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AGILE DEVELOPMENT IN E-GOVERNANCE SERVICES: A CASE STUDY OF THE ESTONIAN RIVER ENVIRONMENTAL FLOWS EVALUATION SYSTEM

Master's thesis

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Tallinn 2021

TALLINNA TEHNIKAÜLIKOOL
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AGIILNE ARENDUS E-RIIGIS EESTI JÕGEDE KESKKONNAVOOLUHULGA HINDAMISE SÜSTEEMI NÄITEL

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Tallinn 2021

Author’s declaration of originality

I hereby certify that I am the sole author of this thesis. All the used materials, references to the literature and the work of others have been referred to. This thesis has not been presented for examination anywhere else.

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10.05.2021

Abstract

Continuous technological growth in the provision of services in government institutions requires efficient methods for rapid adaptation of public sector services to innovative solutions. Adopting the agile approach to developing information systems in e-governance services can significantly strengthen public service delivery. Although public organisations are striving to raise agility by using agile methods, there is limited research focusing on the initial prerequisites for public organisations to adopt the agile approach.

The objective of the thesis project is to develop a web application for an e-governance service for the evaluation of environmental flows of Estonian rivers to issue permits for the special use of water. This is done using a case study applying the design science research methodology reinforced with the agile approach for an iterative and constant improvement process supported for customer engagement. Agile development practices are used to ensure the appropriate and correct web application design that fulfils the end-users needs and provides customer value.

This thesis is written in English and is 61 pages long, including 7 chapters, 12 figures and 4 tables.

List of abbreviations and terms

ICT	Information and Communication Technologies
IT	Information Technology
Eflows	Environmental (or ecological) flows
MVP	Minimum Viable Product
DSRM	Design Science Research Methodology
ASD	Agile Software Development
APM	Agile Project Management
UX	User Experience
UI	User Interface

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1 Introduction

1.1 Research Overview

Technology is continuously evolving. As it matures, the provision of technology solutions must be prepared to offer adaptation to the new advances and organisational demands. The use of information and communication technologies (ICT) has spread widely in government digital services that benefit citizens, companies and public institutions to provide public services more efficiently, quickly and at a lower cost [1][2]. eGovernment not only empowers ICT tools but also requires responsive governance that boosts flexibility to adapt new actions and foster innovation that allow public services to be delivered efficiently [3].

Rapid technological changes highlight the importance to employ methods that can quickly adapt public sector services to innovative solutions. In addition, governments need to adjust to public interests in their internal and external environments [4]. As a response, government institutions have been adopting an agile approach to design responsive Information Technology (IT) solutions leaving traditional approaches behind [5][6][7].

The traditional way of developing projects or so-called waterfall methodology focuses on a step-by-step approach and a strictly defined plan and requirements in such a way that a new project stage must wait for the end of the previous stage, avoiding completely going back to previous phases. This leads to limited opportunity to make changes if the developed project does not meet the expected results [8][9]. Agile development, in contrast, recognizes the uncertainty of developing innovative solutions and leaves room to respond to changes even late in development. If stakeholders find that a different approach produces better outcomes for particular problems, they are able to test from an early stage and have the flexibility to request for changes [10][11][12][13][14].

Agile approach has been used for the past two decades, mainly by software development teams in the private sector [5][11]. Agile development uses short but regular cycles that

deliver value to the customer in order to allow them to provide feedback to adapt and adjust the project according to their needs. Thus, Agile allows more flexible processes that maximise the time spent on directly adding value to the tasks or increments through close cooperation with the stakeholders and constant improvement by reviewing the results at the end of each iteration [12][13][14]. Agile practices have transformed the way software is developed, emphasising active user involvement, tolerance to change, and evolutionary delivery of products. Agile development is focused on the continuous delivery of working solutions with enough value to receive feedback for further development [12] [15][16]. Despite the success of agile practices in the private sector, there is little evidence on the initial pre-requisites for public organisations to adopt agile approaches [5][17].

Currently, governments are undergoing significant changes in terms of information technology as well as being hampered by legacy issues and bureaucratic procedural changes, causing them to have outdated systems that do not allow them to provide more satisfactory public services. Governments must adapt quickly and learn to easily incorporate innovative changes to their current procedures that benefit in the digital service delivery [1][5][6][7]. Although governments strive to be more responsive in terms of providing quality services by starting to use agile methods, there is limited research that addresses the initial pre-requisites on implementing agile approach to assist in the service delivery of the public sector, the conditions in which government agencies can become agile, and how agile methods should match the needs and regulations of bureaucracies [1][5][6][17].

1.2 Research Motivation

In an effort to adapt, improve and innovate public services, government organisations have adopted IT solutions. Even though they perform holistic endeavours to design quality digital services embracing agility, they stand in need of a critical strategy for how information technology solutions for public sector services should be developed. Expecting that agile development can assist in adapting public services to customer and organisation demands, the author's first motivation is to discover how e-government agencies can adopt agile methods to develop IT solutions for common necessities in the provision of public services.

Another personal motivating aspect is the author's enthusiasm for the agile approach to recognise and understand customer needs to produce better results. The author strongly believes that encouraging innovation requires a deep understanding of the business problem rather than proposing brilliant novelty ideas that might not satisfy audiences interests. Therefore, the author's motivation is to think of people ahead of innovative products, and thus innovation will occur with it.

In addition, the author believes that the development of digital services should include the end-users participation in order to develop usable software solutions that address customer needs. For these reasons, the author is motivated to comprehend how the agile approach could be applied in developing systems for public sector services and the pre-conditions to achieve its successful implementation.

1.3 Research Questions and Objectives

As mentioned earlier, governments strive to be more responsive in terms of providing quality services. Governments attempt to boost agility in their development processes; however, there is limited research that addresses the initial efforts on implementing agile development in public sector services. To address this gap and investigate agile development in public sector services further, the following research questions (RQ) were drafted:

RQ1: How to apply agile development in e-Governance services to raise adaptability in the public sector service delivery?

The response to this question intends to identify what aspects should be considered to adopt the agile approach in developing information systems for e-governance services. Additionally, the answer to this question aims to gain in-depth insight into the possible initial prerequisites for employing an agile approach in public organisations. In order to do so, the following additional research question was considered:

RQ2. What are the initial pre-requisites to employ the agile approach in developing software for e-governance services?

This sub-question aims to identify the necessary initial aspects that public sector institutions should consider to collaborate on agile methods to develop software

applications that fit the organisation's internal users and assist in the delivery of quality e-governance services.

In order to answer these questions, this thesis project aims to develop an information system for an e-governance service for a case study for the evaluation of environmental flows of Estonian rivers for the issuance of permits for the special use of water.

Based on the scope of this research, a case study was conducted adopting agile approach and Design Science Research Methodology (DSRM) methodology.

1.4 Thesis Outline

This thesis consists of seven chapters:

Chapter 2 discusses the theoretical framework of the essence of agile development and its latest practices in software and management and public sector services. Then, it describes the literature overview of previous research in the field of agile development in e-governance services.

Chapter 3 explores the Estonian Environmental Flow Evaluation Service case study and describes its background, identified problem and possible solution.

Chapter 4 describes the chosen methodology for this research and provide a detailed plan of the application of the methods to perform this study. Furthermore, it describes the process of the data collection for the case study and its limitations.

Chapter 5 provides the research results of employing the agile approach in the case study and how the results were obtained.

Chapter 6 discusses the results of this research considering the agile development theory and practical research in the public sector organisation.

Chapter 7 present the conclusion of the thesis that responds to the research questions, and describe future research.

2 Theoretical Framework

2.1 Agile Development

Agile development has been widely adopted in the IT industry; however, over time, this concept has spread to the non-technical area with a more hands-on approach [5] [11]. Agile approach was originated from the agile manifesto with the intent to provide a better alternative to documentation-driven software development. Agile manifesto was described in 2001 for 17 software practitioners that were trying to find agility and adaptability developing software [10]. The manifesto identifies a set of fundamental values and principles that provide guidance on how to deal with uncertainty, quickly respond to change in the most efficient and simplest way and help others do so. Hence, the authors of the agile Manifesto chose "agile" as the word to represent the adaptability and response to change that this whole idea embodies [10] [20]. The values of the agile manifesto are expressed in table 1.

Table 1. Agile Manifesto's values [10]

Individuals and interactions	over processes and tools
Working software	over comprehensive documentation
Customer collaboration	over contract negotiation
Responding to change	over following a plan

That is, while there is value in the items on the right, there is more value in the items on the left. The following table illustrates the principles of the Agile Manifesto (Table 2).

Table 2. Agile Manifesto's principles [10]

Our highest priority is to satisfy the customer through early and continuous delivery of valuable software.
Welcome changing requirements, even late in development. Agile processes harness change for the customer's competitive advantage.
Deliver working software frequently, from a couple of weeks to a couple of months, with a preference to the shorter timescale.
Business people and developers must work together daily throughout the project.
Build projects around motivated individuals. Give them the environment and support they need, and trust them to get the job done.
The most efficient and effective method of conveying information to and within a development team is face-to-face conversation.
Working software is the primary measure of progress.
Agile processes promote sustainable development. The sponsors, developers, and users should be able to maintain a constant pace indefinitely.
Continuous attention to technical excellence and good design enhances agility.
Simplicity--the art of maximizing the amount of work not done--is essential.
The best architectures, requirements, and designs emerge from self-organizing teams.
At regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behavior accordingly.

