Master's thesis

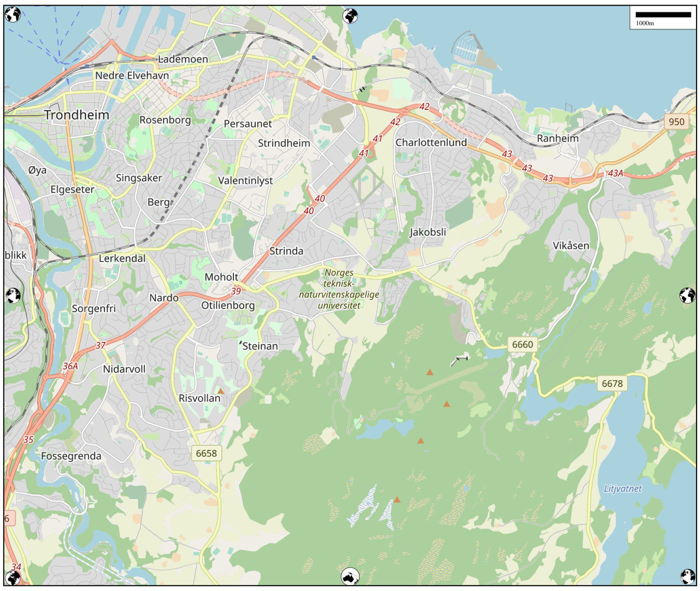
NTNU
Norwegian University of Science and Technology
Faculty of Social and Educational Sciences
Department of Geography

Benjamin Evjen Olsen

Risk perception of natural hazards among high school pupils in Trondheim

A case study using the participatory mapping method Sketch Map Tool

Master's thesis in Lektorutdanning i geografi (MLGEOG)
Supervisor: Martina Calovi
June 2024



SketchMapTool

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Abstract

In a world with growing frequency and intensity of natural hazards, city planning has become more important than ever for mitigating and adapting to the consequences of climate change. A more informed and involved public may create a more resilient community. An individual's natural hazard risk perception will have an impact on what actions they will take in a hazard situation, and how they use and traverse the environment around them. Risk perception is built on knowledge, both general and local, trust in local authorities, and personal experience with natural hazards, both indirect and direct. As a teacher student and soon-to-be teacher, it is important for me to raise awareness for my pupils about the changing environment and how to navigate the ever-evolving sources of information that are available on the internet. In this study, I map and analyze pupil risk perception. The first of the methods I use for collecting data is a survey for the context of what natural hazard knowledge the pupils possess, where they have gotten it from and personal experience. The main method for visualizing the risk perception is done with the participatory mapping tool Sketch Map Tool, which is an open-source tool in development and available on GitHub. The goal of this study is to test how this tool can be used to measure risk perception among high school pupils and see if this method can be used by the municipality for city planning. The Sketch Map Tool is an easy-to-use mapping tool that is low in cost and does not require extensive technological knowledge to use, which makes it quite accessible. The pupil results from this study are not representative for generalization but are indicative that a spark of interest in climate change consequences may require more attention in education.

Sammendrag

I en verden med stadig hyppigere og mer intense naturkatastrofer har byplanlegging blitt viktigere enn noensinne for å redusere og tilpasse seg konsekvensene av klimaendringene. En mer informert og involvert befolkning kan skape et sterkere forberedt samfunn. Den enkeltes oppfatning av risiko for naturkatastrofer vil påvirke hvilke handlinger de vil utføre i en faresituasjon, og hvordan de bruker og ferdes i miljøet rundt seg. Risikooppfatningen bygger på kunnskap, både generell og lokal, tillit til lokale myndigheter og personlig erfaring med naturfarer, både direkte og indirekte. Som lærerstudent og kommende lærer er det viktig for meg å bevisstgjøre elevene mine om hvordan miljøet er i endring, og hvordan de kan navigere seg fram i de stadig nye informasjonskildene som er tilgjengelige på internett. I denne studien kartlegger og analyserer jeg elevenes risikopersepsjon. Den første metoden jeg bruker for å samle inn data, er en spørreundersøkelse for å kartlegge hvilken kunnskap elevene har om naturfarer, hvor de har fått den fra, og hvilke personlige erfaringer de har. Hoved-metoden for å visualisere risikooppfatningen gjøres med det kartleggingsverktøyet Sketch Map Tool, som er et åpent kildekode-verktøy under utvikling og tilgjengelig på GitHub. Målet med denne studien er å teste hvordan dette verktøyet kan brukes til å måle risikopersepsjon blant elever i videregående skole, og se om denne metoden kan brukes av kommunen i byplanlegging. Sketch Map Tool er et brukervennlig kartleggingsverktøy som er rimelig og ikke krever omfattende teknologiske kunnskaper, noe som gjør det svært tilgjengelig. Elevresultatene fra denne studien er ikke representative for generalisering, men indikerer at det kan være behov for mer oppmerksomhet i undervisningen for å vekke interessen for konsekvensene av klimaendringene.

