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Master thesis

Information needs of gravel roads stakeholders

A case study to elicit the requirements of future users of a cloud-based information system

Author: Nada Abbas
Supervisor: Associate Professor Mirka Kans
Examiner: Associate Professor Päivi Jokela
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Abstract

Within any ecosystem, information needs are shared to be fulfilled and to support the ecosystem in a way or another. They are vital for designing appropriate information systems that will provide those needs. In this thesis, the gravel road ecosystem is studied, where efficient information sharing is not enabled due to the lack of appropriate information systems. Thus, when focusing on the gravel roads ecosystem, information plays a crucial role regarding the maintenance acts upon these roads. Moreover, not enough literature investigates the information needs of gravel roads stakeholders with the aim to improve the maintenance of these roads.

Therefore, this thesis intends to elicit information needs of gravel road stakeholders by performing an exploratory case study. The case study forms a part of an ongoing project with the goal to build a cloud-based information system for a sustainable gravel road maintenance. Data were collected through telephone- and online-based interviews with several key stakeholders in Sweden and were thereafter structured through template analysis. The major findings were a set of information needs and several needed sensors within the pre-mentioned information system. This thesis concluded that the future cloud-based information system in the ongoing project is a useful system for sharing vital information among future gravel road stakeholders, considering the variety of needed information that affects the maintenance of the gravel roads.

Keywords

Information needs; gravel roads; stakeholders; road maintenance.

Acknowledgement

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1 Introduction

Chapter one presents an introduction into the main area of concern; the purpose and significance of the study; the research question; the limitation and delimitations; finally the thesis organization.

1.1 Background

Information is a term that is hard to define, even though critical for human beings as it involves everything in our life. It has been said, a while ago, that societies are turning into 'information societies' (Bell, 1972), which is evident nowadays from the large amount of available information.

Clearly, when concentrating on the needs of users, the term information needs comes in mind. Nicholas (2003) defined the term as being the information that people are supposed to have in order to work effectively, solve difficulties sufficiently or practice an interest or hobby cheerfully. When viewing the term from an informatics view, Beynon-Davies (2013) stated that information needs, information systems and Information and Communication Technology (ICT) are the core elements of any informatics infrastructure. Thus, information needs are vital to the design of appropriate information systems that will provide those needs, followed by the selection of a suitable ICT that supports that information system. For this reason, knowing the information needs of users plays a crucial rule when designing an information system (Hörold, Mayas, and Krömker, 2012).

Sándor and Csiszár (2015) shed some light on the fact that most information is used by data owners. However, the transmitted information constitute only a small proportion of all available information, and stakeholders still have a need for additional data. It is therefore important to understand the information needs of not only stakeholders, but also the shared needs within an ecosystem. Stakeholder is a term that refers to the person with an interest or concern in something (Stakeholder, 2020), whereas an ecosystem is a complex network or an interconnected system (Ecosystem, 2020). Within an ecosystem, information needs are shared, which results in many benefits. Among others is the ability to share data online with remote control (Metso and Kans, 2017).

Occasionally, information needs are not met because of factors such as: thinking it is not necessary to consult the stakeholder in what they need; concentrating on how to manage the information system and forgetting about the users of the system; poor communication skills between service providers and stakeholders; or the cost of computerisation (Nicholas, 2003). This motivates the necessity for more investigations of the information needs of stakeholders. Even Shankar, Urban and Sultan (2002) suggested that online trust issues can be solved when stakeholder's trust related needs are discovered and addressed.

In this research, the stakeholders refer to actors involved in the management and maintenance of the Swedish gravel road network: *the Swedish transport agency; municipalities; road maintainers; road associations; and gravel road users*, whereas the ecosystem refers to the gravel road ecosystem that comprises those stakeholders. These stakeholders are inspired from Kans, Campos and Håkansson (2019). Gravel roads is a branch of the transportation system

that need continuous maintenance. In Sweden, they form almost 20% of the total road length (Swedish Transport Administration, 2017).

Already in the 80s, Alfelor and McNeil (1988) acknowledged some problems that are faced by maintenance management systems, and mentioned the need for an ideal system that have a more accurate blading frequency directly related to roads and thus affects maintenance costs of these roads. Also, the need for a system that does not require users to insert design, construction and maintenance options, in order to get data for planning. Saarenketo (2005) mentioned the need for a system that deliver up-to date information about poor driving conditions which can be attainable using radio transmissions, or information system attached to the vehicle. The researcher also referred to the idea of using 'modern weather stations' and 'snow depth sensors', which can be located near spring thaw weakening sensors.

Recently, the European Commission (2020) addressed some challenges to rural areas, which suggests the need for a well-functioning road network. Some of the challenges are the need to improve production efficiency; to enhance the delivery of goods and services; to empower citizens; etc. Those challenges affect citizens, municipalities, technicians, policy makers and others, and indicates the need for keeping these roads in good condition. This calls for a new ICT application that could manage the challenges in an efficient and effective way.

1.2 Purpose statement and research question

The purpose of this case study research is to explore the information needs of stakeholders within gravel road ecosystem. The research aims to support the design of a cloud-based information system targeted for the use of gravel road stakeholders. A cloud-based system is appropriate given the fact that the number of involved stakeholders is high. The study also seeks to explore the information exchange between the stakeholders as well as the user requirements of such a future cloud-based system.

Therefore, this thesis aims to answer a main research question and a sub-question:

- *What is the particular information that the users of cloud-based information systems need?*
    - *What are the information needs of gravel roads stakeholders in Sweden?*

1.3 Topic justification

The significance of this thesis lies in the limited number of studies considering the use of cloud-based information system tools to support gravel roads stakeholders. Saarenketo (2005, p.48) described several ideas and concepts for cloud-based ICT, however, only one system has been implemented in Finland for monitoring maintenance measures. Thus, this thesis will be a vital guide to practitioners and policy makers who need deepened understanding of the information needs of stakeholders when building a cloud-based information system.

1.4 Limitations and delimitations

Some influencing factors that affected this thesis were the existence of 'Covid-19' which affected data collection technique; the limited number of previous researches on the main topic of this thesis; and a delimitation of the sample selection which was based on the chosen ecosystem in this thesis.

1.5 Thesis Organisation

This thesis displays the research done in six chapters, as displayed in *Figure 1*. *Chapter one* presented an introduction into the main area of concern; the purpose and significance of the study; the main research question and sub-question; and the limitation and delimitations. *Chapter two* is the review of the literature which begins with reviewing published literature of general interest for this study. Moreover, the main research topic is reviewed. The chapter begins with the topic cloud-based systems, then moves to the topic information needs in general but also more specifically related to the gravel roads. Afterwards, some tools and technologies regarding gravel road maintenance are mentioned, and lastly, factors of importance to this study are presented in a figure.

Thereafter, *chapter three* presents the methodology of this research paper. It begins with the methodological tradition and approach of research. Then data collection and analysis methods are described, in addition to mentioning how data will be reported and interpreted. Lastly, some reliability and validity measures are mentioned, as well as some ethical considerations. *Chapter four* presents the empirical findings from the data collection. The findings were displayed based on five generated themes, afterwards similarities in answers are presented.

In *chapter five* the findings are further discussed, and the pre-designed figure from chapter two is modified and adjusted based on the new findings. The last chapter is *chapter six,* which concludes the whole research paper. It includes a summary of the key findings; a summary of the research problem and the methodological approach; the contributions to current literature; and some suggestion of future research.

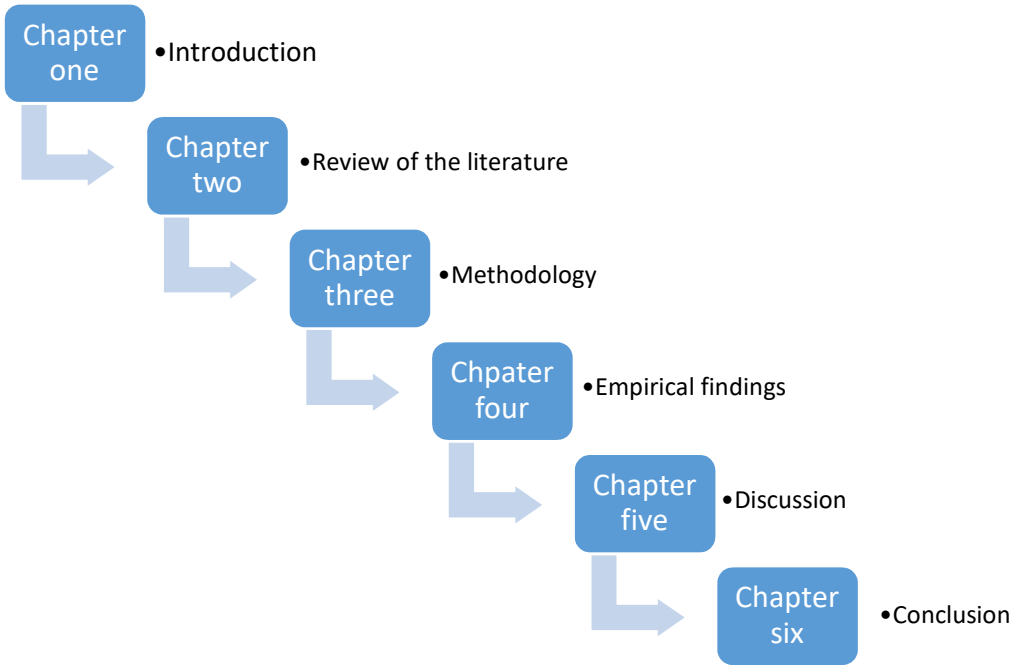

Figure 1: Thesis paper organization.

2 Review of the Literature

Chapter two begins with reviewing published literature generally until the main research topic is reviewed. The chapter begins with the topic cloud-based systems, then moves to the topic information needs in general until it relates it to the gravel roads. Afterwards, some tools and technologies regarding gravel road maintenance are mentioned and lastly, factors that are most important to this study are presented in a figure.

2.1 Cloud-based Systems

With the evolutions and advancements of technology, a huge amount of information is shared online in so-called cloud environments that facilitate the creation of cloud systems including cloud-based information systems (Schmidt, 2012). Schubert, Jeffery and Neidecker-Lutz, (2010) define the term 'cloud' as an open resource system that involves many stakeholders and offer multi-granular services at a defined quality level of services. They also designed a model to display the aspects forming a cloud system. The model was used later on as a resource in many researches, such as Kostantos et al. (2013); Thiel et al. (2015); Nguemaleu and Montheu (2014); and Vermesan and Friess (2011).

Kiswani, Dascalu and Harris Jr (2018) proposed a reference architecture for designing cloud-based Information Systems. The proposed reference architecture consists of five layers (p.852):

- Edge services which are the front line of software in the cloud, that are open to clients. These applications are web browsers, smart devices, IoT devices, etc.
- Application services which provides business logic services for the applications such as domain logic and the functional requirements.
- Metadata services are responsible for the services needed for dynamic user interface generation and the functionality of data access.
- Cloud infrastructure services contain services that are vital for enabling 'cloud applications features' such as multi-tenant support, tracking and analysing.
- Cross-cutting services are there for the support of all the other layers such as configurations, protection, and facilities.

The researchers pointed out that the proposed reference architecture is to be modified based on each software demands. Lastly, as every system faces threats, so is the case for cloud systems. In Thiel et al. (2015), a list of the top threats that could be faced is provided, for example, Data Breaches, Denial of Service, Malicious Insiders or Shared technology issues. These among other threat should be taken into account when designing a cloud system.