Agile approach is often is misunderstood for methodology, process, or framework. However, Agile is none of above [10] [13] [20]. As the agile approach became popular and transformed the way people work in a variety of industries, it also revolutionized the way of thinking. Ultimately, agile is a mindset based on responding and adapting to change, guided by the principles and values of the agile manifesto. The agile mindset

aims to face uncertainty by discovering and learning in the most efficient way possible, harnessing change to gain a competitive advantage and following the manifesto's values and principles [20] [21]. In 2010, the thought-leader in the agile approach, Ahmed Sidky illustrated this "agile mindset" concept, which represents the agile mindset as baseline ruled by the values and principles of the Agile Manifesto and unlimited agile practices [20] [21] [22]. The following figure shows the "agile mindset" approach.

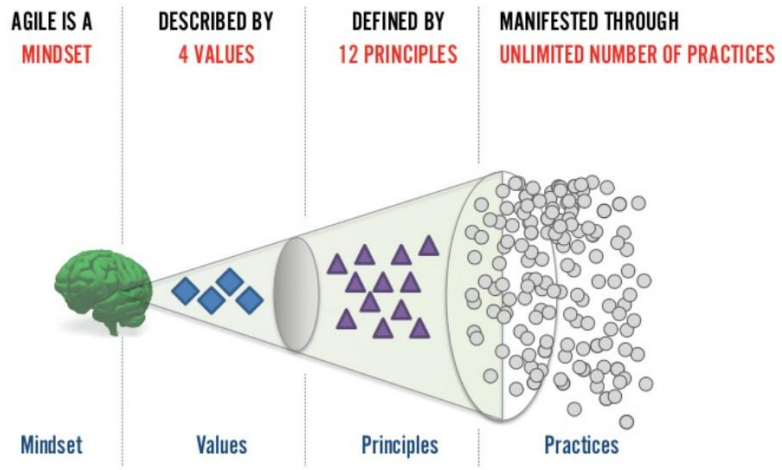

Figure 1. Agile mindset defined by Ahmed Sidky [22]

Agile mindset encompasses practices that support team collaboration and help obtain the best possible outcome from a project [21] [23]. These practices derivate from a variety of agile methods such as Scrum, Extreme programming, Lean, etc. [24]. Agile practices are one stage below agile methods because they act as a small activity of an agile method that addresses different aspects within a project [25]. Although agile methods are at a higher level [15] [25], the agile mindset encourages the use of agile practices rather than methods since agile methods focus on providing a complete structure of processes and rules that must be strictly followed [25]. On the other hand, agile practices can be implemented and adapted depending on the kind of environment or domain. Organisations can therefore adopt these practices by just using parts of the existing agile methods that better fit their needs, or even use their own practises that drives agility in their processes as the agile approach implies [15] [21] [23] [33].

2.1.1 Software Development

Agile software development (ASD) has been considerably employed by hundreds of software companies in an effort to reduce costs and develop software faster [16]. However, while ASD's primary goal is not rapidly to build software or cutting expenditures, these are some of its benefits [12] [16]. ASD aims to fulfil a need to develop software in an environment of rapidly changing requirements and help to reduce uncertainty on the development of a software project by delivering and testing working software through short iterations and customer collaboration [12] [13] [14]. One aspect that characterizes ASD is its special concern on the people doing their work and the way they work together [26]. It focuses on evolving solutions through close collaboration between self-organizing cross-functional teams in which the customer plays an important role. ASD has revolutionized the approach on how software is developed, emphasising active stakeholders' involvement, tolerance to change, and progressive delivery of software solutions [12] [13] [14] [16]. Unlike traditional approaches, ASD adapts to situations in which the product specifications can change frequently or the solution to be built is highly complex, which represents tremendous uncertainty about how the final product should be manifested. On the other hand, traditional approaches known as waterfall methodology for software development assumed that the full set of requirements for developing a software product could be obtained early, thereby reducing costs by eradicating changes [9]. However, eliminating changes lead to an unresponsive adaptation of business conditions that cause business failures. ASD acknowledge that changes cannot be eliminated, and the best strategy to deal with uncertainty is responding to them [16].

Agile software development act as an umbrella term for a set of methods based on the principles and values expressed in the Agile Manifesto [20]. Agile methods are widely adopted by organisations from the software industry. The market demands innovative and high-quality solutions that rapidly meet its needs. Consequently, agile methods serve as a response to this interest [16]. Scrum, Extreme Programming, Lean and Kanban are a few of the urged agile methods which keep the similar fundamental concept of the agile manifesto but differ in characteristics of practices, processes and techniques. Accordingly, organisations can adopt the method that better adapt depending on their business area, organisational structure or work scheme. Although the characteristics of the methods adopted by organisations vary depending on the type of industry and

organisation culture, there is no rule to handle a specific method to employ agile approach [15] [25].

Most organisations that adopt agile methods tend to adopt only some parts of them due to the complexity of the intent to match their processes with the processes and rules of the agile method. Generally, they omit elements of the original method and use only the agile practices that are best suited to their environment. At present, there is a large number of agile practices from the various areas of concern that serve as a guide to developing software in an optimal approach. Some of the most commonly used practices in the software industry are continuous integration, the definition of done, code review, retrospective, daily stand-up, planning meeting, etc. However, the authors of the Agile Manifesto acknowledge that the most important factor is not the best practices for developing agile software, but rather the people who participate in the project are the ones who lead to the success of the project [13] [14] [15] [26].

Agile software development is not considered a defined process as it encompasses regular changes during the product development cycle. Due to a changing environment in which there is staff turnover, evolving technology and changing requirements, it is unlikely that a set of prescribed steps will produce the desired results [12] [13]. In a software engineering context, empirical processes require short cycles for inspection and adaptation through frequent feedback loops that lead to better handle uncertainty on the demands of innovation [12].

2.1.2 Project Management

Building innovative solutions requires an adequate approach to management [16] [28]. However, current management methods still drive rigidity in the project's implementation. The most popular management approach is traditional project management, in which projects are developed on a plan-based approach in a linear cycle. Projects follow a fixed sequence, and requirements are meticulously defined prior to implementation [8] [9]. Although for projects with clearly defined results, processes and requirements, this established methodology is usually appropriate, for innovative or complex products, this can derivate in the project being a waste of resources in terms of time and money, and even more critical it can result in developing a product that does not meet customer needs [27]. The reason behind this prevails in handling uncertainty. In developing an innovative custom product, it is almost impossible to predict the exact

specifications of the entire project and the results they will bring in the end, not only because of a possible miscommunication or different understanding that may exist within the work team or the client but also because the project needs can change over time. One of the biggest risks of developing products is developing the wrong product. Building the correct product depends not only on its development but also on project management [26] [27] [28]. While the traditional approach attempts to reduce uncertainty by confirming product characteristics through detailed documentation, agile project management (APM) reduces uncertainty by discovering and learning through regular customer feedback. APM is an iterative approach to managing development projects that focuses on continuous releases and incorporating customer feedback with every iteration. Regardless of how well planned a product development is, APM recognizes the uncertainty of the future in a changing environment. Whereas in the traditional approach, managers focus on following a plan with minimal changes, APM focuses on successfully adapting to incoming changes through practices that help collaborate and organize work in a way that responds to change and deal with uncertainty [26] [27] [28]. Furthermore, similar to ASD, this agile management approach is based on an agile manifesto. APM adopts practices that drive the project to plan, manage and control. APM adopt practices that drive the project to plan, management and control. Some of the most common agile practices for management are user stories, prioritisation and estimation of work, user personas, planning meeting, etc. [15]. Agile management practices support efficient project management and encourage teams of developers and business people to work together to produce desired results [10] [27].

2.2 Public Service Design

The definition of services has been tried to homogenize during numerous past efforts; it is apparent that there is no single description of the concept of “service”. Its definition can vary depending on the context in which a service is utilized. Despite the discrepancy of a single service definition, the common terms used in the literature to describe services are “activities” or “processes”. Therefore, a service can be defined as the collection of processes for the benefit of an entity whose purpose is to provide value to the business [45] [46].

In the intent for differentiating products from services, the literature suggests that the characteristics of services are intangibility, inseparability, heterogeneity and perishability. Therefore, stipulating that the provision of services does not constitute the provision of goods [48]. However, a different service perspective was introduced in the literature as a service-dominant logic reflects the provision of value to an entity involving the service users to contribute to the service's co-creation. Literature suggests that adopting a service-dominant approach to the provision of public services is essential for designing public services that provide value to stakeholders [47].

Service design helps organizations innovate or improve services by primarily considering the customer needs and balancing them with the business needs. Service design aims to create valuable and desirable services for customers through collaborative methods that include customers and service delivery teams. The evolution of service design has brought six principles that need to be considered when designing a service [49]:

1. Human-centred: Consider the experience of all the people affected by the service.
2. Collaborative: Stakeholders of various backgrounds and functions should be actively engaged in the service design process.
3. Iterative: Service design is an exploratory, adaptative and experimental approach, iterating toward implementation.
4. Sequential: The service should be visualized and orchestrated as a sequence of interrelated actions.
5. Real: Needs should be researched in reality, ideas prototyped in reality, and intangible values evidenced as physical or digital reality.
6. Holistic: Services should sustainably address the needs of all stakeholders through the entire service and across the business.

The service design process involves different activities depending on the method used for developing a service. There is no specific method that needs to be adopted to design a service, regardless of which activities are related to the development of the service; all these activities embrace the same principles above mentioned as well as focusing on understanding users' needs [49]. These activities can be seen in the double diamond

model, one of the most popular service design processes; these activities consist of discovering, defining, developing and delivering. The following figure (Figure 2) illustrates the phases of the Double Diamond model [50].