Foreword

I would first like to thank NTNU for all the experiences and knowledge I have gained from the five years I have been here in Trondheim. The journey has been filled with ups and downs but has ultimately given me an experience that has developed me as a person.

For my master's thesis I would like to thank my great supervisor, Martina Calovi. You brought the Sketch Map Tool to my attention and helped me shape the method for conducting my study. Your words of motivation and your guidance have been invaluable for my completion of this study.

Lastly, I would like to thank all my fellow students for all the great times we have spent together over the years.

Thank you!

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1. Introduction

The environment is constantly changing around us, which makes it important to plan for known and unknown changes that may cause harm to people living together in a community (Amundsen & Dannevig, 2021). High school pupils learn about climate change from many different sources in this digitalized and globalized modern world. The theme of climate change and its' consequences has come more into focus for municipality planning in the last few decades (Amundsen & Dannevig, 2021, p. 2). One of the purposes for a teacher in geography is to educate and prepare the pupils for an ever-changing world, helping them to develop their own tools for critical thinking (Kunnskapsdepartementet, 2017). A way to help them with this is to map out what needs to be done based on their current knowledge. Never has information been so widely available, but how familiar are pupils with the environment around them? They consume information from many different sources, be it social media, other digital sources, school, or the people around them. How does this shape their risk perception of possible local natural hazards? Climate changes have led to more frequent and stronger occurrences of natural hazards, and understanding the risk perception of the public is of high importance for preparing and adapting (Lujala et al., 2015, p. 2). This case study includes mapping of areas with risk for flooding, clay slides or landslides for Trondheim with map data downloaded from *Norges vassdrags- og energidirektorat* (NVE, 2024). Participatory mapping involvingnpupils may be an important input for city planning for preventative measures in exposed areas that they use frequently, and possibly unaware of any danger. Additionally, information about where these pupils retrieve the information about the local environment around them is useful in planning where to share vital information about natural hazards. Knowledge about these hazards play an important role in risk perception (Klonner, Usón, et al., 2021, p. 57).

1.1 Research question

As a geography student and soon-to-be teacher, I have always been fascinated by maps and their use for presenting and sharing knowledge. They are incredibly useful tools that also have their place in the classroom for pupils to create a reference that knowledge can be connected to, as for example mental maps (Nolet, 2022). Additionally, I am interested in city planning and more specifically planning for preparedness for possible natural hazards. City planning and hazard mitigation can be a key element for maintaining a hazard free day-to-day life of citizens, but data is needed to make an assessment in how and where to use resources (Amundsen & Dannevig, 2021, p. 2). This also includes platforms to easily inform the population in the given municipality, and in this case Trondheim. Participatory mapping can be a method to collect data from the public, to contribute to city planning. One such participatory mapping software is the open-source Sketch Map Tool, which is an easy-to-use software for generating maps with OpenStreetMap quality and digitalizing collected data for spatial analysis (Sketch-Map-Tool.heigit.org, 2024b). This is why I am interested in creating a framework for collecting data regarding risk perception among high school students. The main research questions are the following:

What is the perception of natural hazard risk in Trondheim among high school pupils?

Is Sketch Map Tool an effective participatory mapping method to measure natural hazard risk perception among high school pupils? Can the output be used for city planning?

When referring to high school pupils in this paper, I am specifically referring to first year students who attend the common geography course (Kunnskapsdepartementet, 2019) and are between 16 to 17 years old. This is the target group of the participants in this study and the age group that participated. To be able to answer these questions, a participatory sketch mapping tool is used (Sketch-Map-Tool.heigit.org, 2024a). And for the context of knowledge, interest and exposure to natural hazards, the survey tool Nettskjema has been used to collect answers (Nettskjema, 2024).