2.1.1 Cloud-based IS as a solution

A cloud-based information system is thought of as a solution for many problems related to traditional systems, such as those stated in Padhy, Patra, and Satapathy (2012). In their paper on rural healthcare centres, many issues that could be solved by a proposed cloud-based information system were mentioned. For instance, storing patients' data in a locally managed infrastructure can be improved if healthcare data is kept and processed in the cloud by healthcare centres. This allows data providers to manage and access data faster and easier

through the internet (Padhy, Patra, and Satapathy, 2012). Zhang (2012) suggested using a web-based information system to solve concerns related to issuing 'large-scale species range maps', which benefits ecology and biogeography research.

Some researches focused on improving the maintenance of railways using cloud computing. Morant, Galar and Tamarit (2012) suggested applying data mining techniques to transmit railway's maintenance data, in addition to using an asset cloud to gather and manage data. Thus, cloud computing and data mining can solve problems regarding configuration, access to data, and changing control management processes. In addition, Kour, Karim and Parida (2013) used cloud-based technology as a solution to enhance the process of railway maintenance. This technology was used to form the information logistics, which managed different railway system related data.

Adding on, Wang, et al. (2014) investigated the Waste Electrical and Electronic Equipment (WEEE), and addressed the problem of the recovery of disposed equipment. This problem was caused by, among others, the lack of a coordinated strategy to combine the different sectors of remanufacturing. As a solution, a cloud-based WEEE remanufacturing system was developed which provides cloud services and well-managed information over the entire product lifecycle (Wang, et al., 2014).

Yao et al. (2014) investigated a solution for the issues regarding traditional health information technologies (HIT) in China. The issues were: time-consuming and ineffective control of the entire system, mismanagement of vital data allocation, and the obstacles between customers and the server. Moreover, as the aim of the study was to deliver hospital information services to Grassroots healthcare institutions (GHIs) using an effective secured architecture, the researchers proposed a Cloud-based hospital information service delivery platform which integrates hospital information systems.

Furthermore, Mourtzis et al. (2016) addressed problems related to distributing vital information on the current status of machine and cutting tools to concerned departments. The researchers proposed a cloud-based monitoring system. The system would result in reduced maintenance time and higher production rates as a result of getting updated information of any failure in machine tools. Also, Chang et al. (2016) suggested using a cloud-based maintenance system, for problems related to the maintenance of warehouse equipment. Lastly, Mourtzis and Vlachou (2018) proposed 'a cloud-based cyber-physical system' for flexible shop floor management and maintenance dependent upon shop floor situation. This system aims to, among others, increase awareness, improve maintenance of machine tools, and enhance decision making.

Stakeholders have a major role in any cloud system, they are the main users of the system who rely on the service providers to design a system that offers demanded services. Thus, knowing stakeholder's needs is vital as they involve in acquire cloud services (Wollersheim, Pfaff and Krcmar, 2014). As a summary, a future cloud-based system would be beneficial compared to other systems. For instance, users can manage and access data faster and easier through the internet. The system solves configuration problems; enhances control management processes; reduces maintenance time and improves production rates.

2.1.2 User requirements in cloud systems

In order to build a cloud system, there are some requirements that need to be fulfilled. These requirements relates to the stakeholder's aspect. Rimal et al. (2011) discussed many points that have to be considered when designing a cloud system, including having transparency regarding costs and usage of the system; privacy concerns regarding storage of sensitive data which affects users trust; service level agreements (SLAs) between providers and users; assist users to adapt and learn to control personal information in the cloud system; and aiming to design user experience (UX)-driven cloud system.

Clarke (2010) identified some related user requirements of cloud computing infrastructure, such as assurance of data and service integrity; complying with legal requirements which comprise, among others, service and data transmission security, service access controls, and data disclosure; service and data reliability, compatibility and flexibility measures; and privacy policy enforcement.

Another study aimed to develop a cloud-based Building information modelling (BIM) solution through several objectives including identifying practitioners' needs and requirements. Alreshidi, Mourshed and Rezgui (2018) found that users had 'Socio-organisational and legal requirements', such as: improving communication; raising awareness; provide help and support, in addition to many technical requirements, such as: having a notification system; to be able to share and exchange data online; getting security checks for online models; and customized user interface.

Tomzik and Xu (2017) investigated about a cloud-based control system that interacts with soft-tissues and focused on deriving the requirements for that system. The results shows some requirements regarding connection, computational power and usability. Connection requirements include permanent remote connection; short timing of responses; sufficient bandwidth in cloud infrastructure; network connectivity and safety measures. Computational power concerns the cloud infrastructure; and algorithm scalability. Usability refers to having a standardised interface; independent platform; and adaptable system.

Moreover, research by Chauhan and Probst (2017) identified many architectural significant requirements for building a cloud-based system. The requirements were categorised into classes as follow:

- Quality Specific Provisioning that deals with initialization, run-time system behaviour, Service Level Agreement (SLA) achievements, types of user systems and services, and end-user device.
- Interoperability and Integration that relates to offering a clear system interface, governing cloud federation.
- Security and Privacy concerns data and services access, dealing with multi-tenancy, encryption requirements, trusting the cloud and services, legal and regulation requirements, and the liability of the hosted services.
- Collaboration requirements deals with communication internally and with heterogeneous cloud-environments and external services, service interface, and service end-points
- Monitoring requirements regards checking compliance and system configuration concerning quality requirements changes, quality parameters, and resource discovery and composition.

2.2 Information needs

Starting with the term 'Information needs', a researcher must comprehend the exact meaning of the term to avoid any interpretation issue. Line (1974, p.87) defines the word 'need' and other related expression that were incorrectly used in the literature.

- NEED is 'what an individual *ought* to have, for his work, his research, his edification, his recreation, etc'. It is when a person experience abnormal state of knowledge and figure out the knowledge gap and decide to fill it normally *is* when Information needs appear (Herman and Nicholas, 2010).
- WANT is 'what an individual would *like* to have'.
- DEMAND is 'what an individual *asks* for; more precisely, a request for an item of information believed to be wanted'.
- USE is 'what an individual actually uses'.
- REQUIREMENT 'is a useful bridging term; it can mean what is needed, what is wanted, or what is demanded, and can therefore be usefully employed to cover all three categories'.

After exploring the difference between the terms, information needs assessment should be performed. This is the stage where the characteristics of information need are described. Herman and Nicholas (2010), stated that characteristics related to information needs are subject; function; nature; intellectual level; viewpoint; quantity; quality/authority; date/currency; speed of delivery; place of publication/origin; and processing and packaging. These points could be considered when assessing the information needs.

Furthermore, Nicholas and Herman (2010) discussed some factors that determine information needs in another study, such as work-roles and tasks; personality traits; gender; age; country of origin and cultural background; information availability and accessibility; information appetite and threshold; time availability; and resources availability and costs. These factors concern stakeholders of the cloud-based information system that will be designed.

2.2.1 Information needs: elicitation methods and results

In the following, previous studies presenting information gathering methods are described, beginning with Song et al. (2010) who investigated information needs of general dentists for the aim of designing an effective clinical information system. The researchers used semi-structured interviews for data collection, and thematic analysis for analysing data. The results shows a need for access to information about different subjects in a timely manner; improved visual representation of dental problems; links to case-specific evidence-based information; and precise, full and reliable patient records.

Becker et al. (2011) on the other hand focused on finding information needs from service and manufacturing processes. They collected data mainly through semi-structured in addition to observations, document analysis and system analysis. Then in-depth business process analysis was used. The results identified several information needs of, among others, customer solution and records; shipping note; acknowledge base; resource calendar; work plan.

Lammintakanen, Saranto and Kivinen (2010) performed a different research that aimed to reflect nurse managers' awareness of electronic information systems in their daily work. The

problem with the information system was that it did not meet their information needs. The researchers collected data in focus groups and analysed data using ATLAS.ti computer program. The results suggested further studies on information needs of nurse managers across different organisational levels. Some studies built information needs models, such as, Shih et al. (2012), for compensating a lack in current descriptions. The proposed solution was 'an information needs radar model', which assess and gather information about user's needs.

Hörold, Mayas, and Krömker (2012) addressed information needs of users of public transport with intent to design a user-centered passenger information system later on. The process of determining those needs began with identifying the workflow of users; identifying the tasks needed to reach a destination; identifying related information that 'support the tasks'; and identifying personas of passengers. The study concluded several information needs of different passengers including ticket, location, time, connection, network plan, vehicle, and disturbance information. Each passenger varies in his or her need for every type of information.

Wollersheim, Pfaff and Krcmar (2014) investigated the information needs of organizations in the form of characteristics, which are needed when procuring cloud services. The researchers collected data by interviewing 16 different organizations. Thereafter, a quality model named Systems and software Quality Requirements and Evaluation (SQuaRE) was used to structure the collected characteristics. This model was designed based on ISO/IEC 25010 (2011), where it is concluded that the quality of a system reflects the degree to which the system satisfies the specified and implied needs of different stakeholders and hence provide value.

Wollersheim, Pfaff and Krcmar (2014) identified information needs when procuring a cloud service, including information about type of functionality the service is offering; guaranteed availability of service; supported interfaces to application services; number of factors determining a service's fee; and many other information needs. Adding on, Al-Nayeem et al. (2017) explored the information needs for validating evolving software systems. The researchers surveyed 194 Site Reliability Engineers (SREs) at Google to know their information needs. The results show that SREs at Google have an extensive range of information needs, which were of a little focus in related past studies that considered 'source code change' as the major need.

Moreover, Buse and Zimmermann (2012) mentioned how important it is for software development to figure the information needs of development managers. Therefore, the researchers conducted a survey-based study to find information needs of 110 developers and managers at Microsoft. The researchers pointed out that the world is heading into a more data-driven software development and that enormous amount of data will form as a result of Web services and the cloud. Thus, to make the right decisions, people have to understand which information are needed.

Lastly, to capture the importance and solution of data availability and knowledge sharing, Lingegård and Lindahl (2015) addressed some related issues for the railway facility in Sweden. The researchers wrote that the Swedish Transport Administration is considered the responsible actor of the railways in Sweden, whose system provide incomplete and undetailed information about railways, because of contractors who are not motivated enough to provide more details from their operations. There is also the problem of inability to share information from contractors back to the Swedish Transport Administration and project designers. Thus, as a possible solution, if information and knowledge about failures and possible enhancements are transferred back, the existing system will improve the situation.

2.3 Gravel road information needs

After reviewing the literature, there were insufficient results on the topic information needs with gravel roads, which suggests a gap in the literature. In Kans, Campos and Håkansson (2019), the researchers mentioned that roads typically consist of two layers: sublayer and surface layer. The road standards, which was mentioned earlier, is usually determined using four parameters: edges of the road; irregularities on the road; loose accumulations; and dusting. In addition, information about traffic frequency on the gravel roads are important as well for decision making.

Saarenketo (2005) focused on investigating road users' needs and designing a monitoring system. Some of the discussed users' needs were information about traffic safety issues such as uneven frost bumps, steep hills and tight and narrow curves; accessibility to roads, which can be limited due to snowstorms, avalanches block the road, spring thaw, and erosion after heavy rain; and other specific issues related to functional and structural conditions.

The functional conditions, which occur in summertime, could be due to the unevenness, potholes, wash boarding, dusting and firmness. As for the structural conditions, they could be related to drainage, frost heave and roughness. As for the proposed monitoring system, the author suggests noticing some key factors that are needed for an improved system. Those factors comprise, among others: road referencing system; road survey and monitoring system; software and data formats, etc.