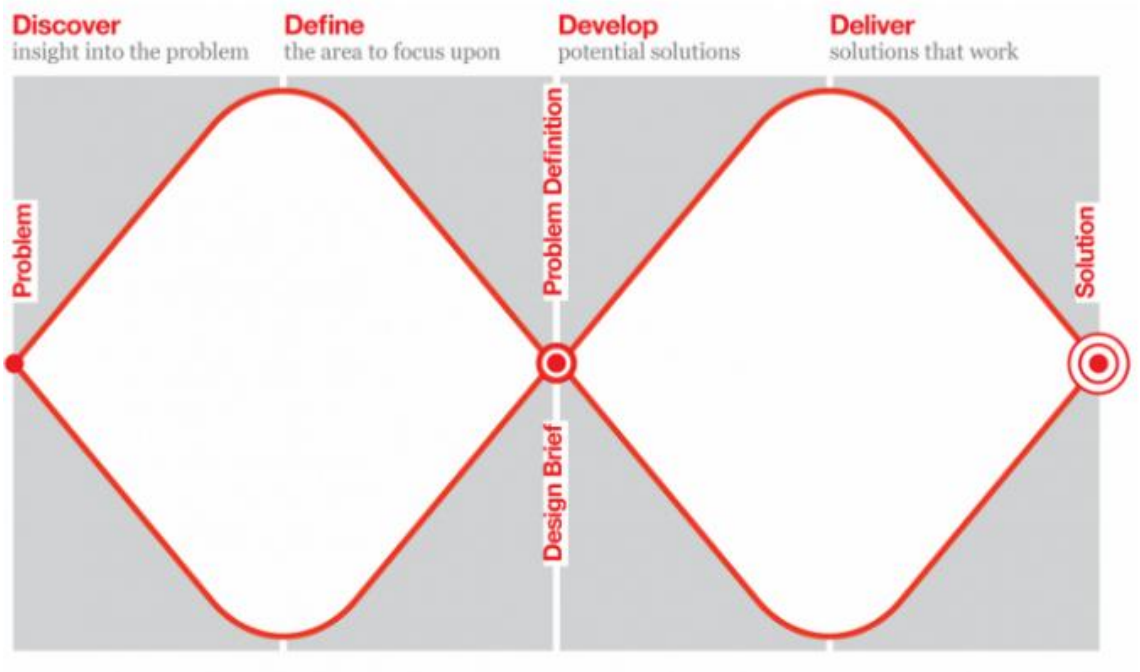

Figure 2. Double Diamond model [51]

Discover activity is the most critical phase since it aims to gather important insights to define the nature of the problem to be addressed; this phase involves communication with the stakeholders in order to clearly understand their needs. Define activity helps to make sense of the possibilities identified in the discovery phase. Define phase involves analysing the information gathered and filter it into ideas to understand the context of it. Development stage involves multidisciplinary work to create solutions and prototype them through an iterative process of developing and testing. Deliver activity is about finalizing the service solution and launching it to the users in order to obtain feedback for further adaptation of the service [50].

The advancement in technology with respect to the provision of services has led to a shift from goods to services. Services have adapted to the provision of information through the ICT in the form of electronic services. e-services are defined as the provision of services over the web [52]. In other words, e-services perform digital interactions through software-based information systems that communicate between a service provider and a service receiver, which deliver some value to the user service [53] [54]. E-services include

the services provided by a service organisation and goods providers who are an important element to provide quality e-services. [55]. Essentially, e-services are associated with the business to consumer (B2C) e-commerce since they assist in producing on-demand solutions to the consumers, which benefit them by providing efficient channels to access a service that increases customer satisfaction [53]. However, e-services are not only associated with B2C, but also can be categorized into three main groups: business-to-business, business-to-customer, and customer-customer [56]. The main characteristics of e-services are web-based technical artefact, interaction, and it is connected to other information systems [57].

The rapid expansion of technology in the public sector had led to the adoption of e-services in public organisations [57]. Public e-services can be seen as government-citizen communication aiming to incorporate a 24/7-vision for government organisations [58]. However, the quality perception of e-services differs from traditional services. There are a variety of models that determine quality attributes for e-services. For example, the five-dimension model (5D) consists of five quality determinants: information availability and content, ease of use, privacy/security, graphic style, and reliability/fulfilment [59]. Similar, the *E-S-QUAL* model entails efficiency, fulfilment, system availability, and privacy [60].

A big number of e-service quality model are based on the SERVQUAL dimensions, which was developed specifically for traditional services. This model is defined by reliability, empathy, assurance, responsiveness, and tangibles and has been highly used in multiple service contexts. Nonetheless, fewer e-service models are focused on the surrounding circumstances to evaluate the digital service. Often, the concerning aspects of e-service quality include accessibility, navigation elements, ease to use, and efficiency; however, these perspectives do not focus on when and where the service process occurs [59].

2.3 Agile in Public Sector

Governments have introduced an “adaptive governance” approach to adapt the form of governance that aims to improve responsiveness to the conditions of a changing environment to benefit the public interests. Adaptation techniques for governance encompass the use of internal and external capabilities and the decentralization of

decision-making authorities, emphasizing efforts from the lower level to inform the needs of the public interest to the higher level [29][30].

Technological developments represent emerging changes that require public organisations to adapt. However, governments face the challenge of adapting effectively and rapidly to changes in innovation due to the imbalance between innovation processes and government policies as well as existing hierarchical structures [17]. Consequently, governments concerned to advance themselves by adapting to the current technologies to provide efficient service delivery are exploring solutions to boost agility and adaptiveness [1][5][6][17]. An example of this is the government of Estonia during its intent to upgrade the technical set-up of the Estonian digital government. The recent initiative of the Estonian government is trying to advance the provision of digital public services through the use of artificial intelligence technology. This initiative aims to adapt to the users' needs on the technology side and significantly improve their experience in the use of public services. This initiative not only tries to adapt to technology changes but also the use of agile development in the design and adaptation to incoming technologies since the traditional waterfall method for the production of public services is not adequate to the growing demand for the needs of public services [31].

The adoption of agile methods is gaining notoriety in public institutions. They have been slowly implemented, and limited studies address the conditions and prerequisites for adopting an agile approach in this area. Despite adaptive governance attempts to respond to and promote agility in the use of technology and innovation, previous studies have identified challenges in adopting agile approaches in the public sector [5][17][31].
Government institutions often have difficulty employing agile methods due to unfamiliarity with the agile approach of public sector personnel, and the absence of participation of government institutions in development processes accentuates deficiencies in the knowledge discovery of business needs to obtain the desired results.

3 Case Study Overview

This research analyses the case study of the water department of the Estonian Ministry of the Environment that is pursuing to develop a web application for the evaluation of environmental flows of Estonian rivers for the issuance of permits for the special use of water. Eflows describe the minimum flow rate needed to ensure the good condition of the fish living in the river; thus, it can be used to estimate the ecological condition of a river.

The evaluation of environmental flows of Estonian rivers application is an innovative system for public sector service previously developed as a research project in an effort to automate the measurement and forecasting of eflows to provide a real-time assessment of the ecological state of the rivers and dams using Estonian hydrological open government data. The system developed for the governmental organisation contemplated being designed to model and interpret scenarios of the ecological status of the river that can support hydrologists, water specialist and river flow rates experts using flow data to assess risks for life in rivers as and demonstrate evidence on it through reports on the ecological status of rivers [41].

However, the previous outcomes of web application highlighted that despite providing an innovative solution, it does not fulfil the user expectations in regards to usability, user interface (UI) and user experience (UX). Furthermore, the previous study of the web application emphasized that a variety of different type of users might be involved in its usage and the software features differ from the contrasting target user groups. Therefore, a proper web application design requires additional work to discover and adapt the customer's needs and provide them with a usable and appropriate product that serves as a component to provide better service delivery [41].

3.1 Service Background

The water abstraction from rivers and dams in the Republic of Estonia is requested by means of an environmental permit for the special use of water issued by the Environmental Board of the Ministry of the Environment. Unless otherwise provided in

§ 188 of the Water Act [39], a water permit is mandatory in any of the scenarios indicated in § 187 of the Water Act [39].

The environmental board receives and evaluates the application for special use of water requested by natural or legal persons to determine the issuance of the permit. In accordance with the regulations established on the basis of § 42 (7) and § 53 (3) of the General Part of the Environmental Code Law [40]; Applicants must provide information of the intended use of the water, and depending on the water use, they must provide the amount of water needed per year, quarter, day, second (m^3), coordinates of the river, the method of determining the quantity of water to be taken among other relevant information stated in the regulation [42].

Based on the information provided by the applicant and the historical data of the water body, such as complaints, flow rates, previous permit information and ecological status, the Environmental Board aims to evaluate whether the requested water abstraction is feasible in a way that does not harm life in the dams or rivers and thus decide whether to grant or reject the requested permit [42].

3.2 Problem Description

The description of the problem was defined based on the answers of the interviews carried out with the user. The problem description is described below.

The current process of issuing permits for the special use of water requires rigorous analysis to determine if the requested water abstraction does not exceed the available resource and does not harm life in rivers and dams. The biggest challenge is estimating how much water can be extracted from the river so that the biota is not affected during the different periods of the year.

The limitations of the current process of analysing the impact of water abstraction are:

- Outdated information on the river's ecological status
- Inadequate models to forecast the impact of water abstraction
- Lack of hydrometric monitoring stations

- Insufficient literature about rivers and flow rates
- Historical data of the river is collected from different sources
- Lack of continuous monitoring when permits are issued permanently
- Insufficient evidence to prove that the permit holder's activities harm the water body

The reasons mentioned above make the decision-making process for the issuance of permits for the special use of water excessively complex and time-consuming.

3.3 Proposed Solution

The proposed solution was defined based on the answers of the interviews carried out with the user. The proposed solution is described below.