1.2 Structure

I start this thesis by looking at the background for why natural hazard awareness is important for public resilience against natural hazards. Afterwards, I will describe how other studies on youth natural hazard risk perception have been conducted with both surveys and participatory mapping methods. Then I will explain who has developed the Sketch Map Tool and its background. Following the background explanation of this study, I will go through some theory on risk perception, participatory mapping and some of the natural hazards that have been mapped for Trondheim by (NVE, 2024). The method for how this study has been conducted will be explained next, with a further explanation of how the participatory mapping tool was used and how the survey was constructed. Additionally, I will discuss some ethical considerations and the quality of this research in the methods chapter. Afterwards, I will present the results from both the survey and the participatory mapping exercise, and later discuss them in the light of the background and theory for this study.

2. Background

2.1 Rising risk for natural hazards and communication of them

It is important to understand the changing climate that we live in. Patterns for changes in weather and natural hazard frequency should be taken into consideration for city planning as a preventative measure in anticipation of changes in the future. Heavy precipitation events will occur more frequently in Norway going forward, with a potential increase up to 40% by the end of the century (Amundsen & Dannevig, 2021, p. 1). This can be particularly harmful in Trondheim that, given its geomorphology, is a prone area to quick clay events, in addition to possible flooding of Nidelva, which can affect buildings in proximity. Since 2010 there have been significant changes to preventative planning for climate change. It is now mandatory for Norwegian municipalities to prepare a climate risks analysis, included in their risk and vulnerability assessments, and could be held directly accountable if it was not documented that an analysis has been conducted (Amundsen & Dannevig, 2021, p. 2). However, there are some barriers for proactive adaptation against natural hazards in municipalities. Some of these include: lack of resources, and “low perception of the need for and motivation to adapt; prioritising tasks other than adaptation…” (Amundsen & Dannevig, 2021, p. 2). I believe that participatory mapping software tool that is freely available can potentially be a way to overcome these barriers and lower the bar for including such data in the planning. There are many logistical costs that often need to be considered when conducting participatory mapping, such as travel, workshops, printing tools and the price for high precision and accuracy data (Kyem & Burnett, 2023, p. 244). The fact that Sketch Map Tool is an open-source software removes the cost for the production and digitization of data, except for the printing of maps (Sketch-Map-Tool.heigit.org, 2024b). The data generated with this software can also be used for analysis in an open-source GIS software such as QGIS (QGIS.org, 2024). With more knowledge of how the younger population use the local environment it may be easier to see the need to- and to delegate resources for proactive measures in these areas.

In order to improve natural hazard risk perception among the population and build more resilient societies, it is fundamental to establish a dialogue between the administration and the citizens (Ge et al., 2021, p. 3136). Risk communication can be seen as a centered way of exchanging such information from experts to the potential affected public, and often regarding specific events, while risk education can be seen as information on hazards transferred in a more general sense from professionals to people in school (Höppner et al., 2010, p. 5). When discussing communication of a message to an affected mass, Shannon and Weaver's general communication process model can be used to visualize the process. The intent and importance of a message can be interpreted in a different way by the receiver. An expert in a field gives information to, for example, the municipality about a large increase in precipitation that is to be expected in the coming week. The municipality will then find a way to communicate that information to the people that could be affected. The receiver is the people affected and the interpretation of the message is the destination. Effective communication should bring the message through despite the noise (Rød, 2017, p. 198). The noise can be anything interfering with the meaning of the message passing on as intended. An example of such noise can be trust in the government (Ge et al., 2021, p. 3135).