The design of a suitable monitoring system could rely on the following factors that were described in (Saarenketo, 2005, p.46): Sensor type and amount, Location of sensor installation, Data collection density, Positioning (especially when using moving vehicles), Data transfer, Data storage and processing, Implementation of the data and decision-making system, and Information system. The author predicted the formation of the internet and wireless communication system; this will facilitate the exchange of information between the road owners and road maintenance contractors. This agrees with the aim of the ongoing project.

Many factors influence the operations and maintenance within gravel road ecosystems, as mentioned in Alzubaidi (1999). One factor is *road standard*. Depending on the class of the road standard, which varies from 1 to 4 (Jacobson, 2014), the frequency of the maintenance measures are performed. A higher road standard decreases traffic costs but increases road management costs. Moreover, *Traffic dependent factors* are considered vital to the extent of maintenance work. Such factors are traffic volume; traffic composition; and vehicle speed.

Geometric factors refer to the width of road; and alignment and profile of the road, and *physical factors* refer to the composition of the wearing course; type of landscape and the surroundings of the road; and buildings. In addition, there are some *meteorological factors*, which are geographic-related factors such as sunshine hours; road conditions when it snows; and humidity. In addition, Alzubaidi (1991) mentioned some major issues that face gravel roads surfaces, which were among others dusting; corrugation effect; having potholes; drainage of water; loose gravel; and damage from frost. All the mentioned factors influence the maintenance costs of gravel roads. These factors are information that needs to be shared. Thus, it is important to keep track of these factors as they influence the information needs in the gravel road ecosystem, regarding maintenance measures, to avoid unnecessary costs.

Additionally, Rashedi, Maher and Barakzai (2018) aimed to capture the current condition of gravel road management in Canada and how much data is collected regarding gravel roads. They examined the elements of a Gravel road management system (GRMS). Such a system needs to include an essential database that stores and maintains inventory, condition, and restore history of paved and gravel roads. Other information to consider are agency policies such as maintenance policies; performance prediction models; and financial analysis for surface upgrade decisions. Lastly, information about structural capacity, drainage, traffic characteristics, road geometry, and opinions of local residents.

2.3.1 Tools and technologies as a solution for gravel roads maintenance problems

Kans, Campos and Håkansson (2019) presented a new measurement method for gravel road's condition, which is less-sensitive than the previous techniques in regard to the road roughness and to vehicle's speed and dynamic characteristics. It aims to capture accurate information on the topology of the gravel road surface. The researchers also described some used practices for classifying and monitoring the condition of gravel roads. Some techniques are used to test gravel road surface roughness, such as Laser Road Surface Tester (Laser RST) and laser scanning technology LIDAR. Also, the roughness of the road can be determined using vibration sensors on smartphones, such as a system called Roadroid that measures road roughness (IRI) using an accelerometer and Global Positioning System (GPS) that saves the data location, as described in the report by Bäckström (2017).

Other techniques are used to measure the road thickness of the subbase layer using ground penetration radar (GPR), as described in TerraTec (2017). The radar transmits electromagnetic waves into the sublayer and receives the reflected waves to detect changes. Lastly, Odelius et al, (2017) described an industrial internet application that uses sensors on smartphones that are attached in-vehicles. This technology combines both data from the weather condition with data from the moving vehicle's sensors to enhance road maintenance in winter.

2.3.2 Factors that are important for gravel road stakeholders' information needs

Based on the Review of the literature, *Table 1* presents a summary of the factors that influence maintenance of gravel roads combined with user requirements in information systems. This study will focus only on user requirements of stakeholders, which is one of the factors needed to design a cloud-based information system (Rimal et al., 2011). This is because the other factors are handled by the system's designers, and users would only be able to answer questions regarding user requirements.

Table 1: Factors that are important for gravel road stakeholders

Road maintenance related factors	Reference source
• Road standard	*Kans, Campos and Håkansson (2019); Saarenketo (2005); Alzubaidi (1999)*
• Weather conditions	*Saarenketo (2005); Alzubaidi (1999);*

• Road condition	➢ Accessibility issues: avalanches, erosion, weak drainage, spring thaw weakening	*Rashedi, Maher and Barakzai (2018): Saarenketo (2005); Alzubaidi (1999)*
	➢ Functional issues: unevenness, potholes, wash boarding effect, dusting, road firmness	Kans, Campos and Håkansson (2019); *Saarenketo (2005); Alzubaidi (1999)*
• Traffic factors	✓ Traffic volume and composition	Kans, Campos and Håkansson (2019); *Rashedi, Maher and Barakzai (2018); Alzubaidi (1999)*
	✓ Vehicle speed	Kans, Campos and Håkansson (2019); *Rashedi, Maher and Barakzai (2018); Alzubaidi (1999)*
• Maintenance policy		*Rashedi, Maher and Barakzai (2018)*
User requirements in IS		
• User interface characteristics	• User friendly system	*Rimel et al. (2011)*
	• Communication internally and externally	*Alreshidi, Mourshed and Rezgui (2018); Chauhan and Probst (2017)*
	• Notification system	*Alreshidi, Mourshed and Rezgui (2018)*
	• Cross-platform availability	*Tomzik and Xu (2017)*
• Network connectivity		*Tomzik and Xu (2017)*
• Provided services characteristics		Chauhan and Probst (2017)
• Cost of using the system		*Rimel et al. (2011)*

The factors in this table will be used as a guide for developing questions for the interviews, in an aim to capture the information needs of stakeholders within gravel roads ecosystem for the purpose of building a cloud-based Information System.

3 Methodology

Chapter three presents the methodology of this research paper. It begins with the methodological tradition and approach. Then data collection and analysis methods were described in addition to mentioning how data will be reported and interpreted. Lastly, some reliability and validity measure are mentioned, as well as some ethical considerations.

3.1 Methodological Tradition

No research is complete without a pre-decided methodology that shows the road taken towards reaching the final results. A methodology certainly follows a scientific paradigm, depending on the nature of the research. In an effort to clearify this statement, a number of different classifications of research paradigms are first presented. Starting with Burrell and Morgan (1979), the researchers suggested four paradigms: functionalist; interpretive; radical humanists and radical structuralist. Orlikowski and Baroudi (1991), who based their classifications on Chua (1986), classified the main research paradigms as: positivist; interpretive; and critical studies. Guba and Lincoln (1994) suggested a different classification: positivist; post-positivist; constructivist; and critical. Finally, Creswell (2014) focused on four paradigms, that were called worldviews: post-positivism, constructivism, transformative, and pragmatism. This thesis will focus on Orlikowski and Baroudi (1991) classification as being the mostly used in Information Systems studies.

Positivist research assume fixed relationships that are pre-determined within specific phenomena that will be investigated by testing a theory to form an understanding of the phenomena. It isolates people's interpretation of the situation being studied and assumes that phenomenon have a scientific explanation. Interpretive research does not necessary impose prior relationships, instead it assumes that people interact with the research and enforce their opinions. This paradigm aims to increase the understanding of a phenomena. Critical research, as the name suggests, aim to criticize a certain phenomenon by revealing contrasts in social systems (Orlikowski and Baroudi, 1991).

This research will move within the Interpretive paradigm. This provides an in-depth insight into people's nature and experiences of gravel roads and how a cloud-based information system will support their daily experiences, and also enhance the maintenance measures. Interpretivism believe that the social world is shaped by the beliefs and actions of people. As for generalizing the results, Orlikowski and Baroudi (1991) wrote that an interpretive research seek not to generalize results, and Lee and Baskerville (2003) stated that a research cannot generalize from a single case study. However, Walsham (2006) disagrees and instead states clearly in previous study that generalization is attainable in four forms: as new concepts; generalizing a theory; specific implication; or contribution of rich insight.

3.2 Methodological Approach

This research followed the Qualitative research approach and base on a case study, which is defined as an approach for conducting a research that entails an investigation of a certain incident within its real context using multiple evidence (Robson, 2002). The type of case study is exploratory. A qualitative approach is most suitable considering the fact that this research is

investigating a contemporary phenomenon, which in this study is the information needs of stakeholders using interviews. This thesis will use Creswell (2014) guidance on the Qualitative research approach as the main source for the methodology part of the research.

Creswell (2014) provided a rich content on each methodological approach. The researcher wrote that qualitative research tends to depend on text and image data. It has different research designs listed under the general qualitative design. These are narrative; phenomenology; ethnography; case study; and grounded theory. A qualitative research typically begins with forming questions to answer, collecting and analysing the data, and lastly interpreting and reporting the results. This is a design that starts inductively; it focus on specific themes to build general themes or meanings, then it turns into deductive approach when a research looks back at the data and check if the evidence collected is sufficient to support the themes or more is needed.

When it comes to researchers roles, Creswell (2014) added that there are many sources of data, such as interviews; documents; observations; and audio-visual information. The researcher itself is vital because he/she is the one collecting data. Thus, as agreed and mentioned by Walsham (1995), a researcher should perform their role in an explicit and reflective way regardless of the chosen data collection technique. The process of the design is flexible and can be changed even after collecting data.

3.3 Data Collection method

Firstly, data were collected using, semi-structured interviews with the target population. Walsham (1995) made clear that researchers need to allow interviewees to give their views on the subject being discussed, and therefore the question asked should not be tightly controlled by the interviewer. This support the choice of conducting a semi-structured interview in this research paper. Telephone or online interviews were conducted, in which audio and/or video was taped and transcribed. It is also recommended to take notes while taping. Creswell (2014) advised on using as many open-ended questions as possible as this allows the researcher to pay more attention to what the participants are saying, and thus presenting participants' perspective as much as possible.

Creswell (2014) advices to use an 'interview protocol' that consists of writing a heading about the date, place, interviewer and interviewee; some instruction for the interviewer to follow; write the questions to ask; have space between the questions and answers; and a final thank-you statement. Furthermore, doing an interview is useful as observing the participants directly (when they use or maintain gravel roads) is difficult to achieve. The preferred language of the interview was English, but, if the interviewer preferred using Swedish, a Swedish version of questions were also available. A limitation to the interview method is that not everyone are expressive or has the same perspective (Creswell, 2014), which is why the sample were purposefully selected based on their potential contributions. This also agrees with Merriam (1988).

This thesis aimed to conduct as many interviews as needed until data saturation is reached. The target population were *the Swedish transport agency; municipalities; road maintainers; road associations; and gravel road users*. This target group is the main stakeholders whose perspectives are the base of this research. The participants were purposefully selected, as

mentioned earlier, using a list of contact information to relevant stakeholders, that was provided by the ongoing project leader. As well as through references by the participants themselves.

The invitation to the interview was sent by email to get an appointment. Note that it is advisable to mention approximately the length of the interview, so that possible participants manage their schedules and feel comfortable when answering the questions. Therefore, in the emails, it was mentioned that the interviews will take approximately half an hour. In addition to that, those who agreed to have an interview chose their preferable language and date for the interview. Also, they received a list of the areas that the interviewer will ask about, in case they needed to prepare ahead.

Table 2 presents the participants and time/date of the interview. The total number of participants was 11. Thereafter, at the time of the interview, the participants were either called on their phones; these were recorded using a recording software or called through a zoom link; these were recorded through the software itself. The clock was set, and the interviewer began with greeting the interviewee and presenting herself. Then the length of the interview was mentioned and the fact that it will be recorded for later use.

Table 2: List of interviewees' details.