The solution to facilitate the analysis and decision-making for the issuance of permits for the special use of water would be to develop a web application to forecast the environmental impact on rivers and dams considering the requested water abstraction and the status of the water bodies during different periods of the year.

The web application will automatically calculate the minimum flow necessary to ensure life in the river and fish pass by using efficient methods to estimate the flows and calculate the available water resource compared to the planned water abstraction. The software will provide automated monitoring of the ecological status of the river, analysis of the impact of water extraction, scenarios-modelling and forecast of critical zones for water abstraction in every season.

The main objective is to provide a more accurate estimation and monitoring of the ecological status of the river to automate the decision-making process for the issuance of environmental permits for the special use of water. Hence, improving regulation and water management as well as river ecosystem protection.

4 Research Methodology

The main objective of this thesis is to develop a web application for an e-governance service for the evaluation of the environmental flows of Estonian rivers to issue permits for the special use of water. This will be done by analysing and understanding the needs of the water department of the Estonian Ministry of Environment as the case study and integrating customer collaboration to create a software product that meets the needs of end-users of the service for issuing water permits.

A case study, DSRM and agile approach were adopted as the methods to design a software solution that solves a customer problem and involves customer collaboration. From a software engineering perspective, the case study was chosen to describe, evaluate, and understand different aspects of the research problem. The case study research design is suitable to obtain comprehensive and contextual knowledge about the particular real-life situation [43]. In addition, this method enables an in-depth exploration of the critical factors and implications of the particular context of the case study. In accordance with the main objective of this research, the DSRM and agile approach were selected to complement the case study since DSRM concentrates on understanding the circumstances of the current situation and finding a new strategy that solves practical problems by creating innovative artefacts [34]. Similarly, the agile approach was chosen to include customer collaboration in the steps of DSRM in order to create the right product through continuous iterations of feedback [10]. Furthermore, qualitative methods were selected to analyse the problem from a point of view of the users of the case study [61].

The structure of the DSRM consists of the following activities; problem identification and motivation, define the objectives for a solution, design and development, demonstration, evaluation, and communication [34] [35]. These activities were aligned to the agile approach in order to adapt the artefact based on the iterative customer feedback loops. Furthermore, agile practices investigated in the literature were applied as an agile method for the development of the IT artefact [12] [13] [14] [15] [24] [25] [28]. The following table illustrates the combination of DSRM and the agile approach to create the IT artefact for this research.

Table 3. DSRM and Agile approach activities [34] [10]

Activity	**DSRM**	**Agile approach**
1	Problem identification and motivation	Identify the business problem and requirements
2	Define the objectives for a solution	Propose a solution
3	Design and development	Develop the artefact in valuable increments of working software
4	Demonstration	Test usability of the web application with the user, and adapt it
5	Evaluation and Communication	Analyse customer feedback

The research covers the above-mentioned activities in the following way:

1. **Problem identification and motivation**. The problem is defined in chapter 1. The theoretical background of the problem is covered in chapter 2 and chapter 3.

2. **Define the objectives for a solution**. The objective of this research is covered in chapter 1. The proposed solution is defined in chapter 3.

3. **Design and development**. The results of the qualitative analysis for the design and development of the artefact are presented in chapter 5

4. **Demonstration**. The demonstration of the created artefact involved the agile review practice to allow the user to test and validate the correct functionality of the artefact. This activity is presented in chapter 5

5. **Evaluation and communication**. The obtained results of the design and development of the artefact are analysed and reported in chapter 6.

4.1 Data Collection

The data collection is performed using qualitative exploration methods [36]. Data collection was obtained in three steps that included three unstructured interviews with one user, a revision of the documentation of the software provided to the user, a review session of the web application, analysis of documents of water abstraction provided by the user, analysis of Estonian regulations of the water act, and constant communication via online (email, video-call) during a three-month period. The aim was to gather relevant information to design a suitable web application that produces high value to the users of the water department of the Ministry of the Environment of Estonia. A user or customer was defined as a person who interacts with the designed web application for the evaluation of environmental flows of Estonian rivers of the water department. The interviews were carried out via video call in the English language, and only one person was interviewed. The interviewee was chosen based on their previous participation as the main user of the case study as well as for being the primary representative of the water department of the Ministry of the Environment. Interview 1 took place on February 4th, interview 2 on February 25th, and interview 3 on April 1st, 2021. Interviews were recorded for their detailed analysis. The analysis and results of the interviews were provided to the principal end-user to ensure the validity of the study. The main interview questions are presented in Appendix 2. The information of the interviewee is described in table 4.

Table 4. Interviewee information from Ministry of the Environment [44]

Name	**Position**	**Department**
Elina Leiner	Chief specialist	Water department

The data collection to develop the IT artefact was obtained through the following three steps explained below:

Step 1: Interview 1 was conducted with the principal end-user of the case study. The aim of this step was to know the user, identify the business problem, understand user needs, gather primary requirements for the development of the web application and request additional useful material. The user was informed that the purpose of this interview was

to design software that completely fulfils their needs. Furthermore, the user was informed how the information provided by them is relevant to the study and explained the plan to achieve a convenient design of the web application that adapt to their demands. In addition, this step was committed to understanding the function and responsibilities of the organisation, the users' roles and their correlation between them and other governmental institutions.

Step 2: This step consisted of conducting interview 2 to delve into the aim of step 1 and discuss the obtained material provided by the user. User was asked about their opinions on how to make the current situation better (ideation for a solution) for them and what is needed to make work more efficient. Additionally, during this step, doubts that resulted from the analysis of the previous interview were discussed with the user.

Step 3: Interview 3 was conducted. This step planned to obtain valuable information in the form of user feedback. The user received the working application as it progresses. The user was asked for feedback on the web application's usability through a video call conversation after the system has been pre-tested. Feedback is recorded and analysed for further improvement of the software.

4.2 Limitations

This thesis project includes the software development and project management of a web application for the public organisation Ministry of the Environment, and it is planned to be used by the environmental specialists of the water department for the service of issuing permits for the special use of water.

This research does not contemplate budgetary control activities, procurement application processes or delimited time from the government organisation to reach the overall project goals. The project was developed under the assumption that the management and development team are not staff members of the government organisation.

Legacy software from government institutions is not comprehended as part of the investigation, and no government institution has established rigorous and formal processes. Moreover, employee turnover within the government institution in regard to the users collaborating on the project was not considered for the research.

Although the objective is to design the web application adapted to the users' needs, correct values of the environmental flows are not obtained in the software calculations due to the actors involved in this project do not have the means to provide these data.

5 Agile Design and Development

The development of the web application for the evaluation of environmental flows of Estonian rivers was performed for the case study, aiming to find the proper specifications for designing a suitable software that fulfils users' needs. This chapter focuses on presenting the results of agile development applied to the case study.

The workflow process and timeline of the project are presented in figure 3 to illustrate how the author obtained the results of this project. The workflow consisted of five tasks: requirements elicitation, documentation and approval; planning; coding; and demonstration and feedback.

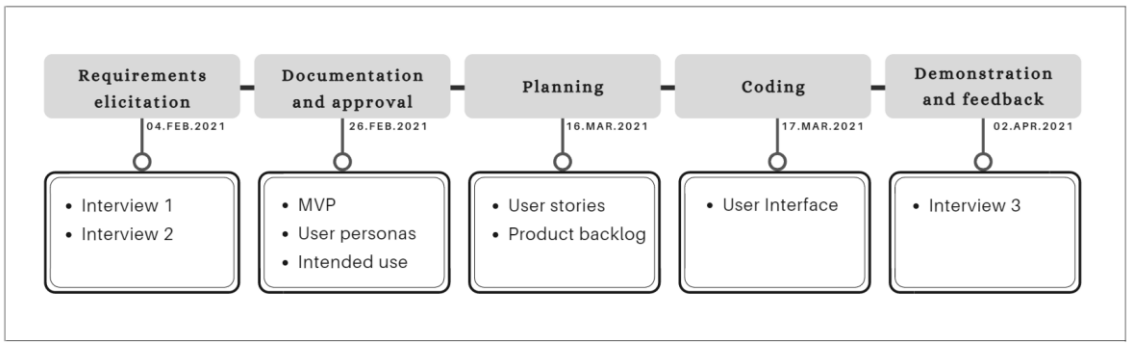

Figure 3. Workflow process and timeline of the project, by author

The upper-level rectangles in figure 3 represent the tasks performed to obtain the results and, at the lower level, the outcomes. This chapter describes a detailed explanation of the results of these tasks.

5.1 Requirements Elicitation

The requirements elicitation was carried out through two interviews with the principal end-user, in which the user was asked to describe her roles in the organisation, daily tasks, workflow, biggest pain points in her work processes, the service relationship with the regulations and her expectations regarding the development of an innovative web application. Subsequently, discussing the problem that the user is interested in be solved. Furthermore, the user was requested to guide through related businesses processes or

limitations, presenting relevant details such as existing documents to examine their current organisation issues. During the second interview with the user, the shared background material was discussed together with the user to be able to better understand her needs in regards to the service. The results of the interviews are presented below.

Interview 1

The principal end-user was encouraged to discuss the process of issuing permits, so that the user commented: *"at the moment we ask to the persons who apply for permits to present us some expert opinion about it, and if they do present it, we have just to trust them, what they present is right, we are not able to control this information, and actually is not available for anybody, so this is our weak spot. We have some problematic cases mainly in the summer time, it's a problem because we don't have enough water"*, the user then was requested to share the common inconvenient issues during the process of emitting water permits, the user mentioned: "*every now and then we have the question; how much water can we allow them to abstract or redirect so the river won't suffer and the biota, and fish, and so on*" at this point one important insight of the problem was stated by the user, that they struggle to discover the amount of water they can allow to be abstracted to preserve life in rivers.