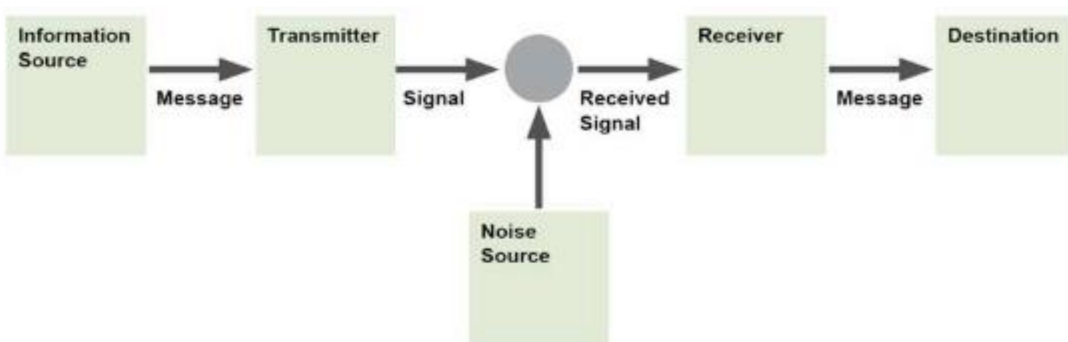

Figure 1 – Shannon's general communication system of a message (Höppner et al., 2010, p. 6).

From a management perspective risk communication has different purposes and functions regarding when it takes place. The communication can be sent before, during or after an event. For this study I am most interested in the "before" phase as it has the purpose of preventing and preparing for possible risks. It also serves the function of awareness raising and providing information. "Information provision" has the important function of showing where to find, and how to interpret and respond to the information (Höppner et al., 2010, p. 17).

Risk education is part of a process to help a learner how to understand natural hazard risks and spread awareness (Höppner et al., 2010, p. 5). Introduction of communication about hazards and what they are at an early point in the school curriculum can help spark interest for, and therefore, more of an understanding of risks and how to act according to them (Höppner et al., 2010, p. 107). Early habits can help shape a new generation with the tools they need to meet a world with growing natural hazards risk. In the geography curriculum in Norwegian high school there are two specific competence goals that target climate change and natural hazards:

- *Explore what changes in the climate means for nature and society locally, regionally or globally*
- *Explore and explain causes for a relevant nature- or environment-disaster and consequences for people, society and nature*
  (Kunnskapsdepartementet, 2019)

Additionally, the core curriculum also specifies that a goal for pupils is to gain respect for nature and nature awareness (Kunnskapsdepartementet, 2017).

2.2 Risk perception studies

2.2.1 A local-scale case study in Italy

Loredana Antronico et al. aimed to identify factors that influence or determine risk perception among high school students between age 13 to 20 in the article *Perception of climate change and geo-hydrological risk among high-school students: A local-scale study in Italy (Antronico et al., 2023)*. The focus on finding these indicating factors lies in that they could help implement more effective communication strategies. Other research about young people's perception of climate change and its causes and consequences shows that they primarily affect other places than where they live and affect other people (Antronico et al., 2023, p. 2). This shows that development of local knowledge is important for understanding hazard risks and acquiring better risk perception. Furthermore, the paper highlights that education about climate change can be a primary factor in raising environmental awareness among the pupils in this age group that attends school. The two hazard risks that this study focuses on are landslides and floods.

The particular aims for the study are to analyze the students' level of knowledge about these water-based phenomena, where they get information from and the most efficient one, how safe they feel, their knowledge about climate change, and their attitudes towards the consequences (Antronico et al., 2023, p. 2). The results of this study highlight that the students get a lot of information through mass social media and from the people around them, such as family and friends. This way of retrieving information affects their attitudes and behavior towards climate change and natural hazard risks. Additionally, good communication through media can spark even more of an interest in this and help them increase their risk perception. Proper communication can also improve attitudes towards government and local administrations. Interest can play an important role in acquiring knowledge among youth. Despite the acknowledgement of disaster risk reduction seemed to be prevalent, many of the schools did not have a curriculum with enough focus on natural hazards and climate change. They concluded that for a more resilient population, the government and authorities need to know the needs of its citizens, and particularly young people (Antronico et al., 2023, p. 12).

2.2.2 Flood-risk perception of students in the Netherlands

Adwin Bosschaart et al. conducted a study on student flood-risk perception in the Netherlands, since it has previously only been studied related to adults, with the study *The role of knowledge in students' flood-risk perception (Bosschaart et al., 2013, p. 1661).* In this study a survey among 483 15-year-old students has been conducted from flood-prone areas in the Netherlands, with a reference group of 134 students from higher elevation areas. The participants have all had geography courses for three years. The survey is divided into two main sections, one about risk perception and the other is a knowledge test about flood hazards. Flood risk perception is a very relevant topic to the Netherlands as approximately 25% of the country land mass is below sea-level (Bosschaart et al., 2013, pp. 1662-1663). Therefore, the possibilities of sea-level-rise because of climate changes could have devastating effects. The goals for this study were to investigate how different factors shaped the students' flood-risk perception.