Stakeholders type	Date/time	Interview type
Swedish transport agency	01/04/2020 at 14.00	Telephone
Swedish transport agency	17/04/2020 at 14.30	Online skype
Municipalities	31/03/2020 at 14.00	Telephone
Municipalities	07/04/2020 at 14.30	Online via Zoom
Maintainers	01/04/2020 at 14.30	Telephone
Maintainers	06/04/2020 at 13.30	Telephone
Maintainers	09/04/2020 at 14.00	Online via Zoom
Road association	31/03/2020 at 13.30	Telephone
Road association	07/04/2020 at 13.30	Telephone
Road user	10/04/2020 at 13.00	Online via Zoom
Road user	10/04/2020 at 14.00	Online via Zoom

The questions to be asked will be listed in a word file in English and Swedish, with an empty space to take notes of answers. The list includes all possible questions that varied depending on the type of stakeholder; municipalities had different question than a road user. The questions are inspired by two sources: Saarenketo and Saari (2004); and Rimal et al. (2011). A list of the English-written questions is presented in Appendix B. Note that the way of asking some questions may have differed, and even some new questions were asked in line with the provided answers. The interviews ended with thanking the participant for their valuable time. Final notes were written after each interview, and the recordings were named after each participant.

3.4 Data analysis method

When it comes to qualitative data, different techniques can be applied to analyse collected data including coding data; writing analytical memos; displaying data with, for example, flowcharts and maps; or using contextual and narrative analysis (Kaplan and Maxwell, 2005). As for coding data, codes can be derived either deductively from prior knowledge and published theories, or inductively while analysing data. One type of data analysis is Template analysis, which is considered a style of thematic analysis. Template analysis underlines the use of hierarchical coding, while combining both high level of structure in the analysed data with the ability to adapt to the research's needs (Brooks, et al., 2015). It aims to thematically organise and analyse data, resulting in a set of codes that represent themes in the text.

Thematic analysis is considered as a broad category of approaches that define and organise themes to interpret data, while template analysis is seen as a style of thematic analysis. Thus, it can only be possible to compare template analysis to other forms of thematic analysis as described in Brooks, et al. (2015). Based on the researchers, template analysis shares flexibility feature with thematic analysis approach in Braun and Clarke (2006). The major difference between the two is that in thematic analysis, themes are usually developed at a late phase after coding all the data, while in template analysis, themes are defined at an early phase to guide the coding process. More specifically, themes would either be defined in an early stage, a *priori* or are added to and modified, later on, using a template to ease the display of the relations between those themes.

Template analysis is appropriate especially when a researcher aims to investigate and compare different perspectives of different participants within a certain context (King, 2012). This data analysis method suits well with the aim of this thesis, which is to investigate the information needs (perspectives) of different stakeholders within the context of gravel roads.

Steps for performing a template analysis start with creating the main template, interpreting, and finally presenting the template analysis. Brooks, et al. (2015) listed the steps as follows:

1. Familiarise yourself with the data before analysis, for example in the case of an interview, it is advisable to start reading the transcripts and side notes.
2. Highlight unique texts and words as the first step in coding data. It is possible, to begin with a *priori* codes, which can be redefined or deleted later.
3. Arrange themes into a clear cluster and define the relation between the themes in a hierarchical form.
4. Design the initial template based on the defined themes. It is possible to use the basic subset of data before beginning to code all collected data. In other words, if a researcher conducted 20 interviews, it is possible to start with codes generated from 5 interviews to design the initial template, as long as the template 'captures a good cross-section of the issues'.
5. Apply the initial template to additional data. The themes in the template can be redefined, added to, or deleted as necessary. For example, other than the 5 analysed interviews, in this step it is advisable to apply the initial template to another 5 interviews out of the 20. The aim is to keep revising the template until a rich revised version of the themes is obtained.
6. The final step is to finalize the template and apply it to the complete set of data.

Regarding this research, collected data were analysed using template analysis. First of all, the recordings were transcribed and/or key answers were written in a joint excel sheet file to sort data in a clear way. A transcription website called 'amberscribt.com' was also used to help with the transcribing; to increase the accuracy of the written data. Swedish transcriptions were translated into English, where the basic terms were defined according to Skanska's construction dictionary (Tarawneh, 2017).

The transcripts were read more than once in order to have an overview of the text. Afterwards, a *priori* codes list was defined, which was based on the factors that are important for gravel road stakeholders in *1*. Codes were written on a separate paper and while reading through the transcripts, whenever they appeared, the text would be highlighted. Also, while reading through the text, whenever new codes appear, they would be highlighted in a different colour. Additionally, all collected codes were gathered into one file to define relations, which resulted in identifying themes.

Afterwards, the initial template was designed, which was applied to 5 out of the 11 interview transcripts. Each stakeholder category had two or more participants; therefore, each one of the 5 selected transcripts was from a different category. Lastly, the final template was applied to all collected data. It presented a set of top-level and lower-level themes, as shown in Appendix C. In addition to the data analysis, the similarities in stakeholders perspectives were displayed in *Figure 2*.

3.5 Reporting and interpretation of data

Based on the findings of the analysis, a descriptive framework of information items will be provided in the form of tables and figures. This provides a rich insight into the information needs of each participant. Walsham (1995) mentioned that a researcher needs to report not only the findings, but also the sites where the data was collected; the reasons for the choice; the total number interviewed; their professional positions; other sources used; and the time period of the research.

3.6 Reliability and Validity

Some measures are taken to ensure the reliability of the findings. According to Creswell (2014), one qualitative reliability procedure, which is inspired from Gibbs (2007), is to check that codes maintain the same meaning during coding of data. In addition, as this research aims to collect participant's opinions and get as much descriptive information as possible, the interviewee will choose their appropriate time and dates of the interviews to avoid feeling uncomfortable while answering.

As for ensuring the validity of the findings, first, there will be a constant connection with the project's leader, associative professor Mirka Kans, who supervises each step of the research and assist with providing vital information, references and further guidance. Second, Creswell (2014) suggested applying more than one validity strategy. In this study, two strategies will be applied. Firstly, adding comments about any *bias* brought to the study as a result of the researcher's background, e.g. 'gender', 'culture', 'socioeconomic origin', etc, which might

affect interpretation of the findings. This strategy was also mentioned in Merriam (1988) for validating case study data. Secondly, the transcripts of the interview will be sent to the interviewees to make sure the written words were as said in the interview (Hagens et al., 2009).

3.7 Ethical considerations

This whole research is administrated by the faculty of Technology at Linnaeus University, Sweden. As the research often deals with personal information, there are some ethical considerations that should be considered when designing a research. Referring to Pimple (2002), six domain of research ethics were identified:

- Integrity
- Collegiality
- Protection of human subjects
- Animal welfare
- Institutional integrity
- Social responsibility

Protection of human subjects included two subcategories that were considered in this research. One is confidentiality, by assuring that sensitive data, such as names or professions, will not be shared with anyone or published in the paper. Also, participants gets the option to participate in this study which will be kindly requested in the invitation emails. The other is anonymity of the participants; when reading the empirical findings section, no reader can identify who the exact participants were.

Another subcategory is obtaining informed consent from participants before the interviews begin. This consideration was obtained by applying several requirements mentioned by World Health Organization (2019, p.18). Among others are stating the fact that the activity is research; the voluntary nature of study participation; the aim of the research study; the methods to be used; and the data collection procedure. All these requirements were stated in the electronic invitations to the interviews. A copy of the informed consent letter is presented in Appendix A.

Lastly, the uncertainty regarding the current epidemic, Covid-19, requires a researcher to consider the consequences that may affect health. Therefore, it was vital to interview participants using any communication medium other than personal interviews. Risks to health were mentioned in National Committee for Research Ethics in Science Technology (2009).

4 Empirical Findings

Chapter four presents the empirical findings from the data collect. The findings are displayed based on the generated themes, afterwards similarities in answers are presented in a designed figure.

This chapter consists of two parts. First, themes that presents findings from interviews are presented, second, the similarities in answers are displayed in *Figure 2*. After analysing collected data, Appendix C presents the final template of generated themes, which presents information needs of stakeholders. The following description of themes present the findings from all stakeholders.

4.1 Stakeholders information needs from interviews

Theme 1: Fixed gravel roads-related information

This theme includes analysed information regarding gravel roads identification factors. These include both permanent and variable information. The permanent information include road standard; name, number and dimensions of the road; and Road owner/s and responsible maintainers. The variable road identification information includes information about the carrying capacity of the road.

Beginning with the Swedish transport agency, it is considered one of the most important stakeholders considering maintaining road in Swedish. They own roads, often maintained by private companies after a bidding process that ends with writing contracts. The contracts are based on achieving a certain road standard 1- 4, where 1 is the highest standard and 4 the lowest. They then pay contractors to maintain the roads and keep track of the maintenance process. One participant said that they need information about the road status in addition to information about the road network:

> *"You measure the road network with laser, and then you get the profile on the road, and you also get how, for example, deep the depth of track is along the road and other unevenness."*

Also, they need information about four different parameters to assess roads, as said by one of the participants:

> *"1.The dimensions of the road, if it has potholes and so on*
> *2.Whether the road is uneven at x level; the water should go to the ditches*
> *3.Whether the road is loose or not; the particles should bind together*
> *4.Dust: can you drive in a certain speed and still see the car in front of you."*

The second category of stakeholders were municipalities. In Sweden, not all municipalities maintain gravel roads. Those who do usually have a direct contact with road associations who inspect roads themselves and report back to the municipality. Municipalities do have a point of view on the management of gravel roads. Also, they sometimes take care of the Swedish transport agency's roads. Thus, when asked about what information they need to maintain a gravel road, one participant said:

"We usually get a call from road associations about those gravel roads that need maintenance"

The third stakeholders category are maintainers who are those contractors who maintain the roads. They are assigned by the road owners, municipalities or the Swedish transport agency. Responses from this stakeholder category adds a lot to this research paper, as it directly defines the needed information when maintaining a gravel road. Beginning with what information is needed, it was noted that maintenance is done during different times of the year, so a person needs to maintain gravel roads in different ways. Adding on, the responses were:

"First and foremost, we need to know which road it applies to, there are usually either road numbers or road names. You also know what the standard road has, how much gravel needs to be applied, is it on all the road or just part of the road. And if it needs edge cutting of the ditches."

"An important thing that affects the need for maintenance is what type of ground the road is on. Roads that lie on mountains or moraine often have little need for maintenance. Roads that lie on mud or old seabed often end up worse and need to be maintained more."

"This is done during different times of the year, so you need to maintain gravel roads in different ways. .. It is best to have a plan because the gravel road consists of the superstructure section and partly the wearing course. The wearing course can simply be refilled. And there's a lot of work to do with it."

The fourth stakeholders category is road associations. Road association are there to support the needs of road owners and report problems regarding road status, and they have a direct contact with the corresponding municipality. The participants were first questioned about what information on gravel roads is needed to maintain these roads. The responses were as follows:

"An active management of the roads that can point out any shortcomings. Also, how much heavy traffic goes on the road such as wood / gravel and other heavy traffic. A road clerk who fills pits and potholes and ensures that road culverts are cleaned so that water can pass unimpeded, and who assesses what needs to be done according to a 5-year plan."

"To see if the road body needs action. All gravel roads need to be reinforced by increasing carrying capacity; you plane in material that makes the road stronger."

