Conceptualizing the study, creating the questions, and figuring out the logistics are all part of the planning step for focus groups (Chacko, 2018). This study mainly focuses on environmental, economic, and social perspectives as sustainability domains, allowing for a holistic assessment of the negative effects of road transport on IWT. Hence, during this phase, the researchers prepare a manuscript for the main concept and key aim of the study to be introduced to all the participants during the introduction part of each session, to help the participants understand the main objectives of the study. Then, as specified in Table 1, the researchers generate pertinent questions that addressed the aim of the study. Each main question has a set of follow-up questions to ensure the topic is saturated. In addition, consider some general questions that are specified for gaining more data related to the topic with more concentration on the case of Egypt.

Table 1: The focus group questions

Perspective	No.	The main questions of the moderator guide	Code
Environmental Perspective	1	How do you evaluate the impact of IWT on the environment in comparison to road transport?	E1
	2	Which special environmental advantages do you see with more dependence on IWT?	E2
	3	Are there any possible adverse effects on the environment that come with IWT that need to be taken into account?	E3
	4	How much weight does sustainability have when selecting the modes of transportation?	E4
Economic Perspective	5	In your experience, how do the costs of IWT measure compared with road transport?	C1
	6	What are the cost-effectiveness aspects that encourage using IWT instead of road transport?	C2
	7	How do unforeseen costs (e.g., repair, delays) differ between IWT and road transport?	C3
Social Perspective	8	How safe do you think the IWT's safety records are in comparison to those of road transport?	S1
	9	Have you personally encountered or seen any safety-related issues in either mode that have affected your decision?	S2

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Perspective	No.	The main questions of the moderator guide	Code
General	10	What particular improvements are required for IWT to gain greater popularity in the logistics services in Egypt?	G1
	11	In order to build a more effective supply chain, how can IWT be successfully linked with other means of transportation in Egypt?	G2

Source: The authors

Regarding the logistical organization of the groups, every group is made up of experts who, albeit displaying variation in other pertinent aspects, share certain common qualities. Additionally, to put the research into context, it is done online via an online platform to facilitate participation, with sessions planned for Fridays and Saturdays on June 7th, 8th, 14th, 15th, 21st, and 22nd. Every session lasts between 90 and 100 minutes, and small groups are chosen to provide a setting in which each member can actively contribute to the conversation, whereas smaller groups provide more room for discussion and comprehensive investigation of the many issues.

Participants Pooling

The subject matter-related criteria are used to choose participants. However, because prominent people can influence others in the session, it is advisable to hold many group sessions. Furthermore, gathering data from multiple group conversations allows the researcher to compare and contrast results among groups (Krueger, 2014). In this study, six focus groups are formed, each with six transportation and logistics experts from different sectors such as freight forwarding, multimodal transport, shipping, trucking, and customs clearance companies. The participants' bio information is summarized in Table 2, and the complete categorization is explained in Appendix Table A1. Arabic is used as the language of communication to avoid any potential misunderstandings caused by the usage of English.

Table 2: Bio question data Analysis for 36 participants

Bio Information	No. of Partici-pants	
Gender		
Male	34	
Female	2	
Age		
22-30	1	
31-35	3	
36-40	7	
41-45	10	
46-50	5	
51-55	10	
Educational level		
Bachelor	28	
Master's Degree	5	
PhD Holder	3	
Job type		
Trainee	1	
Full-time	35	
Occupation	**Code**	
Freight Forwarder Company Owner	1	FFO
Road Transport Company Owner	2	RTO
Multimodal Transport Operator	2	MTO
Operator	6	O
RTA Responsible	2	RTA
Shipping Customer Service	7	SCS
Documentation	4	DOC
Custom Clearance	5	CC
Freight Forwarder Sales	7	FFS

Source: The authors

The participants' identities have been obscured, so they are asked to briefly introduce themselves only by providing their age, years of experience, job position, and duties. It is highlighted that the research is carried out for academic purposes. Following the introduction, the moderator discusses the focus group guidelines and conditions, such as confidentiality, respect for each other's viewpoints, and session time frame. Then, each group discusses the different benefits and drawbacks of IWT compared to road transport, notably from the perspectives of the environment, economy, and society. Following a moderation framework, open-ended questions are posed to begin the debate, followed by focused follow-up queries and general questions, as demonstrated in Table 1.