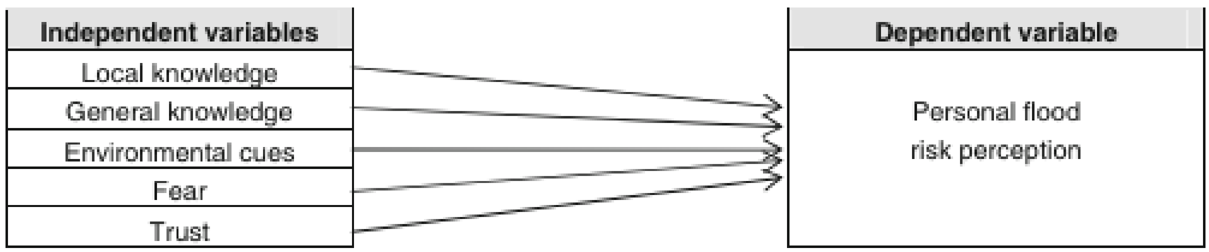

Figure 2 – Variables used in the study for flood-risk perception (Bosschaart et al., 2013, p. 1667).

Here, the different variables that would contribute to the total personal flood risk perception are presented. Local knowledge is a factor that covers the knowledge about the local environment and possible risks associated with the area. General knowledge can be perceived as the knowledge that one obtains from different sources and a more surface knowledge. The Environmental refers to the knowledge of how the causes and effects of the relevant hazards are, while fear and trust lies in personal experience with authorities and hazards.

The measurements of risk perception were done by asking a series of 18 statements where the participant would answer on a five-point scale from “disagree completely” to “agree completely”. Knowledge was measured in two parts: general knowledge about the Netherlands, and local knowledge of the surrounding area of the school. The knowledge test had 10 multiple-choice questions and 15 “true” or “false” questions. (Bosschaart et al., 2013, pp. 1669-1670). The results of the study showed that the level of knowledge, both local and general, among the students was low (Bosschaart et al., 2013, p. 1671). Since the knowledge tests were based on the common school curriculum, this education’s effectiveness may not have been too high. It is dependent on the specific students and teachers for them too. Perhaps, as earlier mentioned, the trust in national and local flood-risk control may be the cause of a lowered interest for attaining more knowledge in this field among the students. The study also differentiated the students living in lower flood-prone areas and the control group from higher elevations. The risk perception of personal flood exposure was much higher for the students living in the flood-prone areas, as could have been expected (Bosschaart et al., 2013, p. 1671). Which means that students in these areas have some awareness of the possibility of a flood-hazard happening and affecting them. The general perception of exposure was much higher than local exposure (Bosschaart et al., 2013, p. 1673). This is very much the same trend as seen in the previous mentioned study.

One of the conclusions from the study was that the large trust in flood-risk management could be a reason as the risk perception among this age group was so low. Especially when they also read and learn a lot about how well the flood-risk handling is done in the country. With this knowledge there may no longer be the need to feel any sense of risk. The role of the geography teachers in improving the students' hazards knowledge and awareness is also pointed out. This is individual for each teacher, but also based on the material of the curriculum and books that they have at their disposal. The low level of knowledge among the students may be a result of and/or the reason for low interest in the subject. Additionally, local knowledge is highly lacking, which needs more attention to how this can be communicated to this group in a more efficient way, both through media from authorities and in education. The theme of "it won't happened to me" is also prevalent in the low fear and high trust results combined with the low local knowledge (Bosschaart et al., 2013, p. 1675).

The majority of risk perception research has been done among adults. (Bosschaart et al., 2013, pp. 1661-1662). The same is also the case for Norway. When searching for other research about participatory mapping of pupils or young peoples' risk perception I found very few. The youth is an important part of the population and need more attention in research for risk perception to create a more resilient community.