The last category of stakeholders was road users. Road users are those who use the road and drive in order to reach a certain destination. If we take into account the previously mentioned stakeholders, it is found that almost everyone uses the roads for a certain purpose. However, in this thesis, road users are only those who drive along the road, thus not belonging to any other stakeholder group. Two participants were interviewed who are private users that drive to reach their work. When asked about the road standard of the roads they drive, they did not know. It seems that such information is not important, unlike the case for previous stakeholders.

Theme 2: General opinions about the effect of weather on gravel roads

This theme includes all analysed data about participants opinions about the quality of the roads in different seasons, and the importance to know about upcoming weather status. Beginning with the Swedish transport agency, the two participants were asked about their opinion of the quality of the roads during winter and summer, and if weather affects the conditions of the roads. As it is clear, the weather do affect gravel roads significantly and both answered that gravel roads are in an acceptable shape during winter and summer.

Then, when participants from the municipalities were asked about the quality of the roads in winter and summer, both replied that it is acceptable, but in winter they get worst because of the weather. One participant did say that still the problem of dusting occurs. Both participants said that it is important to know about the upcoming weather status, in order to plan work in a better way:

> *".. especially now at beginnings of spring, it is important that when you pave and sand the roads that you make it as clearly as possible, to get advantage of the natural moisture in the road body."*

As for maintainers, when asked about the importance of knowing about the upcoming weather status, they agreed because this helps in planning work, and one advantage of this is that:

> *"if you have made a finished gravel road, which can be both with gravel and edge cutting of the ditches, then it can be good if it rains a little after so that the gravel fits slightly."*

Then when asked about the quality of the roads in winter and summer, lengthy answers were provided, which reflects the huge effect of the weather on the condition of these roads. One participant responded that in autumn, when it rains, potholes and grooves form, and some close-knit patterns form, which needs to be paved:

> *"when autumn comes, so you can put on some wearing course layer, and it depends a bit on what the Swedish Transport Administration has on budget."*

Then in winter, when roads are usually freezing and slippery, maintainers tend to sand the roads. Also:

> *"A gravel road must be frozen in order to plow it, otherwise you plow the gravel into the ditch."*

Afterwards, in spring when snow/ice begins to defrost, one of the major problems occur which is thaw weakening where a maintainer needs to go out and gravel the road:

> *"As the layer of snow and ice melts, the road surface becomes soft. Because the road is still frozen in the bottom, the melted water from the surface cannot sink down the road."*
> *"When the road keeps on thawing, it makes so much water in the road that it loses its carrying capacity."*

Then, some additional replies about gravel road maintenance during different seasons:

> *"Most of the roads needs gravel in the spring when it's dry. Certainly, you get to gravel in the autumn and summer, but you have to do it when it's not too wet and messy on the road."*

"In the summer, gravel roads almost always get pits and potholes, which must be repaired about once a month. But since you plane a gravel road 1-2 times a year, the road, in addition to the potholes, is often more even than a road that is paved with asphalt or oil gravel."

As for road associations, when asked about the effect of weather, they said that it does affect roads and it is important to know about the upcoming weather. On the other hand, when the road users were asked about their opinion of the quality of the roads in winter and summer, they responded:

"In summer, the quality is good. In winter, there are potholes and water gatherings. Sometimes there are tree branches and logs."

"There are rocks on the sides of the road. If these are for lining the road then these should be bigger and be marked, because when you go backwards you don't see the rocks if they are small."

Then when asked about the importance of knowing the upcoming weather, they both mentioned that they usually get notifications on their smartphones regarding the upcoming weather. However, it did not occur to them to check the weather status specifically in the area of the gravel roads.

Theme 3: The different effects of weather on gravel roads conditions

This theme reflects information about the issues of gravel roads as a result of the direct effect of weather. These can be either accessibility issues such as weak drainage, edge cutting of ditches and road culverts, spring thaw weakening, branches and tree logs barriers. Or Functional issues such as unevenness, quality and composition of road material, potholes, wash boarding effect, dusting, loose gravel/road firmness

Beginning with the Swedish transport agency, the participants emphasized the problem of spring thaw. Spring thaw happens when ice on road surface begins to thaw as a result of the rise of temperature in spring. The water gets trapped under the surface as the sub layer stays frozen, which results in weakening the gravel materials. The problem here is when heavy transport moves forest through these roads to factories and thus damages these gravel roads. The other participant emphasized that the surface of the road can change completely after some heavy rain, in addition to the dusting that occur in very dry weather, where both can affect roads:

"Partly if it rains, we get a certain impact on the road. As well as if it is very dry for a longer period, it also has its effect on the road surface. And this is when one usually hears that there is quite a lot of dust on the gravel road during certain periods of time."

Some accessibility problems such as avalanches that could block the roads are possible only in Northern Sweden, unlike drainage problems, which are common and at the same time handled though a specific technique:

" The water is transported along our roads in our road ditches until they arrive at some road culverts… which handle both stormwater and other water, such as streams."

When it comes to functional issues such as having unevenness, potholes, wash boarding roads, dusting and weak road firmness; they occur very often in addition to another problem, loose gravel, which might be related to the road firmness. It affects traffic safety as well. Usually all these issues depend on the composition of the wearing course:

> *"Wash boarding and potholes form because the composition is not hundred percent correct; the material does not bind with each other properly because it is either lacking fine material or coarse material. It is the composition that is very important on the gravel road to get a good evenness and bonding unit so that it binds together properly. Partly the composition, but also the quality of the rigid material in it, so that it does not consist of either too loose or too rigid material."*

In addition to the composition, the quality of the rigid material in the road is also important; it should not be very loose or very rigid material. The loose materials will be broken by passing vehicles, whereas the bigger stones are eventually broken into smaller fractions and into fine materials, which means that they lose carrying capacity. Thus, the participant said that it matters to achieve a certain stone quality.

As for municipalities, when asked about the accessibility issues, both participants said that drainage and spring thaw weakening are common. One focused on the problem of poor drainage in the answers and the other focused on the problem of drainage, and said:

> *"Drainage can happen, then it is important that the water pour off, otherwise water will gather in the road body."*

Regarding the functional issues, such as potholes, dusting and wash boarding roads, these issues occur to a limited part of the gravel roads. One participant said that they form because of heavy rain and the other said that they form because of heavy traffic:

> *"When the weather is dry and the fine gravel disappears, the road becomes as washboard."*

Moving on to answers from maintainers of the roads, when asked about the accessibility issues, avalanches are again not a problem as municipalities usually are responsible of moving the snow out of the roads. Drainage of the water occurs which means that ditches grow on and needs to be constructed every 6 years in spring and/or summer. Also, that drainage is usually not a complete flow of water instead tends to be like a curly flow that ends up in the ditches. Another accessibility issue was mentioned as follows:

> *"The most important thing for us who drive a truck on the roads is not to have too many branches from trees that stand out because it can damage the truck."*

As for the functional issues, moving vehicles cause gravel to move and disappear into ditches. One participant commented that potholes are not always a result of the destruction of the road, instead occurs as a result of the poor construction in the sub layer of the road. This means the quality of the gravel material affects the condition of the upper road:

> *"Unevenness may depend on the quality of the gravel material…Washboard roads also depend on the quality of the gravel."*

The fourth category, road association were also asked about these issues. Regarding the accessibility issues, it seems that avalanches does not occur, but the other issues do. In addition, one participant added to this point that:

> *"When you have applied in road-metal in the road body then you have a stable source of strength in the road body and surfaces that keep coating against heavy trucks and increase sustainability."*

As for the functional issues, both said they happen and agreed that the quality of the road materials reflects back on the condition of the road; the likeliness that wash boarding to happen for example depends on the materials of the road. Maintainers usually build up to 30 cm wearing course in the road body.

Lastly, road users were asked about these issues. When it comes to the accessibility issues, avalanches never appeared on the roads, but bad drainage of water was a very common issue. Moreover, functional issues such as potholes and wash boarding, and unevenness, were noticed from time to time. The participants were asked following question that replaced the one about the maintenance policy: 'What do you do when a road needs maintenance? 'One participant answered:

> *"Nothing and I keep going because I don't know much about the road for example what to do, who is responsible for fixing the road, who owns it and whom to inform about problems."*

The other participant said:

> *"I would drive very slow and if I could I would change the road if I knew from the beginning that there is a big pothole ahead."*

Theme 4: On road traffic factors affecting gravel roads structure

This theme presents information about the effect of traffic factors, including vehicle's type and speed, and traffic volume, on the condition and maintenance of the gravel roads. Beginning with the Swedish transport agency, when participants were asked about the effect of traffic factors on gravel roads, the responses were:

> *"These are quite bad roads. I mean, the drainage isn't very good, which means that big lorries, heavy vehicles tend to, especially when it comes to spring, tends to destroy the roads almost completely. So, people actually need to reconstruct them from almost the bottom of the road."*

> *"There is the impact from how much traffic we have.. it affects if there is very heavy traffic on the road, truck traffic, above all. Also, how much of the road is used by heavy traffic instead of passenger car."*

As for participants from the municipalities, when asked about the effect of traffic factors, the participants responded:

> *"When driving fast gravel can become loose."*

"What affects most is the number of vehicles; how many vehicles naturally pass this road, and how much heavy traffic is there."

On the other hand, according to the maintainers, the traffic safety of gravel roads were seen to be acceptable. As for traffic factors, all participants mentioned the fact that these roads are the least busy because of continuous maintenance:

"..there is quite a lot of maintenance on a gravel road."

Still, they do affect gravel roads status, especially if there are lots of forest nearby:

"To cultivate forests, you also manufacture paper. So, you have a percentage of some very heavy traffic because of trucks and things that move woods, which are often very heavy."

Another response was:

"We who go out and gravel the roads, we get information about how many people drive on those roads."

Participants from road associations were also asked about the effect of traffic factors. Both participants agreed that these affect roads, especially with the increase of heavy traffic. This is why it is best for vehicles to adapt their speed to the road status. One of the reasons of the traffic volume is that:

"Many people move out into the countryside which also increases traffic."

the last category of stakeholders, road users, were not asked about the effect of traffic factors. Such questions are usually proposed to participants with expertise and professional opinion who can provide answers in relation to the maintenance of the gravel roads.

Theme 5: Information about gravel roads maintenance

This theme concentrates on the analysed information regarding maintenance of gravel roads based on the answers from the interviews. It is also interesting to know about the maintenance policy that is applied by each stakeholder. Beginning with the Swedish transport agency, in addition to using the four parameters to assess the roads, they pay much attention to choosing the right affordable road standard level; considering the traffic factors:

"we try to, on socio- economical matter, to decide which type of road is a good level to have."

When asked about the frequency of road maintenance, the answers relate primarily to the condition of the road, while noticing that different methods are used as well:

"It depends on road standards, the best roads are maintained two times a year, the worst types maintained once a year or even every second year."

It was also noted that they can afford a large machine to do heavy work every second or third years but can afford doing simple tasks such as dust prevention every year.

When participants from the municipalities were asked about the maintenance policy, they answered that they usually maintain the roads each year and plane 3 times a year.

As for the maintainers of the roads, one participant said that the municipality has scheduled maintenance plan that gravel roads should be paved every year and private road exits every three or four years. In addition, private forest owners call maintainers and report problems of the roads. Another participant responded that they check the roads, sand so that roads do not dampen. In addition, in summer they repair potholes and unevenness and in autumn they pave the roads.