The author then delved into the problem and challenged the user to specify the content of the data provided by water users; hence the user: "*they request this amount per month also quarterly and also yearly amount*". This response helped identify some of the features needed in the web application: the amount of water requested per quarter and the amount of water per year.

Identifying different types of users requesting the permits, the user commented: "*the users can be hydropower plants, also fish farms, there are also some big companies which produce some building materials*". Aiming to understand the factors considered by the user to grant a permit for water abstraction, the user mentioned: "*if we don´t have enough information when users say they want to take away some amount of water from the river, then we might have this question: can we allow it? If we don't know if we can allow this, then the legislation allows us to ask from the companies to present extra material, some expert opinion, if the water abstraction amount is ok*" also added: "*we don't know too much about every water body"*, The problem then lies that the public organisation does

not have enough information to demonstrate how much water can be drawn from the river.

In order to identify the user roles in the organisation, the user described them as: "*very different things, mainly am dealing with dams, when I issue permits I have to the same way all over Estonia, we have six specialists issuing the permits, and I am their supervisor, this specialist work with me in this institution*". Furthermore, the user was encouraged to discuss her expectations on regards to a possible solution that could help to better perform user work processes; thus, the users stated: "*I think this system can show us when it is possible to issue the permits for example in which month we can or which month we cannot*".

Additionally, the user expressed that one more problem is the lack of data that they require to do their work of analysing data from the river: "*we don't have enough data because we don't have sufficient monitoring stations, we have the data calculations from the Environmental agency because they are responsible for these monitoring stations in the river, maybe we can talk to them and ask exactly what information they have*", consequently, in the same comment the user stated the presence of one more stakeholder organisation which is the Environmental agency.

Interview 2

The user explained how the water users send the documents provided previously by the end-user of the organisation; the user replied: "they only can present data through this web service we have" "*if something is missing, we can ask for more information through this system*" "*when they present this data we need to check if it is true, this one example that I sent you about this fish farm there was only one number water amount per year, so sometimes these water users are lazy, they don't present the whole data, so if they present one number we can calculate also*"

In an intent for obtaining extra information to understand what is the data needed of the river and how they have access to it, the user mentioned: "*We have this obligation in law which says that we have to figure out or find out any information that could be relevant, so we have to deal with all this that I wrote down, complains, the information from national monitoring reports, also literature sometimes is helpful, anything that give us some kind of information about this river, also sometimes it could be a bit wider of every*

aspect that is or could be influence through this application later". Furthermore, user was challenged to describe the process to discover the current status of the river, so the user commented: "*we only have this information about river if someone has presented a complaint to the environmental inspectorate, this department is also is now in the same environmental board, they are dealing with complaint and these regular checks if the water user is acting according to the permit*"

Regarding the process of obtaining the mentioned information from the inspectorate, the user expressed: "*if the inspector has detected something wrong with the river and it is found that the water user is not following water permit conditions, then the inspector has to inform us, and the main result is that we have to change the permit*". Moreover, the user communicates in regard to the main problems that the lack of data from the river represent a challenge to demonstrate to the water users that issues are detected related to their water abstraction; thus, the user commented: "*there is not enough data to show if it is the water user fault, one of the questions is also that no one is measuring the exact amount of water in the river, so if we have this kind of problems with some water user, then we have to prove that there is less water in the river than the mentioned in the permit*" "*it is difficult, and if the water user already knows that someone had made a complaint, he may change his water abstraction he may leave some more water in the river, and when the inspector is ready to measure the water in the river, it may no longer be a problem, so it is very complicated, and we might need very different things to do*."

Another problem was detected when the user mentioned: "*we analyse all the data that we have gathered, the status information could be out of the day because not every river is monitor and analyses each year, and it might not reflect the situation in the river right now*", stating that a problem is outdated river data.

Finally, the user expressed requirements for the system based on their needs as: "*first we need to know how much water is in the river, in spring and so on, and then we can take this information that the water user has presented, and then we can compare how the flow rates changes during the year and how the planned water abstraction might affect the water levels*", this represented the user's needs and desires for having a tool that can analyse environmental flows.

5.2 Documentation and Approval

In order to have a common understanding of the problem on both sides (the user of the public organisation and the development and management team), project documentation was created as a result of interviews 1 and 2. The documentation created and shared with the user were the definition of the problem, proposed solution, MVP features, user personas, and intended use. Problem definition and solution are defined in the case study chapter 3. The proposed MVP, the identified users of the system and the intended use of the application are presented below.

Minimum Viable Product

The MVP is an end-to-end web application that enables an automated evaluation of river environmental flows. The application should forecast the minimum flow rate of the rivers during a range period considering the amount of water requested, weather and minimum flow rate required for fish passes. The web application should calculate:

- Amount of water in the water body during different seasons of the year
- Amount of planned water abstraction per year, quarter, month, day, second (m^3)
- Amount of water necessary to ensure life in the water
- Planned abstraction m^3/sec higher or lower than the available resource

The web application should be able to receive the values of the amount of water requested, the river location, the forecast method and additional values that affect the calculations of the environmental flows. In addition, it should display the calculated results in a simple and easy to use user interface and be able to export the obtained results to a printable document.

User personas

During this project, two different types of users were identified. However, only the principal end-user was involved in the development of the web application and is classified as a permit issuer, also referred as the customer. The users identified for the web application are described below.

Permit issuer — Elina: She works in the water department of the Ministry of Environment; she is in charge of analysing requests for the special use of water and issue water permits. She receives applications from water users such as fish farm, hydropower plants and irrigation and tries to determine if the requested water is feasible to abstract considering the river environmental conditions for life in the river and other aspects such as the weather in the different seasons of the year and other historical factors as well as regulation compliance. Elina works together with data analysts who process and analyse data provided from the water requests.

Data Specialist — Edna: She is in charge of analysing data from water abstraction requests and providing results to the permit issuer user. Edna employs specific methods to analyse the minimum flow rates requires for life in the river and tries to analyse them against the requested amount of water. She also considers external data from other government institutions, such as hydrological data in order to obtained optimal results in the data analysis of rivers.

Intended use

- The system is intended to be used by the Environment board to determine the amount of water required for life in the rivers and dams
- It is intended to be used to estimate the current and consequent impact of water abstraction in the rivers and dams
- It is intended to be used to visualize the critical zones through insightful graphs

5.3 Planning

During the planning session, user stories were drafted for the development of the web application. The amount of work and development tasks were defined, planned and assigned by the project manager to the developer and were placed in Jira software tool for proper management of them. User stories and product backlog were drafted as result of interviews 1 and 2 based on the customer requirements. User stories and product backlog are described below.

User stories

The user stories were described in story cards defining the general specifications of the web application and the acceptance criteria. User stories are illustrated in the following figures (figure 4-7).

Description: As a Permit issuer user, I want to be able to select a specific location inside a river so that I can easily visualize where the water levels need to be measured.
Acceptance criteria: • User can select a location by clicking on the map • When user select a location on the map, the coordinates gets populated • The river name is founded based on the location selected by the user • If a river is found, the 'River dropdown' auto-selects the river found • User is not allowed to select a location where there a river does not exist • If the user tries to click in an area with no river, a modal window is shown to the user with the following text: 'No river was found under the selected location'

Figure 4. User can select the river location where the water is drawn from, by author

Description: As a Permit issuer, I want to be able to search for a river by giving coordinates so that I can easily input where the water levels need to be measured.
Acceptance criteria: • User can input coordinates of the water abstraction • After the user input the coordinates, the map shows the given location in the map • Coordinates must be entered in X and Y value • If the coordinates do not match with a river location, a modal window is shown to the user with the following text: 'No river was found under these coordinates'

Figure 5. User can indicate water abstraction coordinates, by author

Description: As a Permit issuer user, I want to indicate the type of water use given by the water user, So that I can know what kind of procedure needs to be done to measure the water levels.

Acceptance criteria:

- User can select the type of water use in a dropdown
- The dropdown list contains the following items ordered alphabetically:
  Aquaculture
  Expansion of water body
  Groundwater abstraction
  Surface water abstraction
  Use of Hydropower

Figure 6. User can indicate the type of water use, by author

Description:
As a Permit issuer user,
I want to set the amount of water requested by the water user,
So that I can calculate the amount of water requested during a period.

Acceptance criteria:

- User can input the amount of water requested per year - numeric input “Annually”
- User can input the amount of water requested per year quarters - 4 numeric inputs “I Quarter”, “II Quarter”, “III Quarter”, “IV Quarter”
- The daily amount of water is calculated automatically after the user input the annually water abstraction
- The value of the amount of water requested per day is generated - disable input “Daily”
- The amount of water per second is calculated automatically after the user input the annually water abstraction
- The value of the amount of water requested per second is generated - disable input “Second”

Figure 7. User can indicate the amount of requested water abstraction, by author

Product backlog

The product backlog consisted of an ordered list of what needed to improve the web application. The product backlog items were created by the project manager and were managed into Jira software in a Scrum board. The following figure shows the items of the product backlog inside the Jira software.