2.2.3 Understanding risk perception from floods: a case study from Chaina

Yi Ge et al. conducted a- study on the public risk perception for helping to develop better communication strategies with the article *Understanding risk perception from floods: a case study from China (Ge et al., 2021).* In this study the authors collected their sample dataset using a survey distributed among 702 respondents in urban areas and peri-urban areas in Nanjing, which is the capital of Jiangsu province in eastern China, and in the southern area of the Yangtze river (Ge et al., 2021, p. 3125). It explores the relationship between risk perception and exposure to flood hazards. When it comes to the design of the survey itself it was based on five domains: "flood perception, experience, flood protection, social trust and demographic data" (Ge et al., 2021, p. 3126). The results of this analysis suggest that the relation between exposure and risk perception was significant. That experience can make people more aware of the actuality of a risk, and that they may be more cautious moving forward (Ge et al., 2021, p. 3119). Social trust also had a significant importance on risk perception. Especially trust in family members and their knowledge (Ge et al., 2021, p. 3130).

2.2.4 Effects of disaster education on children's risk perception and preparedness

Ayse Yildiz et al. conducted a study where the aim was to examine the effects of natural hazard disaster education on children and how this affected their risk perception and preparedness, with the article *Effects of disaster education on children's risk perception and preparedness: A quasi-experimental longitudinal study (Yildiz et al., 2024)*. This education lasted 18 months and involved a total of 720 school children. The main goal for this program was to improve their awareness and risk perception through discussions, visual material, and interactive teaching. These interactive processes can be perceived as deep learning meta-cognitive learning. The discussion of the knowledge they should acquire in this education program further enhances the idea that people learn through interacting with others (Nolet, 2022, p. 251).

Some conclusions and recommendations from this article from further studies was that focused education on the subject could help children pay more attention to preparations for disasters. The visual elements that showed effects of landslides, for example, made it easier for the children to understand outcomes and consequences. In this study they also concluded that despite the risk and natural hazards of being a part of the school curriculum, the way it is taught may need to change and give the topic more focus and depth. Better hazard risk education did show an improvement for the participating children (Yildiz et al., 2024, p. 13). They also emphasize that "…young people need to be concerned about environmental hazards threatening a sustainable future", and that education initiatives can help the children get an interest for engaging with environmental issues (Yildiz et al., 2024, p. 11). A way to get more attention to the authorities about the need for more focus on hazard risk education in school is to map and collect data on how the current risk perception and understanding is among children in school.

2.3 Sketch Map Tool

Climate changes and increased temperatures have led to an increase in natural hazards and disasters, which requires adaptation in planning (Amundsen & Dannevig, 2021, p. 1). This has resulted in preventative measures integrated in planning processes to be adaptive for change going forward. Local knowledge can also be integrated to a larger degree in these planning processes, and the Sketch Map Tool is such a mapping method originally invented to collect local knowledge in the context of flooding (Klonner, Hartmann, et al., 2021). The aim for this mapping method is to visualize and communicate collected data in an understandable way. The maps are also made with OpenStreetMap data, and a quality check is performed for the data in the local area of the map that is made using their tool (Sketch-Map-Tool.heigit.org, 2024a). The OpenStreetMap History Database is developed by the Heidelberg Institute for Geoinformation Technology (HeiGIT) and allows for OpenStreetMap data for any chosen spatial-temporal extent (Klonner, Hartmann, et al., 2021, p. 3). HeiGIT has also developed The Ohsome Application Programming Interface which has access to the OpenStreetMap data and allows for analyses of it and quality checking of the data (Klonner, Hartmann, et al., 2021, p. 3). The quality analysis of the chosen area is given when generating the map Figure 5. The tool is meant to be used in participatory mapping approaches, and an easy-to-use tool for local authorities or shareholders. The PDF generated document of the map contains a QR-code which is necessary for automatic georeferencing. It is important that the QR-code and the globes that form the map boundaries to be visible when digitizing the maps, and the georeferenced map can be used for visualization for further analysis when generating GeoTIFF files (A georeferenced picture of the map) (Klonner, Hartmann, et al., 2021, p. 3).

The Sketch Map Tool is a work in progress project that is continuously improving with the help of potential users of the tool (Klonner, Hartmann, et al., 2021, p. 15). HeiGIT and the GIScience Research Group from Heidelberg University have been developing the project in close collaboration with each other and several sponsors (Sketch-Map-Tool.heigit.org, 2024b). The prototype for the project started in 2018 and has been in development since. The first freely accessible stable version of the project was in 2023, with the newest relaunch of the stable version earlier in 2024 (Sketch-Map-Tool.heigit.org, 2024b). For a more detailed description of the development history, see Figure 3. Additionally, the code of the Sketch Map Tool is freely available on GitHub, so that programmers can help support the project and share areas that need improvements along with possible solutions (Sketch-Map-Tool.heigit.org, 2024b).