On the other hand, participants from road association said that they get notified of the need for maintenance, and the gravel road maintenance is done as soon as possible. The municipalities have many road associations, who are responsible for a certain number of miles. They hold meetings annually to keep track of the updates and further plans. Afterwards road association try to catch interest to maintain certain roads and then apply for government grants and financial support. When asked about the maintenance policy, road association do check the roads at least once a year and the paving is done three or four times a year. The main aim of road associations is:

> *".. to reduce manufactured gravel, reduce the number of road planes, to make better roads and save the municipality money."*

Lastly, road users were not asked about maintenance policy as they are not involved in such a process.

Theme 6: Dependency on technology

This theme regards questions that are related to technology and the information system. The participants from the Swedish transport agency were asked about their departments' dependency on technology to find information. Some applications are used to do measurements, but they also depend on personal inspection of roads through assigned consultants. They use an application to keep track of contractor's work using GPS on contractor's vehicles to check if they are doing their work effectively. There are applications that measure unevenness, which also translates into different data regarding loose gravel and potholes.

Some techniques and sensors that could be useful to the Swedish transport agency were for example:

> *"It'll be great if ordinary cars or trucks have cameras that tell us that now it's beginning to form potholes."*

> *"Sensors that measure unevenness, some type of moisture ratio in the road body or the similar, maybe the profile of the road, to ensure that the water can run off the road surface then."*

The agency, as mentioned by one participant, need to have more control over the roads, which does not have to be in real-time. They are willing to pay for the future information system. Participants were asked: 'Which information is important to access?', one participant added:

"Preventive maintenance, which means we need to know the climate and temperature and weather conditions next week, after two weeks and so on."

The point here is that not only information about the road surface is needed, but also about weather forecasts. Consequently, the Swedish transport agency would help companies plan their work and maintenance efficiently, especially after knowing where the spring thaw weakening is on the gravel roads.

When participants from the municipalities were asked about the use of technology, none reported their dependency on technology to get data. They did mention an application that is used for gravel roads owners, but usually they rely on personal observations of the condition of the road. The communication with other stakeholders is commonly done through the telephone or emails.

As for their opinion about the future system and the ability to communicate with other stakeholders, both agreed that this is a good idea and that:

"It is not wrong for the public and farmers to report their point of views, surely it does provide some maintenance assistance."

Moreover, maintainers on the other hand usually inspect the roads themselves and get reports of any problems from those who live nearby. One participant added:

"The government documents what to do, for example, installation. It is primarily what it looks like on the roads. Then we have someone who is responsible for the owners; to understand what should be done."

All participants use telephone and emails to communicate with other stakeholders. When asked about communicating through the future system, one participant said:

"It can be good. There was an app before where members or residents can report things to the board about problems e.g. lighting pole. They took a picture on the telephone and the administration system, like the road association, contacted each other."

Regarding which information about gravel roads needs to be available in the future system, mostly weather related information is important in order to plan maintenance at the appropriate time:

"Preferably when you have a large area to gravel the road, you can do another coordinated gravel if you know that the weather looks the same there."

When asked about their opinions of this future system, one participant said that it is good to know about the road status to control heavy traffic driving on the roads. It also depends on what the sensors of the future system will measure. As an example of sensors that benefit the work maintainers are:

".. sensors that measure how much is the source depth in the road; when the cold or frost goes out of the way, then it loses a lot of its carrying capacity."

Another participant said that this system would benefit everyone, especially the fact that it gather information about gravel roads. Adding on to this point, not all gravel roads needs to have gravel so often, which means that the future system can save costs of extra work and material. Usually, to gravel a road depends on the traffic volume and base road condition. The participant continued:

> *"I think this is a very worthy step in. To be used so much, so I see that it should be a simple cloud-based system in that case."*

In addition, the third participant said that no such system is available nowadays, only one a few years that uses sensors on the cars, which drive around the roads continuously to record changes.

Finally, the maintainers were asked which information is important to access on the system, and the answers varied between road standard; source depth of the road; smoothness of the road; if there is dust; and if there are any irregular patterns or washboard patterns on the road.

Moving on the answers from road associations, participants said that they prefer to get information through the Swedish transport agency. They communicate with road owners though meeting and through text messages. Nonetheless, telephones and emails are necessary for communicating with all stakeholders. When asked about their opinions of the future system, they both mentioned that this would lower costs:

> *"Sweden has 37,000 miles of separate roads and there is a lot to look at every year, so it is important to have a good road from the ground up."*

In addition, a question about which information is important to access in the system:

> *"Weather status: many who work with gravel roads do not have the skills or resources, so, getting information on this is great. Also, it is important to do the right thing of course, that you have the right kind of machines."*

As a final note, all information that would benefit all stakeholders is good to have, as said by one participant.

Finally, when road users were also asked about technology and their dependency on technology to get information. One participant said that google and YouTube are the main source of information. Everything that needs clarification and every question that needs answers is available there. The other participant added:

> *"I use technology a lot and I learn to use an app through instructions or videos of the app. To decide to use an app, I tend to look at ratings of the app and if it is free."*

Thereafter, a question followed about having a function to communicate with other stakeholders in the system, which was acceptable by both participants. They were asked about which information on gravel roads they need to get notifications about, and one responded with information about maintenance works on the road or serious functional issues such as potholes. The other said:

"While I use the app, to get navigations of the roads with sound orders just like google maps."

Moreover, the participants were asked which information is important to access on the system. This question included both needed information as well as needed functions. The answers were as follows, which added new points not mentioned previously:

"Having a navigation system, having sensors for detecting animals crossing the street to increase safety. To have services such as ability to call ambulance or police directly from the app which shares location."

"Information about maps – navigation, current road status, time to destination, and to be able to see the current clock. It would be nice to have data about the road owner and responsible maintainers, as well as if there are any animals that cross the road."

Lastly, they were asked if they would use the system while driving along the gravel roads. One agreed because it will give updated information about the road, and the other denied because it is not necessary to use it. It was also mentioned by both participants that there is a need for a function to connect directly to those who can pull cars when they get stuck in the ditches.

4.2 Similarities in answers

This section aims to provide a wider viewer on the relations between the themes and stakeholders with the aid of a clear diagram. *Figure 2* displays the similarities in stakeholders information needs. The dots placed on the horizontal lines of the figure indicates that an exact or a similar answer was provided by the stakeholder, and the vertical lines represent the stakeholder type. The first category of similarities present the analysed information needs, and the second presents the need of sensor data.

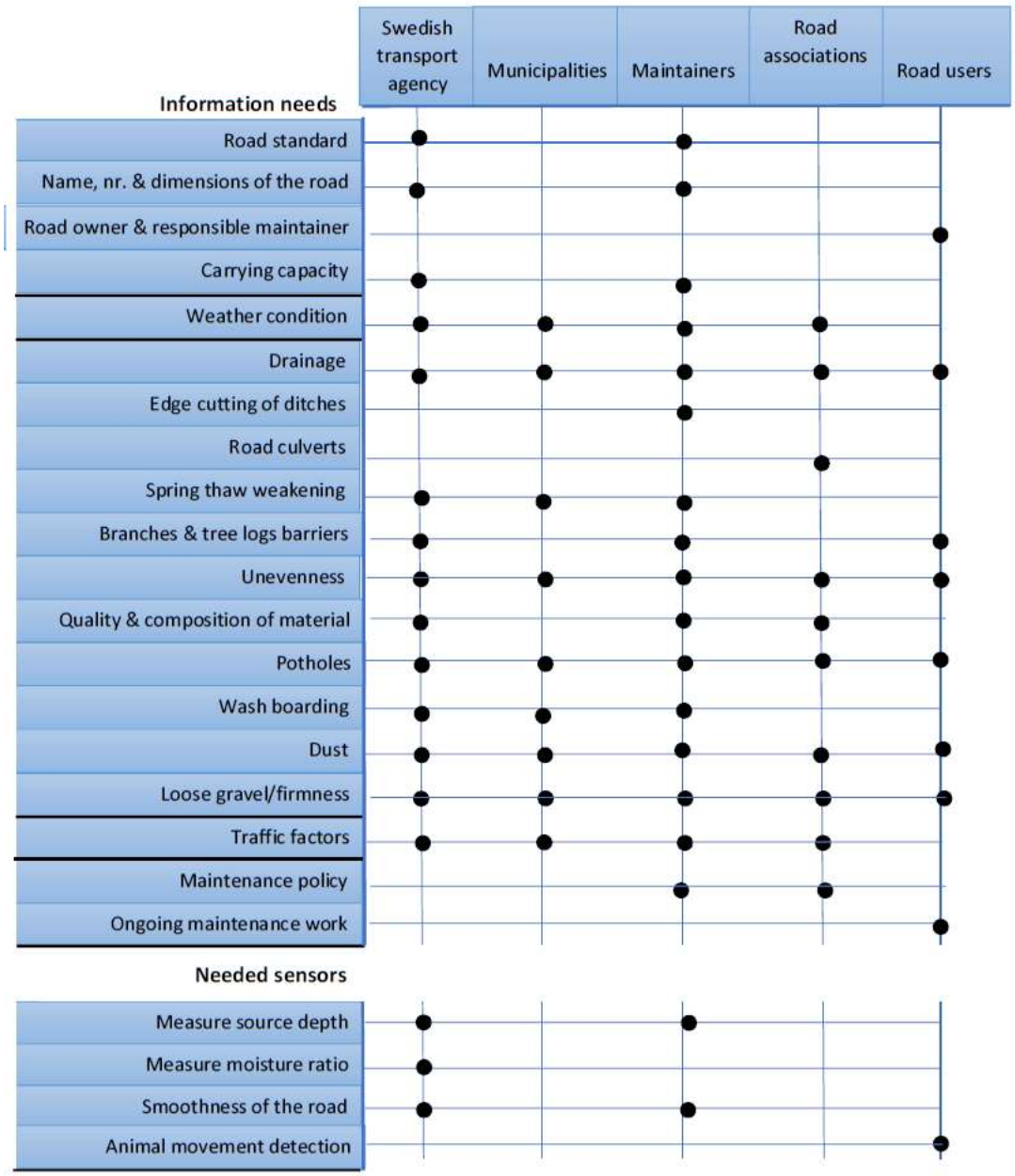

Figure 2: Similarities in interviews' answers

5 Discussion

Chapter five further discusses the findings, presents a new figure of the information needs of gravel roads stakeholders based on the analysed data, and summarises the both explored and pre-defined information needs in a table.

After presenting the empirical findings using the major themes and thereafter presenting the similarities in the collected answers, this chapter aims to further discuss the findings and explain the analysed data. It should be noted that due to the current epidemic 'Covid-19' that affected the world and Sweden, data collection technique has changed as individual interviews with stakeholders is no longer a choice, and thus all interview were mobile-, telephone- or online interviews.

In addition, regarding the factors of the user requirements in IS (presented in *1*), the interviewees lack sufficient information about using a similar system for maintenance. Thus, when asked about their dependency on technology to get information about gravel roads, the majority of answers said they rely on personal inspections and assessments, and less on technology. The questions themselves are relevant for designing an Information system, however, they could be asked later on in the development process step.

Therefore, discussion in this chapter will go through the information needs and simultaneously discuss all the answers from each stakeholder. Thus, the chapter will follow the order of the factors presented in *1*.

5.1 Discussion of findings

Road Identification

Road standard in Sweden are classified into 4 levels, depending on the condition of the road. Based on the collected data, both the Swedish transport agency and maintainers showed a need to know these standards when gravel roads are being maintained. This was mentioned in Alzubaidi (1999) and Kans, Campos and Håkansson (2019). The Swedish transport agency needs this data because it defines the current condition of their road, and thus if these roads need maintenance, they would hire maintainers to enhance the road to a pre-decided level. They also base their assessments of the roads on four parameters: cross fall and road edges; irregularities on the roads; existence of loose aggregate; and dust, as mentioned in Kans, Campos and Håkansson (2019). Therefore, maintainers would need to know the road standard as well.