Content Analysis

To reduce redundancy and inefficiency, both human-based and automated content analyses are performed. The automated method can significantly reduce the time associated with evaluating broad text data (Haddad and Nasib, 2023). Accordingly, the analysis process is divided into three main stages: preparation, organization, and reporting, as follows:

- Initially, transcripts are thoroughly checked to

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guarantee the correctness and interpretation of the data. Furthermore, every transcription has been translated from Arabic to English for purposes of analysis.

- The text is organized with brief notes and titles in the margins, with emphasis on appropriate phrases and keywords. Coding is carried out by hand as well as with NVIVO software to take benefit of both methods.
- NVIVO is used to code into acceptable categories for study ("environmental", "economical", "social", and "general"). After the text is categorized into code categories, the codes are manually input on NVIVO, and the findings for each participant in the focus groups are summarized and assigned to the appropriate code. Finally, the discovered categories and subcategories are integrated, examined, and interpreted, as outlined in Table 3.

Results and Discussions

Participants in a series of focus group meetings give vital information regarding the operating reality, infrastructure problems, and views of IWT. This section seeks to summarize the findings from these discussions, emphasizing the important themes and patterns that arose. The discussion focuses on how IWT might help to improve overall transportation efficiency in Egypt. It also looks at the barriers raised by focus group participants. Table 3 summarizes the analysis of these arguments.

Environmental Perspective

Environmental implications

Participants unanimously rate IWT as having a considerably lower environmental impact than road transport. Many participants indicate confidence that IWT contributes to lower GHG emissions, which can mitigate air pollution. They also highlight some environmental hazards related to road transport, such as high air pollution and considerable noise pollution. However, the majority of them have expressed worries regarding IWT infrastructures and potential ecological consequences, such as disruptions to aquatic ecosystems. It implies that, while IWT provides environmental benefits, it is critical to address these concerns to secure the mode long-term development, implying that these factors must be carefully considered in future developments.

The environmental advantages of IWT

Participants pointe out many important environmental benefits connected with greater reliance on IWT, with several emphasizing that IWT often generates less GHG per ton of cargo than road transport. This is due to the higher fuel efficiency of larger barges. Participants also underline that transferring freight from roads to waterways might dramatically reduce air pollutants such as particulate matter and NO_x, hence improving urban air quality. Four participants (P31, P32, P34, and P35) provide extensive information about road transport, specifically diesel trucks, which are prominent in Egypt and contribute heavily to NO_x and particulate matter.

However, two participants (P25 and P30) comment that even barges use diesel as a primary fuel source, and three specialists (P26, P27, and P29) respond that the fuel efficiency of barges compared to trucks varies greatly depending on specific parameters such as cargo type, distance, and vessel or truck design. A popular estimate is that one barge can normally transport the equivalent of 15 to 20 trucks. In terms of fuel usage, this means that the barge frequently needs substantially less fuel to convey the same amount of cargo over the same distance.

The possible adverse effects of IWT on the environment

Many participants highlight that, while IWT is generally more efficient, there are major hazards involved with barge accidents or fuel leaks, which can cause significant water pollution and have a negative impact on the Nile water quality and aquatic life. To expand the percentage of transportation via the Nile River, the government must undertake stringent monitoring and enforce regulations that penalize illicit conduct. Given the limited number of private organizations working in Egypt's IWT sector, such approaches could be especially effective in guaranteeing compliance and conserving this vital resource.

The importance of sustainability

Regarding sustainability, several participants attempt to demonstrate that sustainability does not exist in actual or economic activities, particularly in developing countries. From the customer's perspective, all that matters is that the products arrive as soon as possible and at the lowest possible price. (P29) confirm that in the transportation business, the only effective elements in decision-making are cost and speed. Another participant (P09) responds that sustainability is an issue for both the environment and the economy, choosing more sustainable modes of transportation can result in long-term cost benefits because they typically use less fuel and put less burden on infrastructure.

Economic Perspective

Cost structure

During this phase, the first question occupied the most duration of the focus group of all sessions, and nearly all 36 participants contribute to the discussion, with each response based on his/her professional experience. The debate focuses on the many sorts of costs that emerged in both modes, which are divided into two categories: capital costs and operational costs.

Capital costs:

Some participants state that the investment expenses for IWT are relatively significant including transportation means, river port expansion, and navigational waterway preparation. When referring to road transport with low capital expenses is reflected by the cost of acquiring the fleet, which is considered significantly extremely low when compared to IWT. While others refer to the cost of building roads, road transport ought to consider its average share as capital expenditures.