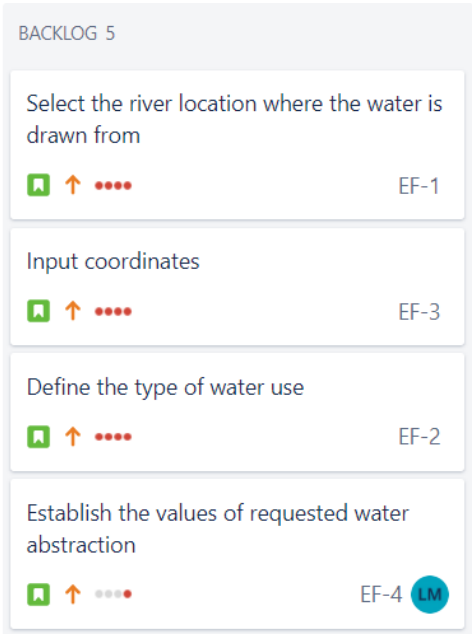

Figure 8. Product backlog in Jira software, by author

5.4 Coding

The actual coding of the web application was performed during this task. The software developed is an end-to-end web application that enables an automated estimation of river environmental flow compliance. The software product was developed based on the analysis of the user responses from interviews 1 and 2 and according to some of the MVP features. As mentioned before in the case study chapter 3, this application was not developed from scratch and was improved and adapted according to the user x specified needs as well in the case study and customer documentation and approval. As a result of the programming of the web application, the following user interfaces were created, and they are shown in figure 9 and figure 10.

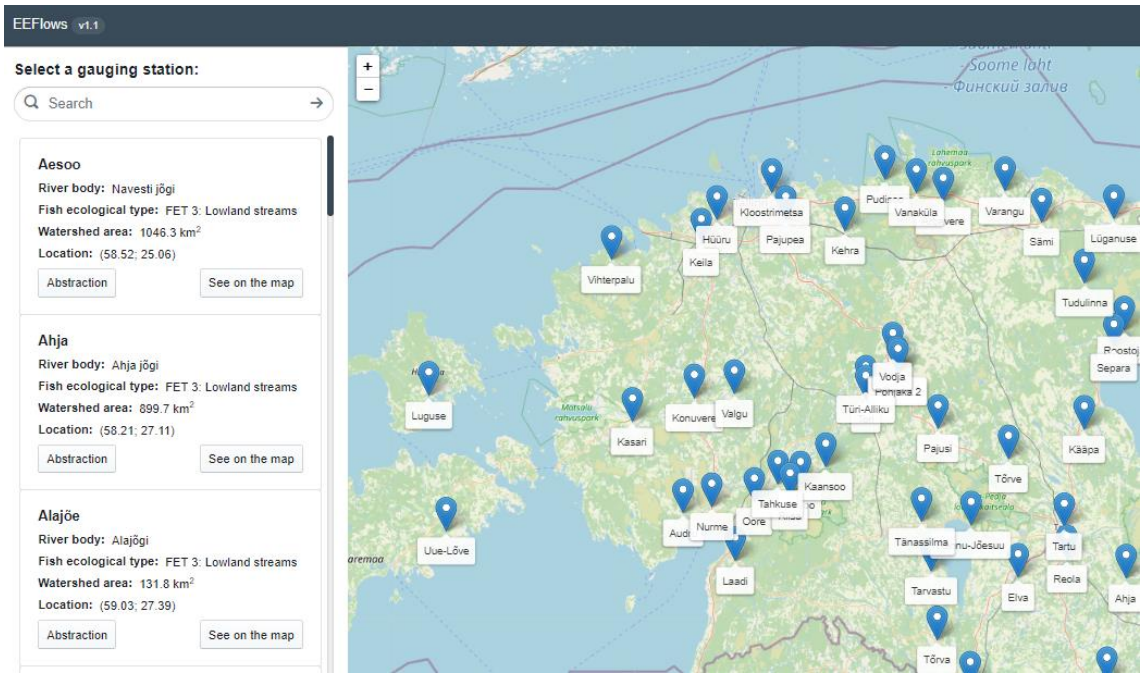

Figure 9. User interface of the web application for selecting the rivers for water abstraction, by author

The above illustrated (figure 9) represent the initial view of the user interface, in which the end-user is able to select the river or the gauging station from which they want to do the analysis of water abstraction, and it was designed to fulfil one of the customer needs which is to be able to analyse water abstraction from rivers. This view allows the user to select an Estonian river from the map or from the left list column and move to the section of water abstraction analysis presented in figure 10.

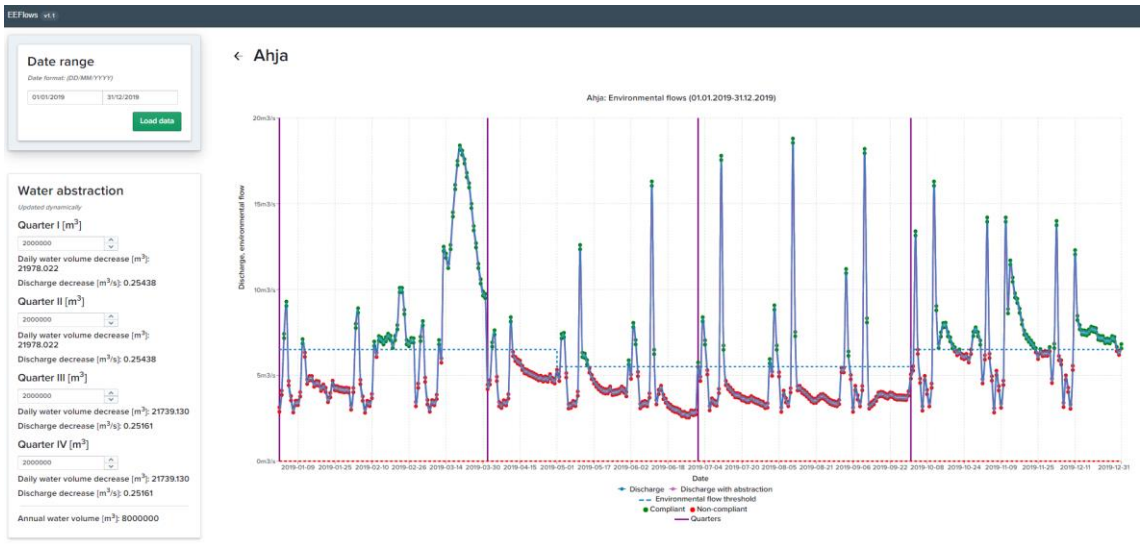

Figure 10. User interface of the web application for the analysis of water abstraction from rivers, by author

This image (figure 10) was designed for the user to insert the values of water abstraction received from the water users. As stated in the results of interviews 1 and 2, this figure fulfils the user requirements by providing a tool that can receive parameters of the amount of water in m3 requested per quarters from a specific period of time and automatically calculate daily water volume decrease [m3], discharge decrease [m3/s],
annual water volume. Consequently, the main feature of this part of the system is to show to the user the scenarios where the requested water abstraction is feasible and when it is not. This is done by displaying a graph that shows red dots when the requested water abstraction is environmental flow threshold and do not complain, and green dots when it compliant; the above is illustrated per quarter periods as suggested from the user responses from interview 2.

As the result of the use of this web application, the user provided some feedback that is presented in the demonstration and feedback sub-chapter. The outcomes of using the web application can reflect that this version of the system was better accepted than the original stated in the case study since this application is addressing the customer needs stated in the requirements elicitation sub-chapter

5.5 Demonstration and Feedback

Interview 3

During this interview, the user was asked for feedback about the web application. The developer previously released the modification of the software to a live environment. As a result, the user received valuable functional software that could test and validate to ensure that the work performed met the requirements. Subsequently, an online meeting was arranged to discuss the feedback provided by the user. The form of feedback was listening to user comments about the web application. When the user was asked to enter the dates into the system to make the calculations, the user mentioned, "*is this the water period when then water user needs to abstract it? the thing is that they can apply for permits that last forever, so we don't have this date or due date*" at his point user indicated that in some situations the system should allow to leave the end date empty and have a date by default. The user was explained that a period is required to make the predictions of the flow rates, and the user suggested having one year as an example.

Once the user input the data into the system, the user received an explanation on how the results of the system are obtained; for this, the user responded to double-check if the user understood correctly "*all these green dots of the environmental flow threshold we have enough water, and everything with these red dots bellow the environmental flow threshold there is not enough water for fish*". Based on this calculated information in the system, the user was asked about the decision-making process to decide whether to grant the permit or not "*first, I need to know what calculations are behind of the environmental flow threshold because when the water abstraction is connected to damming, we use environmental flow threshold and when we don't have we have a little more room for playing so maybe we could have another line in the graphs with the methods."*

Consecutively, the user continued testing the web application and mentioned about the dates shown in the system that "*on the one hand I would like to see quarter only are, but on the other hand, it may be that the quarter is too big and I would like to see more weeks, especially during summer*". In the end, user commented "this example in the screen shows very clearly that the red dots are throughout the year, but I would really like to show this to our specialists and see what kind of question they come up with so we could give you better information of what are the next steps", indicating that the web application need more feedback from other users.

6 Discussion

In this section, we return to our research questions and discuss the initial pre-requisites to apply agile development in e-governance services. The first question, concerning the implementation of agile approach in the public sector under the question: **"How to apply agile development in e-governance services to increase adaptability in public sector service delivery?** And the second question: **What are the initial pre-requisites to employ the agile approach in developing software for e-governance services?** In accordance with the developed web application as the IT artefact obtained as a result of this thesis, the analysis of the results of agile development of the web application are discussed in this chapter to respond to the research questions.

This project demonstrated that close collaboration with end-users of the case study web application and the utilized agile practices highly benefit in the proper design of innovative software products for public sector services, which help to provide an overview of the initial pre-requisites on the implementation of agile development in e-governance services. User engagement and cooperation, as well as previous agile development experience from the team, were crucial in achieving the study goals and answering the research questions. As the main contribution of this research, the author explains these findings below.