In addition to road standard, a related information that is needed by the Swedish transport agency and maintainers is data about the road number; road names and dimensions of the road. in addition to information to the current roads status regarding the carrying capacity, as it is affected by factors such as traffic and weather. Also, information about who owns the roads or who is responsible for maintaining the road, which is already known by the all stakeholders except for road users, who were the ones needing such information, in case they want to report a problem on the gravel road.

Weather condition

Weather condition affects directly and indirectly the gravel road condition. It has different effects depending on the season of the year. Weather was mentioned as a factor that affects roads in Saarenketo (2005) and Alzubaidi (1999). It causes accessibility issues in winter to those who drive along the road. In addition, it causes functional issues in the summer that affects stakeholders as well. Information about the weather was needed by the Swedish transport agency; municipalities; maintainers; and road association. It affects the maintenance plan as sometimes a little rain is needed after constructing the roads and sometime knowing if there is a storm coming is important to change the maintenance plan.

The road users did not need such information because they might use a dedicated application for weather status, or they are not regular users of the road. This was evident in one of the answers who said that the gravel road can be avoided, and thus it is not a primary road to use.

Road condition (accessibility/functional issues)

When the participants were asked about the accessibility issues, all responded that avalanches are not a common issue, unlike what Saarenketo (2005) wrote. This is because with the advancement in machines and communication, any snow blockage on the road are removed so that the transportation of the vehicles is not affected. It should be noted that all interviewed stakeholders live in the Southern Sweden where avalanches are rare, unlike Northern Sweden were avalanches could cause an accessibility problem, as said by one participant form the Swedish transport agency. As for the problem of erosion after heavy rain, this was not mentioned by the participants probably because gravel roads do have ditches and thus any soil erosion would not reach the roads in the first place.

When it comes to the drainage of water, all stakeholders consider this as a major problem and need information when it occurs. This was supported by Rashedi, Maher and Barakzai (2018), Saarenketo (2005) and Alzubaidi (1991). The excess water is transferred from the roads to the ditches and then to the culverts. Therefore, information about the road ditches and culverts are important because if they are assessed regularly, they prevent a serious problem. This drainage does not only affect the road surface, but even the sublayers if water leaks into the ground. This could be why it is important to know about any poor drainage, in addition to the condition of the road ditches and culverts. This is also evident in one of the maintainers' answer, who said that they do need to know if edge cutting of the ditches is needed. Also, one participant who represented a road association said that they need to know if road culverts are clean so that water can pass through.

Another issue is spring thaw weakening when water from the snow and ice begins to defrost in the beginning of spring. Spring thaw affects the carrying capacity of the road, as said by one maintainer, which is a term that was repeated many times through the interviews because of its importance. Even one participant from a road association suggested implanting metal in the road body to increase the carrying capacity. In addition, spring thaw causes a problem when forests are moved by heavy traffics through gravel roads, as said by one participant from the Swedish transport agency. Also, because of having forests near these roads, some branches and tree logs ends up on the roads. These branches and logs damage maintainers trucks and also hinder the passage of road users on the road.

Moving on to the functional issues, and beginning with unevenness, this is an issue that is faced by all stakeholders. These appear in summertime because of the damage of heavy rain in winter. Usually they are either detected with eyesight or using sensors. Both of the maintainers and one from the Swedish transport agency said that the cause of the unevenness is due to the quality of the gravel material and the composition of the material. The gravel material on the surface of the road is referred to as wearing course. These are also the causes of the potholes on the road surfaces. Participants used other words such as pits and grooves in addition to potholes, which are considered functional issues on gravel roads. Potholes are considered issues that occur to all stakeholders as they affect the usage and maintenance of the roads.

Moving forward to the issue of wash boarding, which is when the weather is dry and the particles move to form patterns on the roads in the shape of a wash board, or, as said by one maintainer, close-knit pattern or irregular pattern. This issue is caused by the quality and composition of the wearing course. That is why information about the road material are important for maintenance purposes. Alzubaidi (1991) mentioned wash boarding issues with the word 'corrugation', and Saarenketo (2005) mentioned the issue as one that occurs in summertime. It is as said by one from road association that maintainers build up to 30cm wearing course in the road body, which could be to support the road. A similar effect on the road occurs when particles turn into dust in the air because of strong air or traffic speed. Knowing about dust is also important because it is a problem that occurs in dry weather, and that needs dust prevention.

The last functional issue is road firmness. It can be said that the term 'road firmness' itself was not directly mentioned but other effects that reflects the firmness status of the road were mentioned such as loose gravel. Information on loose gravel is needed by the Swedish transport agency when assessing the roads. Loose gravel depends on the composition of the wearing course, which is why the high speed of vehicles cause gravel to become loose, as said by one participant from a municipality.

Traffic factors

As explained previously in chapter 2, traffic factors relate to vehicle's speed and to traffic's composition and volume. Regarding the findings, the Swedish transport agency, municipalities, maintainers and road associations do need information about these factors. The Swedish transport agency mainly mentioned how heavy vehicles tend to destroy gravel roads. These heavy vehicles such as trucks and lorries increase in number the more forest are nearby, because they tend to carry wood to factories, as mentioned by one maintainer. In addition, traffic volume was mentioned by most stakeholders as being a factor that affects the road condition. If a gravel road gets more traffic volume than its capability, then it tends to get paved with asphalt to increase the carrying capacity. According to Saarenketo (2005); Alzubaidi (1991); and Rashedi, Maher and Barakzai (2018), information about traffic factors are needed for road maintenance.

Maintenance policy

The maintenance policy relates to the maintenance plan that is followed to maintain roads. It includes for example, which roads to maintain; how much material to use; how many times a year. All these are considered information that are needed for the maintenance of gravel roads as mentioned by maintainers and road associations. Rashedi, Maher and Barakzai (2018) wrote this as information required for capturing the condition of gravel roads. One maintainer said it

is vital to have a plan as a road consists of many layers and much work is needed, thus a plan would save time and resources. Also, municipalities have plans for maintenance.

Other needed information

Based on the analysed data regarding stakeholders dependency on technology, some stakeholders proposed having sensors to collect information about different variables on the roads, such as sensors to measure source depth of the gravel road. This is beneficial when maintaining the roads because the depth gives information about the surface and sublayer when digging; to check if the wearing course is sufficient; and when constructing the ditches. Another sensor needed is one that measure moisture ratio in the road body because when paving and sanding the roads, maintainers benefit from the natural moist in the road body. In addition, sensors that measure smoothness of the road, as mentioned earlier, seems to be interesting to get information about the current status of the roads. Finally, sensors that detect animal movements were also mentioned as being beneficial when using the gravel roads.

Intention to use the future information system

Most of the participants showed interest and willingness to use the system and others did not. Those who might use it when it is developed said that it will help road owners, farmers, users and others to report problems faster on the system. Another advantage was that the system can save costs of buying extra materials, and will save time as shared information about the gravel roads conditions will decrease the time needed to inspect the large number of roads in Sweden; only those that need maintenance would be inspected and maintained effectively.

A final note is that the Swedish transport agency and the maintainers need more information regarding the maintenance of gravel roads than the other stakeholders, as *Figure 2* clearly displayed. They are the most interested in road identification data. Also, as it is shown in the figure, information about the weather; road condition; and traffic are needed by almost all stakeholders, whereas information about maintenance policy are needed by maintainers and road associations given the fact that they engage in the maintenance process of the roads. Clearly, road users showed interest in information about the functional problems because they mostly are visible on the surface area of the roads, unlike the accessibility issues such as spring thaw because these are most interesting to the road experts; the other stakeholders.

5.2 Explored information needs of gravel roads stakeholders

After reviewing, analysing and discussing the findings of this study, the factors that are important for gravel road stakeholders (presented in *1*) were tested through template analysis. Some factors do still apply to this research's sample group, and some were modified or rejected. In addition, other new findings that adds to the literature review were noted and presented in *Figure 3*. These findings present new explored information needs that were not mentioned previously in the literature review.

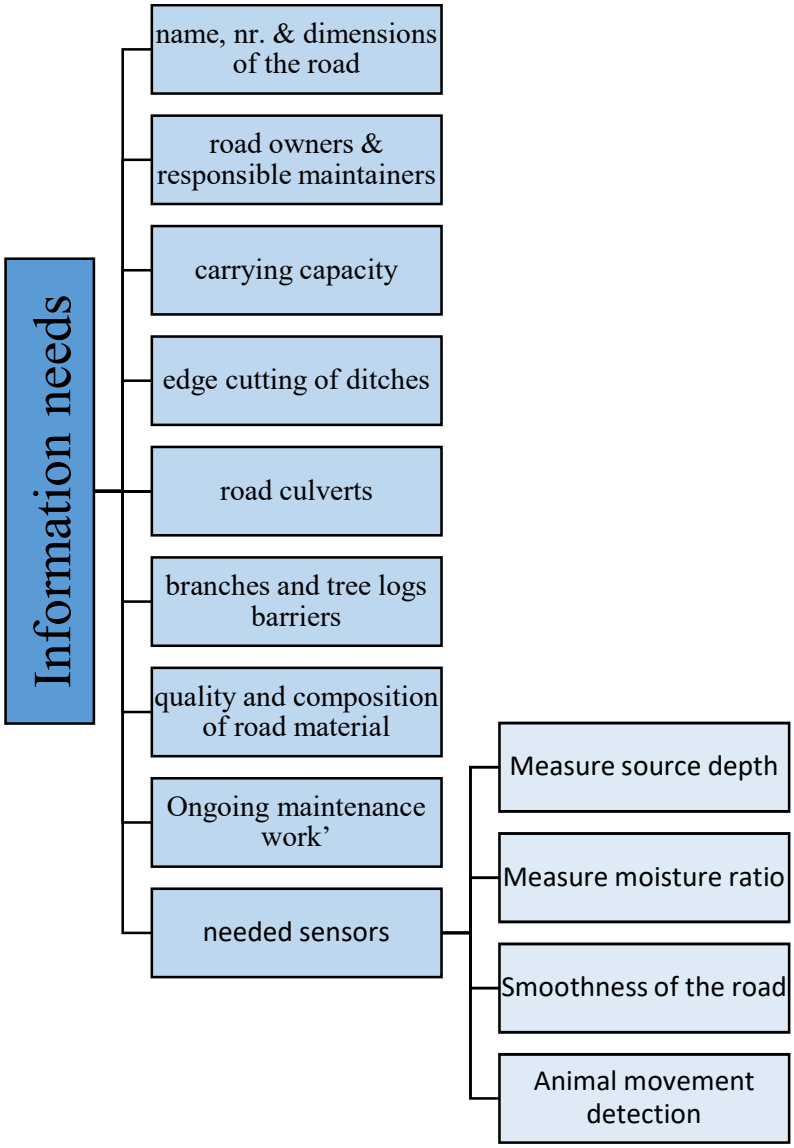

Figure 3: New Information needs of gravel road stakeholders not mentioned in the literature review.

5.3 Summary of explored and pre-defined information needs

After reviewing the literature and performing this research, the new findings with the pre-mentioned information needs, that apply to this research's sample group, were combined and presented in a modified version of *1*. The aim is to ease the presentation of data and to summarise all information needs that were concluded in this thesis. This is presented in *3*.