Operational costs:

- All participants agree that IWT has cheaper fuel costs per ton/km compared to road transport, whether it is heavy fuel oil, diesel (for barges), or diesel (for trucks). In the case of IWT, economies of scale are significant in reducing costs. Barges can transport massive volumes of goods at once, while sharing the fuel costs across these volumes.
- According to (P05), IWT incurs additional costs beyond those of road transport. For example, labor costs such as IWT may have greater initial costs in terms of professional manpower for navigation and barge operation; nevertheless, other participants note that even if they are higher, the principle of economy of scale also addresses this issue. Some others (P26, P27, and P29) state that for substantial amounts of commodities transported over long distances, as previously discussed, one barge can be equivalent to 15-20 trucks. Thus, one or two labor wages will eventually be less than that of 15-20 truck drivers.
- The debate includes a comparison of IWT maintenance costs against road transport. IWT maintenance costs are quite cheap because barges require less regular maintenance than vehicles. Other participants, however, inform that barges might face challenges such as hull maintenance and engine repairs, which can be costly if not addressed regularly. Finally, most of them agree that, while IWT incurs maintenance expenses, it is less expensive than road transport in terms of cost, frequency, and quantity of units conveyed.
- In some sessions, the arguments include additional operational costs related to IWT, such as port and terminal fees, handling costs, port facility charges, and navigation and pilotage fees (where applicable). All participants agree that these costs are relatively low in road transport, which primarily are represented by handling costs and other surcharges related to the shipments that are already paid by the service buyers themselves. However, (P03, P09, P12, P34, and P35) confirmed that IWT has lower operational costs than road transport, even with these additional charges.

In general, (P22 and P23) identified the absence of information about the cost structure, which is considered a fundamental issue in the IWT that needs to be addressed. The majority of participants are aware of the structure of the costs related to road transport, which may be simply computed. As a result, it may provide clients with a final rate for transporting certain goods from point to point by road; nonetheless, if the same quantity has to be transported for the same distance via IWT, the cost cannot be estimated easily. Only two participants (P14 and P26) in all sessions have quit information and confirm that it is easy to know it whether by asking in the RTA or sending a quote to any public or private companies working on the IWT. They add that it differs from one season to another according to the water level. In addition, there are some other conditions, for example, the movement of tourist boats from Luxor to Aswan.

Cost-effectiveness

(P10 and P20) state that the economies of scale idea is the most important aspect that might encourage the use of IWT. Barges can transport huge amounts of goods in a single trip. This capacity enables operators to divide their fixed costs across a larger cargo base, lowering the cost per ton. (P01) notes that ??? what can be described as cargo volume and states that this factor is important in reducing fuel costs for IWT.

Other participants emphasize the importance of maintenance costs as a cost-effective factor in IWT. Road transport frequently has greater maintenance costs owing to the regular use of vehicles and the infrastructure. While IWT barges do require maintenance, costs may be reduced because they are not subject to the same road conditions. (P19) notes that while addressing maintenance costs, it must

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include depreciation costs as one cost-effective element in IWT, which typically has lower yearly depreciation costs than road transport because of longer asset lifespans and higher value retention. Other participants remark how trucks often have shorter lifespans (about 5-15 years), resulting in greater annual depreciation costs. Barges usually have longer lifespans (often 20-30 years), leading to lower annual depreciation costs when divided over their lifetime.

Unforeseen costs

Regarding unexpected costs, (P05) identifies several cost-related factors that may give advantages to road transport, as reflected by transit time for time-sensitive cargo; hence, road transport may be preferable despite higher costs. In addition, (P07, P22, P25, P36) during different sessions mentioned tariffs, taxes, and environmental laws as having an impact on the overall cost for both modes. Furthermore, the majority of participants indicate that road conditions and congestion can raise truck rates and transit times, making IWT desirable because it frequently uses established waterways that can bypass crowded urban areas, minimizing delays and fuel waste.

Social Perspective

Safety Records

Mainly, all participants believe that IWT has a better safety record than road transport, particularly in terms of accidents and fatalities. Participants (P04, P14, P34, and P35) state that road transport is associated with a significantly greater rate of accidents, injuries, and fatalities. Furthermore, factors such as driver error, speeding, and poor weather, particularly for dangerous goods, frequently result in spills and fires. In contrast, participants (P08, P15, P18, P21, P26, and P33) state that IWT has fewer incidents than transportation by road. Barges typically go through less busy areas; therefore, the chance of collisions is lower than on congested roadways.