Finding one: Think of people before product — focusing on customer needs and delivering value. At the beginning of this research and before having interviews with the user, we had in mind a different problem and a different solution; however, once we interviewed the user, our perception of the problem and solution completely changed. It is crucial to identify the problem before you start thinking about the solution or building the product. One should not assume that developing an innovative product will be the solution for customers; instead, we should identify their needs. The author suggests that in order to examine customer needs, it is essential to identify the business problem first. During the requirements elicitation, the author gathered information that allowed to identify the problem that users of the current service were facing and propose a solution and MVP. In order to carry out this workshop, a representative group of stakeholders was

involved. The primary goal of this requirements workshop was to understand what the users were hoping to achieve with this software project, identify their business process and the challenges in their current processes [37]. Consequently, this action allowed to emphasize with the user and maintain close communication. This workshop allowed to see the big picture of the project, obtain the essential requirements to start building the MVP that solves customer problems. Furthermore, the results indicated that the interviews to gather requirements were effective in identifying the problem as demonstrated in the user interface, which shows the alignment between stated user problems and the software solution. In addition, in order to validate that we were solving the identified problem, a review session was done through interview 3. This consisted of providing working and valuable software to the customer; thus, the user was able to test the usability of the system. It is crucial to understand the meaning of "valuable" or "deliver value", in this project context, "delivering value" meant that customer received a usable product with a user-friendly user interface, with which the user interacted with the system and sufficient features that the user can validate the product from an early stage.

Finding two: Customer engagement is crucial in agile development. The user was made aware of the way in which it would be working during the development of this project. The project manager explained to the user that it was necessary to collaborate closely together with the developer, project manager in order to ascertain the correct design of the web application solution. The user was informed that meetings would be held every three weeks to review and validate the results obtained at the end of each iteration in which the user would be given to test the working software in order to provide feedback and improve the application. As a result, the user was excited to learn that the best way to provide feedback would be by testing the web service rather than just receiving documentation of the project. Although the user was not familiar with agile development or agile manifesto, the user did not receive any training or education in the agile approach. Despite that, the user showed constant commitment and active participation during the entire project and provided valuable feedback that helped to improve the web application. Contrary to the literature stating that individuals in organisations that use agile practices should obtain training in the implementation of agile approach [17], the results of this research suggest that agile training is not a prerequisite to utilize agile practices in the government organisation to obtain customer collaboration

and reach to the desired outcomes. In this research project, the user did not receive training on the agile approach; however, the user was explained how the team, including the user, would be working through iterations, in which the user committed to providing feedback at the end of each iteration after testing the working web application. It can be inferred that the fact of not training users in the agile approach does not represent any barrier in the agile development of the web application. However, it is crucial that the customer collaborates with the team throughout the project cycle. This study reveals that rather than training the users on agile methods or practices, it was necessary to make the users aware that the main objective of maintaining constant communication and active participation in the team is to build and validate the appropriate product that adapts to their needs. Although the user was actively collaborating on this project, the time limitation to complete this study was not sufficient to meet all the customer needs through the development of the MVP; however, the end-user provided us quality feedback that benefits to improve the web application in the future and to continue adapting the system to their needs.

Finding three: Skilled team and agile manifesto embracement. The agile development of the web application as concerned the development and management team adopted the principles and values of the agile approach. Aligned with the theories that encompass agility by embracing the agile manifesto [10], the results indicated that the management and development team needs to support the required changes in development-related processes to reach the accurate solution for the creation of the system. The involvement of the team working in an agile manner refers to paying special attention to the people factor in the project, which involves expertise, technical skills and communication as indispensable components to boost agility. In addition, the research revealed that the successful implementation of an agile approach requires users, developers and managers to understand their roles and responsibilities in the project setup.

Finding four: Choose the adequate agile practices that better adapt to the organisation. In line with the theories of using agile practices to boost efficiency in the development processes [15], the results revealed that employing agile practices rather than specific agile methods represent a significant advantage to better adapt to the current processes of the public organisation. Although the fundamental theory of agile practices involves specific structure, agile practices were much more flexible to adopt instead of employing specific processes and rules incorporated in the agile methods. The research

showed that choosing suitable agile practices involves having experienced agile practitioners to determine the appropriate techniques to perform during a project. In addition, the selection of these practices is highly dependent on the work processes of the public organisation so that the chosen practices do not generate a disruptive impact in the current environment in which the users of the organisation are used to working. The agile practices used for this project consisted of planning, user personas, user stories, and review.

During the planning session, the amount of work and development tasks were defined, planned and assigned. The team members who participated in this meeting were the developer and the project manager. In this event, the team members discussed how to obtain the work planned done and committed to completing the planned amount of work. As a result, the aforementioned team members were actively involved so that they could gain a solid understanding of what was expected to be achieved and what was the priority of the tasks.

User personas were identified from the interview with the user as stated in chapter 5; this allowed to have a clear understanding of the types of users who will use the web application. Moreover, user personas were useful to define the user stories and provide a context for the team members of who are the individuals targeted to use the system.

The user stories were created in written form to capture a general explanation of the description of a software feature from the perspective of end-users. The user stories aimed to simplify the way the web application requirements are expressed so that the stakeholders could clearly understand how a system feature should work and avoid incorrect assumptions. Moreover, the user stories were created in such a way that they could be used to create valuable releasable software for the end-users, and thus they could test them and provide feedback. The meaning of valuable software in this context refers to a releasable piece of software that is usable to the users. The user stories were created according to the following template [38]: “As a [persona], I [want to], so that [some goal]”. In addition, the user personas and acceptance criteria were considered to draft the user stories. Acceptance criteria indicated the characteristics and behaviour that must be met to complete a user story and was useful to establishing a testing criterion [13].

The review practice aimed to receive valuable feedback from the user in order to improve the web application. During the review event, the project manager notified the user via email of the new changes of the software and was provided with the link to access the web application and instructions on how to test it. The developer previously released the modification on the software to a live environment. As a result, the user received valuable functional software that could review and validate to ensure that the work performed met the requirements. Subsequently, an online meeting was arranged to discuss the feedback provided by the user.

Finding five: Organise a small team consisting of an end-user, developer and project manager. According to the literature of agile manifesto [10], a team structure conformed by business and technical people was adopted to collaborate together in the development of the web application. Individuals involved in this project were defined as the principal end-user, developer and project manager. For the purpose of this project, the author acquired the role of project manager, and the researcher of the previous study as the developer [41]. The team participation during the development of the project consisted in two parties conforming a team made of three individuals.

One part consisted of two experts in agile development, and it is represented as "Development and Management team" integrated by a developer and a project manager. The other part refers to the public organisation "Ministry of the Environment" consisted of principal end-user of the web application or customer. The following figure illustrates the structure of the agile development project.

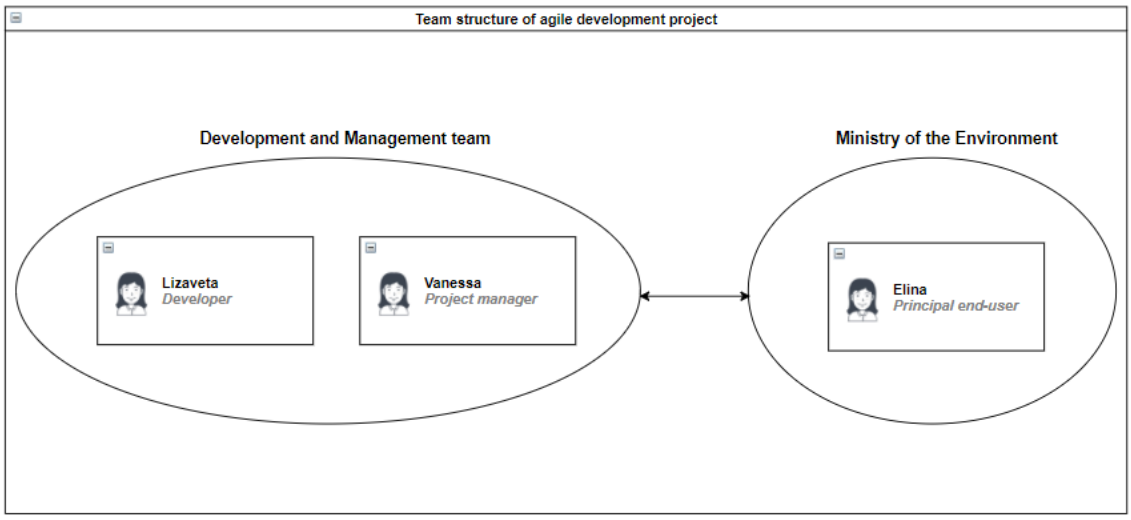

Figure 11. Team structure of the agile development project, by author

Aligned with the literature that states that it is essential to have an optimal organisational structure, composed of key stakeholders, a development team and a management team in the form of a small team of between three and nine people [14], the results demonstrated that having a small team help to easily convey information between the team members and users, the results of this research revealed that a team of three people was competent enough to obtain the results expected by the user in the web application.

Finding six: Identify key stakeholders at an early stage. Although the collaboration theories between stakeholders and development team suggest that fundamental entities must be involved in the project cycle [10] [26] [27], the results indicated that excessive time commitment is required to identify and reach the correlated government departments and institutions required for data acquisition for the web application development. Aforementioned represents a tremendous disadvantage since a government institution can be associated with several others which are essential to obtain the desired results on web application. The results of this research exposed that it is crucial to identify all the parties involved from an early stage, thus increasing the speed and efficiency of the product development process. However, this research project did not reach all the necessary stakeholders at an early stage due to the size of the government institution and the large number of government departments correlated to the water department of the Ministry of the Environment. Despite this, the implementation of agile development in the development of the web application was performed without involving all the stakeholders, instead only the one key stakeholder collaborated.