To explain what was justified in table 1: the first part 'Road maintenance related factors', the title road standard became a subtitle under 'Road identification', which includes another three subtitles: name, nr. & dimensions of the road, road owners & responsible maintainers, and carrying capacity. These new subtitles were added because more data about the road identification was needed by stakeholders, other than road standard. As for the second title weather conditions, it appeared that they are still a key information when it comes to maintaining gravel roads.

The third title 'Road condition' included accessibility issues and functional issues as subtitles. In the modified table, the accessibility issues did not include avalanches and erosion as issue as these were not considered issue to stakeholders. However, the issue of drainage is included, in addition to two other accessibility issues that are the edge cutting of ditches and road culverts. Spring thaw weakening was also included in the modified table, and branches and tree logs barriers on the road were added.

As for the functional issues, unevenness of the road was included in the modified table, and quality and composition of road material were added. Potholes, wash boarding effect, dusting and road firmness still exist in the modified table. A modification was that after analysing, road firmness, it was noted that loose gravel refer mostly to the firmness of the roads, and thus the two terms were combined in one. The fourth title ' Traffic factors' was included in the modified table in addition to the title ' Maintenance policy'. However, a new title 'Ongoing maintenance work' was added because this information was also needed by a stakeholder.

A fifth title was newly added which was 'Needed sensors' that included the information that were needed by stakeholders if sensors are set on the roads. Such information were about source depth; moisture ratio; smoothness of the road; and animal movement detection. As for the second part of the figure 'User requirement in IS', it was removed because not enough data was collected regarding this part, as mentioned in the beginning of chapter 5.

Table 3: List of new explored and previously defined Information needs of gravel roads stakeholders

Road maintenance related factors	
• Road identification	❖ Road standard
	❖ name, nr. & dimensions of the road
	❖ road owners & responsible maintainers
	❖ Carrying capacity
• Weather conditions	
• Road condition	➢ Accessibility issues:, weak drainage, edge cutting of ditches and road culverts, spring thaw weakening, branches and tree logs barriers
	➢ Functional issues: unevenness, quality and composition of road material, potholes, wash boarding effect, dusting, loose gravel/road firmness
• Traffic factors	✓ Traffic volume and composition
	✓ Vehicle speed
• Maintenance policy	
• Ongoing maintenance work	
• Needed sensors	➢ Source depth
	➢ Moisture ratio
	➢ Smoothness of the road
	➢ Animal movement detection

6 Conclusion

Chapter six concludes the whole research paper. It included a summary of the key findings; a summary of the research problem and the methodological approach; the contributions to current literature; and some suggestion of future research.

6.1 Conclusion

This research paper aimed to explore the information needs of gravel roads stakeholders. This area of concern lacks sufficient prior studies and supports an ongoing project that intends to design a cloud-based IS for enhancing maintenance of gravel roads in Sweden. The design of this research paper was an exploratory case study, which served to fulfil the intended aim of the project. The main research question and a sub-question was '*What is the particular information that the users of cloud-based information systems need?',* and *'What are the information needs of gravel roads stakeholders in Sweden?'*. Interviews were conducted to collect data of these information needs. Some of the key findings in this study either supported, neglected or added new variables to previous studies.

The key findings suggests that stakeholders need information about road identification including road standard; name, number and dimensions of the road; road owner and responsible maintainer; carrying capacity and weather condition Also, information needs regarding road condition issues that are categorized either as accessibility issues or functional issues. Other needed information are of traffic factors and information on maintenance policy and ongoing maintenance work. In addition, some sensors were suggested by stakeholders to be included in the future information system. Lastly, when stakeholders were asked about their need of the future cloud-based system, the majority of the stakeholders showed interest for using such a system and even refered to some possible benefits of using the system.

Thus, as a conclusion to the whole research, the future cloud-based information system in the ongoing project that this thesis is part of, is considered a useful system for sharing vital information among future gravel road stakeholders. The thesis also added new information needs based on the recently collected data, which increased the knowledge in this area of concern. Referring back to the chapter 1, the reasons why information needs are not met were not consulting stakeholder; ignoring the users perspectives; poor communication; or computerisation costs, these can be avoided with the future cloud-based system as it exclusively concerns the needs of users.

As for the societal challenges, that were mentioned in chapter 1, such as the need to improve production efficiency; to enhance the delivery of goods and services; to empower citizens, the future cloud-based system could serve to support these needs in the society. Hence, sharing information regarding gravel roads maintenance affects the production of road materials for example, enhances the condition of the roads for heavy transport that delivers goods, and increase citizens or stakeholders knowledge regarding these roads. This cloud-based information system add benefits to the society.

6.2 Contribution

Given the fact that this research paper is a case study of the information needs of gravel road stakeholders in Sweden, the designed figures and tables of the similarities in information needs (*Figure 2*) and the concluded information needs (*Table 3*) can be considered as a reference. These can be used in the process of designing the part of the cloud-based system that concerns the information needs of users. Also, several new information needs of gravel road stakeholders (*Figure 3*) were concluded which adds to the literature review.

6.3 Future Research

As a suggestion for future research, it is interesting to investigate the information needs of gravel roads in other cities and countries, with the help of a picture of a prototype of the system that an interviewer asks about. This prototype could be shared with the interviewees before performing interviews. This could help interviewees formulate their answers based on what their requirements are. Another point that could be used in future research is using a second data collection technique besides interviews, for example surveys, to explore even more information needs that comes to the interviewees mind in their leisure time.

6.4 Acknowledgement

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Appendices

Appendix A: Informed consent letter

Hej (name of participant)!

Jag heter Nada Abbas. Jag är en mastersstudent vid Linnéuniversitetet i Växjö. Jag håller på att skriva en avhandling om informationsbehov för intressenter för grusvägar, som är en del av ett pågående projekt som kallas Hållbart underhåll av grusväg, som leds av docent Mirka Kans. Projektet syftar till att bygga ett molnbaserat informationssystem som underlättar underhåll av grusvägar och därmed tjänar alla inblandade intressenter.

Jag kontaktar dig för att bjuda in dig att delta i den här studien via en telefon- eller videosamtal intervju. Jag ställer några öppna frågor kring de tidigare nämnda projekten. Intervjun kommer att ta ungefär en halvtimme. Jag hoppas verkligen att du har lite tid till intervjun eftersom din information kommer att vara värdefull för mitt papper och för projektet.

I fall du får ha intervjun på engelska går det jättebra, annars på svenska. Ingen personlig information kommer att nämnas för att garantera din konfidentialitet. Och om du behöver verifiera min identitet kommer jag att hänvisa till projektledarens kontaktinformation:

Namn: Mirka Kans

E-post: ……

Telefonnummer: xxx xxxxxxx

Svara på detta e-postmeddelande för att bekräfta eller förneka ditt deltagande. Om du har några frågor är det här min kontaktinformation:

Mobilnummer: xxx xxxxxxx

E-post: na222ny@student.lnu.se

Vänliga hälsningar,

Nada Abbas

……

Linnæus University
Sweden

Faculty of Technology
SE-391 82 Kalmar | SE-351 95 Växjö
Phone +46 (0)772-28 80 00
teknik@lnu.se
Lnu.se/fakulteten-for-teknik

Hello (name of participant),

My name is Nada Abbas. I am a masters student at Linnaeus University in Växjö. I am doing a thesis paper on information needs of gravel roads stakeholders, which is part of an ongoing project called Sustainable maintenance of gravel road, that is led by associate professor Mirka Kans. The project aims to build a cloud-based information system to assist the maintenance of gravel roads and thus serves all involved stakeholders.

I am contacting you to invite you to participate in this study, through a telephone or online interview. I will ask some open-ended questions related to the projects mentioned earlier. The interview will take approximately half an hour. I sincerely hope you have some time for the interview as your information will be valuable for my paper and for the project.

Its preferable to have the interview in English, however in case you prefer to have it in Swedish, that is also possible. No personal information will be mentioned, to guarantee your confidentiality. And, in case you needed to verify my identity, I will reference the project leader's contact information.

Name: Mirka Kans

Email: ……..

Telephone nr.: xxx xxxxxxx

Please reply to this email to confirm or deny your participation. Also, if you have any questions, these are my contact information:

Mobile nr.: xxx xxxxxxx

Email: na222ny@student.lnu.se

Best regards,

Nada Abbas

Appendix B: List of possible interview questions

What kind of information you need to have to maintain a gravel road?
What is your opinion about the quality of the road in winter? in summer?
Is it important for you to know about upcoming weather status? And why?
How likely is it for accessibility issues to occur such as: having avalanches that block the road, erosion after heavy rain, drainage of water, spring thaw weakening?
How likely is it for functional issues to occur, such as: unevenness, potholes, wash boarding, dusting and road firmness?
What is your opinion about the current traffic safety? Why?
How are gravel roads affected by traffic factors (vehicle's type and speed, traffic volume)?
Can you tell me shortly about the maintenance policy of gravel roads?
When was the last time the gravel road was maintained and what kind of maintenance was done?
Can you tell me shortly about your/the departments dependency on technology to get needed information?
How do you communicate with other road users, owners, maintainers, authorities?
What is your opinion about including a function in the cloud system to be able to communicate with other stakeholders?
In the cloud application, and regarding the previous gravel road questions, which information you need to get notifications about?
Is it important to get real-time (updated) information while using the app?
What do you think of such future system?
Will you use such a system?
Are you willing to pay for the system or the provided support?
Would you like to add something more that I might have missed?

Appendix C: Final template of themes

1. Fixed gravel roads-related information
    - 1.1. Road identification
        - 1.1.1. Permanent road identification information
            - 1.1.1.1. Road standard
            - 1.1.1.2. Name, number and dimensions of the road
            - 1.1.1.3. Road owner/s and responsible maintainers
        - 1.1.2. Variable road identification information
            - 1.1.2.1. Carrying capacity of the road
2. General opinions about the effect of weather on gravel roads
    - 2.1. Quality of roads during different seasons
        - 2.1.1. Acceptable
        - 2.1.2. Needs lots of maintenance
    - 2.2. Importance to know about upcoming weather status
        - 2.2.1. Affects maintenance work
        - 2.2.2. For better planning
        - 2.2.3. Not important
3. The different effects of weather on gravel roads conditions
    - 3.1. Accessibility issues
        - 3.1.1. Weak drainage of water
        - 3.1.2. Edge cutting of ditches and road culverts
        - 3.1.3. Spring thaw weakening
        - 3.1.4. Branches and tree logs barriers on roads
    - 3.2. Functional issues
        - 3.2.1. Unevenness
        - 3.2.2. Quality and composition of road material
        - 3.2.3. Potholes
        - 3.2.4. Wash boarding effect
        - 3.2.5. Dusting
        - 3.2.6. loose gravel/road firmness
4. On road traffic factors affecting gravel roads structure
    - 4.1. Traffic factors
        - 4.1.1. Traffic volume and composition
        - 4.1.2. Vehicles speed

Linnæus University
Sweden

Faculty of Technology
SE-391 82 Kalmar | SE-351 95 Växjö
Phone +46 (0)772-28 80 00
teknik@lnu.se
Lnu.se/fakulteten-for-teknik

5. Information about gravel roads maintenance
    5.1. Applied maintenance policy or plan on roads
    5.2. Ongoing maintenance work
6. Dependency on technology
    6.1. Technological tools and devices used
    6.2. Needed sensors in the future system
        6.2.1. Source depth
        6.2.2. Moisture ratio
        6.2.3. Smoothness of the road
        6.2.4. Animal movement detection
    6.3. Opinions about the future system