Safety and Decision-making

In response to this question, most of the participants describe a variety of personal experiences with safety difficulties in both IWT and road transport, with a general opinion that road transport seems riskier due to frequent accidents and unpredictability. Participant (P32) has witnessed multiple accidents, primarily on highways especially at night, caused by the erratic behavior of other drivers paired with catastrophic road conditions. Additionally, (P02, P03, P14, and P31) add that in their logistics work, road transport involves a lot of delays due to road accidents.

While (P08 and P26) report that water transportation is generally safer. Delays may occur in IWT, but based on their experiences, they believe the safety margins are diverse, and the system is more controllable and trustworthy. However, there are significant issues about how IWT handles emergencies. As a result, it appears that many participants have had unfavorable experiences with road transport, either seeing or being involved in accidents. IWT, on the other hand, appears to raise fewer safety concerns.

Table 3: NVIVO list of frequently discussion directions

Perspectives	Parameters	Mode	Discussions	Directions	Effects
Environmental	Ecological Outcomes	IWT	Fuel consumption efficiency for barges	Lower GHG emissions	Positive
				Mitigate air pollution	Positive
				Improving urban air quality	Positive
			Dredging and enhancement operations	Disrupt local aquatic habitats, affecting fish populations and overall biodiversity.	Negative
			Fuel leaks from barges		
			Expand the percentage of transportation via the Nile River	Negative impact on the Nile's water quality	Negative
		Road	Low fuel consumption efficiency for diesel trucks	High air pollution	Negative
				Contribute heavily to NOx and particulate matter	Negative
			Increase the number of trucks	Considerable noise pollution	Negative
	Sustainability	IWT	Fuel efficiency and cost savings in the long term	Sustainable transport mode	Positive
		Road	Customer needs	Speed	Negative
				Lowest price	Negative

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Economic	Capital Cost	IWT	Docking cost (barges building)	Considerable investment cost	Negative
			River ports construction		
			Preparing the navigational waterways		
		Road	Purchasing modernized fleet	High capital cost	Negative
			The average share of road constructing		
	Operational Cost	IWT	cheaper fuel costs per ton/km	cheaper operational cost	Positive
			Lowest labour cost		
			Minimal maintenance cost		
			Absent of information about the cost structure	Ambiguous	
		Road	Higher fuel cost per ton/km	Cost-effectiveness of fuel	Negative
	Cost-effectiveness	IWT	Economies of scale	High cargo volume	Positive
				Reducing total transportation cost	
			The long-life span for transportation means (20 - 30 years)	Low depreciation cost	
		Road	The economy of scale concept is not applicable	Low cargo volume	Negative
				Increasing total transportation cost	
			The average life span for transportation means (5 - 15 years)	High depreciation cost	
Social	Safety	IWT	Low accidents rates	Better safety records	Positive
			Almost no injuries or fatalities		
			No training for emergencies	Handling emergencies inefficiently	Negative
		Road	Drivers' errors	High accidents rate	Negative
			Speeding		
			Poor weather		

Source: The authors

The results of this study are consistent with the positive outcomes associated with IWT development as highlighted in the literature. Hence, this study indicates that IWT in Egypt offers substantial opportunities to address key environmental, economic, and social challenges, notably through reductions in congestion, CO_2 emissions, and air pollution, alongside enhanced safety and lower costs. These outcomes align closely with the experiences of countries like Germany, the Netherlands, and Belgium, where IWT has been successfully integrated into their transport systems, contributing to the reduction of total transportation costs and offering a sustainable alternative to road and rail transport. The high cargo volume and cost-effectiveness of IWT in these regions serve as clear examples of its potential, reinforcing the relevance of this study findings for Egypt's transportation future. Thus, the results of this research not only highlight the significant benefits of IWT in the Egyptian context but also underscore the alignment with European best practices, demonstrating the viability of IWT as a sustainable transport solution.