In sum, the results of this thesis project revealed that the implementation of agile development benefited not only to improve the UI and UX, but also to satisfy the needs of the users and provide customer satisfaction through fulfilling their expected demands. Furthermore, this thesis project can be beneficial for the service of issuing permits of the water department of the ministry of the environment, since the development of this web application fit as one of the main characteristics of e-services, which is a web-based technical artefact to enable two-channel interaction between the organizations in a B2B approach [57].

The reliability of this research could form the basis of follow-up research, as this work did not consider alignments with government procurement processes to develop a software project or restrictive government conditions that must match with regulatory procedures. In addition, the interpreted results can be biased as the author of this thesis has experience in agile development, which is an advantage to implement a successful agile project, but can also result in bias perceptions. Nonetheless, the results are likely to be principally valid to answer the research questions.

7 Summary

This research aimed to apply agile development in an e-governance service in a case study of the Estonian Ministry of the Environment to determine the proper design of a web application that fulfil customer needs. In order to achieve this objective, a study was performed under the research questions; RQ1: How to apply agile development in e-Governance services to raise adaptability in the public sector service delivery? Besides, RQ2: What are the initial prerequisites to employ the agile approach in developing software for e-governance services? To respond to these questions, a case study was carried out along with the development of an IT artefact based on DSRM and the agile approach.

The analysed results of the developed IT and literature review help to close the gap of the necessary aspects to consider to apply agile in a public sector in terms of the prerequisites to implement agile development in public organisation services based on the customer needs. As the main contribution of this research, the author recommends considering the described six findings as the initial prerequisites to apply agile development in e-governance services.

Finally, future research can be suggested to address agile development alignments with public procurement processes to develop a software project. In addition, further research can be devoted to improving the developed web application, adapting it to a final stage in which the client is satisfied with the visualization of the data shown by the system. In addition, further research should incorporate all necessary stakeholders' participation to obtain optimal data that support the development and improvement of the web application.

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Appendix 2 – Base Interview Questions

1. What does the Water Department of Ministry of the environment do? What is it about?
2. Could you tell me about the work you do? Which tasks are you in charge of?
3. What are your biggest pain points in your work process?
4. What is the hardest part of doing that?
5. Why is it hard?
6. How do you measure/ assess the ecological status of the rivers? Tell me about this process
7. Estimation part formula (methods) - Which methods do you use to estimate the river environmental flow compliance?
8. How do they obtain and process the data? From an API? From a Database? From an Excel? How does it work?
9. What do they do with datasets?
10. How do they report? Graphs
11. Environmental permit issuing - How do you manage this process?
12. How do you assess the granting of a permit for the special use of water?
13. Would it be helpful for you to have a tool that can make these calculations?
14. How do you do the calculations of water abstraction?
15. Do you monitor the compliance with the permit?

Appendix 3 – Idea Mapping

Letter sent by Elina:

Water user has to apply for the water permit if it plans water abstraction from surface water more than 30m3 per day (or plans to use hydropower).
Abstracted water can be used for Fish farming, irrigation, manufacturing plant cooling water, etc.

According to law, water user has to provide data about how much water is needed per year, quarter, day, second (m^3) and from which river is it taken (name, coordinates). Hydropower users don´t have to provide this data, but usually they give information about used turbines and its water consumption.

Water user has to describe technological equipment used for water abstraction and also tell us how is the amount of taken water measured. Mainly it is only calculated, not really measured.

If we take river Pedja, where the water user is going to take 28 703 000 m^3/year we have to calculate it back to m3 per second, day and quarter. We have to look if we have other data about this river and flow rates and try to analyze if this abstraction is possible/available.

If the water user has had a water permit before, we can compare what was done before, what where the abstraction amounts, what has been the status of river, have there been complaints and so on. Water permits used to have a due date, now permits can be issued for ever. So, if the water user has no big changes in his application and there are no problems seen, we can assume that the planned abstraction is suitable for the river.

If there have been problems, the river is dry or the Fish pass has no water, we have to find some data to show the water user that there really is a problem. Literature doesn´t have sufficient data about all rivers and flow rates. We have some knowledge about the flow rates if we have a hydrometric monitoring station on the river. If a web-application can do the calculation about what is the amount of water in the river during different seasons, what is the amount of planned abstraction and how much water is needed for life in water, then it could be a helpful assistance for us.

If the water user is new to us, no previous history, we have little data anyway. So, any kind of background data would be helpful. Data about river flow rates can be calculated or from the hydrometric station – we can use both.

Calculation in very simple way:

Water in river – water needed for life in water - amount needed for Fish pass (if exists) = x m3/sec .

X m3/sec could be the available water for potential water users.

We can compare if the planned abstraction y m3/sec is higher/lower than the available resource.

Also, it can be shown on graph. Like the web application is functioning right now, all the lines could be added to graph, and it will draw the critical zones.

We know that the critical zones may be in summer, but since climate is changing, there are more Fish farms starting operating, and there are no new hydrometric stations being installed, we would be thankful for this kind of help.

Appendix 4 – Graphical representation of the water use situations

The following figure shows the representation of the water use situations. The figure is a drawing elaborated by the principal end-user (figure 9).

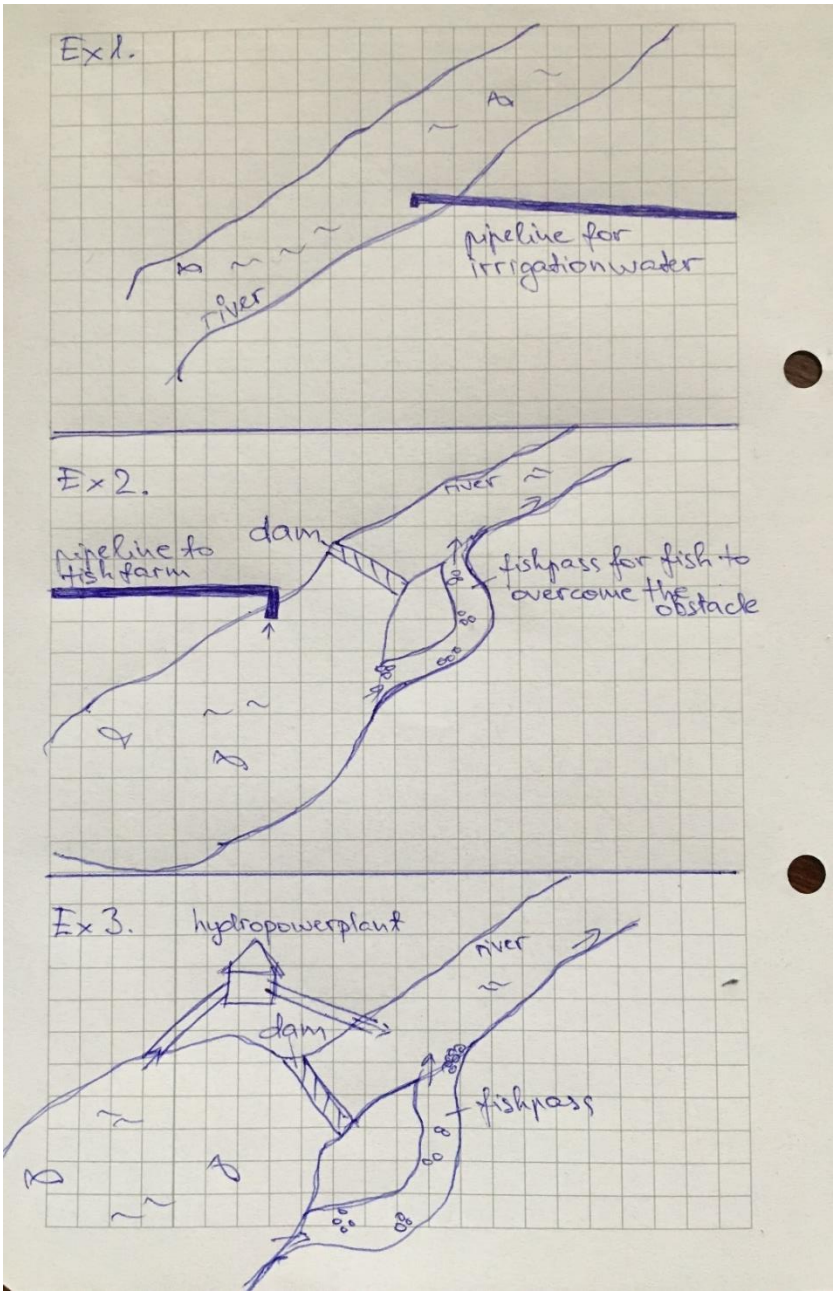

Figure 12. Water use situations

Appendix 5 – Comments send by the user

The following text content is an email sent by the principal end-user in order to provide and insight of the discussion topics for the last revision of the web application:

Hello

I put here some of our thoughts for tomorrow´s discussion.

1. We have doubts that the data about Ahja river is not correct, too many peaks and too many red dots throughout the year.
2. Environmental threshold is a constant right now. Would it be possible to make it a character that we can change ourselves?
3. If we draw a graph, would it be possible to download it to share the info with water user?
4. The graph as now is hard to understand. If the abstraction amount is entered, the new dots could be different color? Also it would help to see the graph only one quarter at a time (so the graph would be wider horizontally). Also more detailed view on the vertical scale would be helpful.
5. The service will be useful if it could work on any river at any point.
6. Data about one year can be very different. In every day work we use long term daily average data.
7. If we have a working service at some point, what are the possibilities of where it will be put? Who owns the service, who owns the server etc.

All the best,

Elina