Conclusion and Recommendations

This paper has highlighted the significant disadvantages of road transport in Egypt, particularly its adverse impacts on the environment, economy, and social well-being. The excessive reliance on road transport contributes to severe environmental degradation, including increased CO_2 emissions and air pollution, as well as higher levels of congestion, which exacerbate inefficiencies in the transportation system. Economically, road transport incurs substantial operational costs and contributes to the growing financial burden of infrastructure maintenance. Socially, the negative externalities of road transport, including safety risks and reduced quality of life due to traffic-related problems, further strain Egypt's transport ecosystem.

In contrast, the study has demonstrated the considerable potential of IWT as a viable alternative to road transport. IWT offers several key advantages, including sustainability through reduced emissions,

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cost-efficiency via lower operational and infrastructure expenses, and improved safety. Furthermore, the findings indicate that IWT could significantly alleviate congestion, reduce transportation costs, and enhance the overall efficiency of cargo transport in Egypt. The possibility of integrating IWT into Egypt's transportation sector as an alternative mode to road transport has been confirmed through data collected from focus. The experts affirmed that IWT presents a more sustainable, cost-effective, and safer solution, with clear advantages over the current over-reliance on road transport.

The study also suggests that the implementation of IWT in Egypt could be a transformative step towards a more sustainable and efficient transport system. Drawing on the successful experiences of countries in Europe, such as Germany, the Netherlands, and Belgium. However, realizing this potential requires strategic planning, investment in infrastructure, and policy reforms to facilitate the development of comprehensive IWT networks. In conclusion, the findings of this study provide compelling evidence that the IWT can play a pivotal role in addressing the pressing challenges faced by Egypt's transport sector, offering a sustainable, cost-effective, and environmentally friendly alternative to road transport.

Finally, the moderator encourages a broad argument about the situation in Egypt by raising two additional questions, G1 and G2, which help to develop additional viewpoints and to conclude the Egyptian situation, primarily, the improvements required to enhance IWT utilization in logistics services in Egypt. Furthermore, regarding the involvement of IWT in the supply chain and the entire transportation sector in a multimodal transportation system to maximize the benefits. Moreover, the insights gained from the focus group conversations not only emphasize the need for a shift in transportation paradigms but also serve as a solid platform for future research and policy development targeted at improving Egypt's logistics sector.

Most of the participants believe that one of the key challenges is the infrastructure, such as the need for improved cargo ports and terminals along the Nile River, because most docks and facilities are obsolete, slowing down operations, particularly loading and unloading systems. Participants also highlight how important it is to maintain rivers. Some stretches of the Nile River are difficult to navigate due to sediment buildup or debris.

Some recommendations have been generated for improving IWT operations, increasing intermodal connectivity, and encouraging broader acceptance of waterways as a critical component of Egypt's transportation network. Whereas IWT in Egypt offers substantial implications to address key environmental, economic, and social challenges The authors summarize the various participants' points of view in each session. Accordingly, the prevalent recommendations that summarize over all sessions are as follows:

- **Accessibility and better integration with other transport modes:** A smoother system is required for transferring commodities from waterways to trucks or railways instead of Athar Al-Nabi port. If there were more intermodal hubs where commodities could be promptly transferred, IWT would be more efficient. Additionally, the notion of logistics centers that connect the various modes of transportation might help to smoothly connect IWT with highways and railways.
- **Reliability and real-time monitoring:** shipments on waterways can be delayed due to weather or navigational problems. Consequently, with improved tracking technologies or communication systems for barge operators, companies could have greater trust in delivery schedules. This improvement would significantly increase companies' reliance on IWT.
- **Promotion, awareness, and marketing campaigns:** many companies are not completely aware of the potential of IWT. Hence, there is a need for government or private sector initiatives that demonstrate how inland waterways can lower costs and environmental impacts, perhaps attracting more logistics companies to use this mode.
- **Upgrading the fleet:** newer barges are required to lower pollutants and improve fuel efficiency, which is becoming increasingly crucial for businesses. If Egypt can promote IWT as a green solution by investing in eco-friendly barges driven by green fuel, it may be able to attract more logistics companies looking to improve their environmental impact. Also, in terms of capacity, some of the barges are not large enough to satisfy rising demand, so with larger and more modern barges, IWT could handle much more tonnage, making it more competitive with road and rail transport.
- **More investment in training plans:** barge operators, port personnel, and logistics managers all need to complete specific training programs. The more skilled the staff, the fewer errors and delays. Additionally, those who are better trained will be able to deal with emergencies or unanticipated circumstances more effectively.

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Study Limitations and Future Scopes

While this study provides valuable insights into the potential of IWT in Egypt, several limitations must be acknowledged. Firstly, this study is primarily descriptive, offering a qualitative exploration of the potential benefits of IWT based on existing literature and expert opinions. However, it lacks empirical, practical data that could provide more definitive conclusions regarding the viability of IWT as a large-scale solution in Egypt's transportation system.

One key limitation is the reliance on expert opinions collected through focus groups, which, while insightful, do not provide quantitative validation of the environmental, economic, or social claims appointed in the study. For instance, to confirm the feasibility of implementing IWT in the Nile River, a more detailed practical study is needed to assess the river depth, navigability, and capacity for handling significant cargo traffic. This could include on-the-ground surveys and technical assessments to gather more precise data.

Additionally, this study does not include quantitative analysis, which would be essential for verifying the potential environmental and economic impacts of IWT in comparison to other transport modes. A comprehensive cost-benefit analysis, incorporating real-world data on transport costs, emissions reductions, and safety improvements, would provide a more robust and statistically grounded understanding of the advantages and challenges of IWT in Egypt.

Hence, several avenues remain open for further exploration, which could include the following areas:

- **Economic Impact Analysis**: focusing on conducting a comprehensive economic analysis comparing the infrastructure costs of both road transport and IWT. This could include a detailed assessment of the investment required to develop and maintain IWT infrastructure, compared to the current and projected costs of road transport, including maintenance.
- **Environmental Modelling**: building on the environmental benefits highlighted in this study, future research should aim to create a model that quantifies the actual reductions in CO_2 emissions and other environmental consequences that would result from the adoption of IWT.
- **Regional Feasibility Studies Beyond the Nile River:** While this study primarily focuses on the Nile River utilization; thus, further research should explore the feasibility of IWT in the Nile River, including the possibility of multimodal transport solutions that minimize reliance on road transport.
- **Technological Integration:** Another important area for future investigation would be the role of emerging technologies in enhancing IWT efficiency, such as automation, digital navigation systems, and eco-friendly propulsion technologies.

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Appendix

Table A1: Detailed information regarding the focus group participants

Sessions	Participant code	Gender	Age	Educational level	Job type	Occupation
1	P01	F	22-30	Bachelor	Trainee	DOC
	P02	M	51-55	Bachelor	Full time	O
	P03	M	51-55	Bachelor	Full time	O
	P04	M	41-45	Bachelor	Full time	MTO
	P05	M	36-40	Master's Degree	Full time	RTO
	P06	M	31-35	Bachelor	Full time	DOC
2	P07	M	41-45	Bachelor	Full time	DOC
	P08	M	41-45	Bachelor	Full time	RTA
	P09	M	46-50	PhD Holder	Full time	O
	P10	M	36-40	Bachelor	Full time	CC
	P11	M	41-45	Bachelor	Full time	SCS
	P12	M	51-55	Bachelor	Full time	FFS
3	P13	M	36-40	Bachelor	Full time	CC
	P14	M	51-55	PhD Holder	Full time	FFO
	P15	M	46-50	Bachelor	Full time	SCS
	P16	M	41-45	Bachelor	Full time	FFS
	P17	M	36-40	Bachelor	Full time	CC
	P18	M	41-45	Bachelor	Full time	SCS
4	P19	M	51-55	Bachelor	Full time	O
	P20	M	51-55	Master's Degree	Full time	O
	P21	M	41-45	Bachelor	Full time	SCS
	P22	M	41-45	Bachelor	Full time	FFS
	P23	M	51-55	Bachelor	Full time	MTO
	P24	M	46-50	Bachelor	Full time	SCS
5	P25	F	36-40	Bachelor	Full time	CC
	P26	M	51-55	Bachelor	Full time	RTA
	P27	M	41-45	Bachelor	Full time	SCS
	P28	M	31-35	Master's Degree	Full time	DOC
	P29	M	31-35	Bachelor	Full time	RTO
	P30	M	51-55	Bachelor	Full time	FFS
6	P31	M	36-40	Bachelor	Full time	O
	P32	M	41-45	PhD Holder	Full time	FFS
	P33	M	46-50	Bachelor	Full time	SCS
	P34	M	51-55	Bachelor	Full time	FFS
	P35	M	46-50	Master's Degree	Full time	FFS
	P36	M	36-40	Master's Degree	Full time	CC

Source: The authors