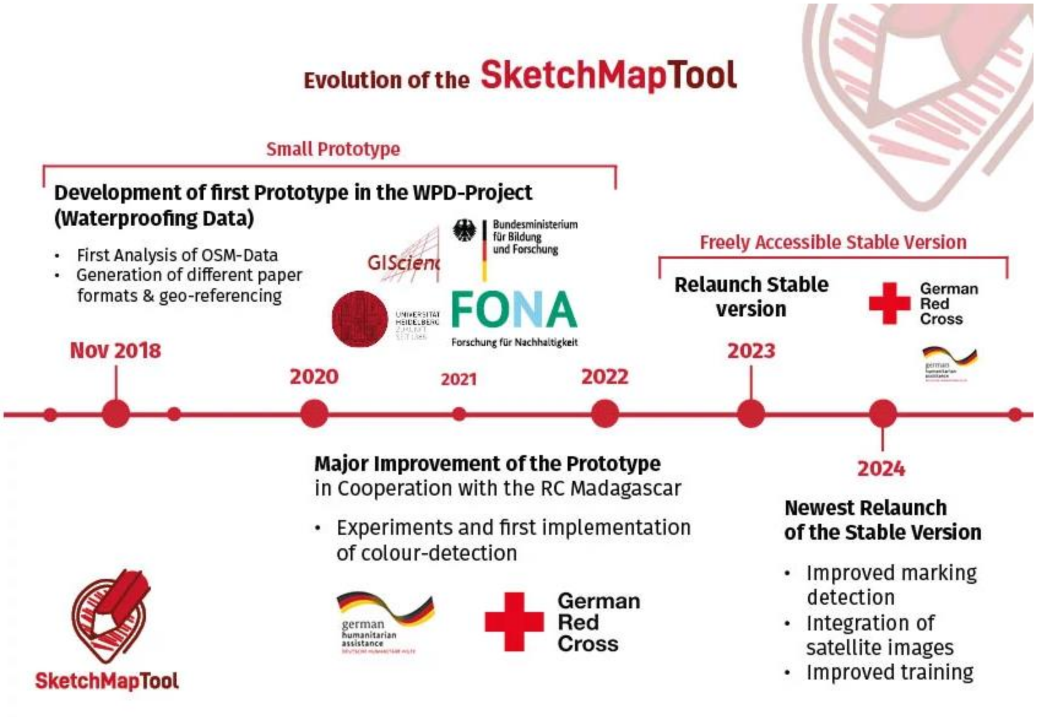

Figure 3 - The evolution of the Sketch Map Tool. Picture taken from the "About" page on their webpage (Sketch-Map-Tool.heigit.org, 2024b).

2.3.1 Participatory mapping studies

Another case study has been conducted in Ederbach, Germany, where the tool was used to involve citizens in a disaster risk reduction process (Klonner, Usón, et al., 2021). The use of paper and pen approach makes the tool more accessible as a participatory process since it removes the technological barrier of participating using digital means. With Sketch Map Tool, the base map contains data from OpenStreetMap, which makes the map spatially correct and the georeferencing of the maps saves a lot of time in correcting the data (Klonner, Usón, et al., 2021, p. 69). One of the conclusions from this study was that "Future research should investigate the additional value of tools like interactive platforms that can combine knowledge captured with sketch maps together with official measurement data..-" (Klonner, Usón, et al., 2021, p. 69). This specific conclusion is addressed, in this thesis, where I compare the results of the Sketch Map exercise done with pupils to the local natural hazard map data from (NVE, 2024).

The relatively low cost of using the Sketch Map Tool approach makes it easily accessible and adoptable at a local community level. It can be sent out to the field in paper format to people who do not need to have any specific technological knowledge and then sent back either in paper format or directly as pictures to the authorities or institutions that will analyze the data. To visualize the data can be done with reviewing the maps of the collected data with the accuracy of the OpenStreetMap, or it can be sent to other authorities who can analyze the data by digitizing it and visualizing it with a GIS software (Klonner, Hartmann, et al., 2021). However, the tool may not be fully applicable to more remote areas as the areas may have fewer landmarks and infrastructure. This may make it hard to read the map and fill in proper and accurate information (Klipper, 2024, p. 8).

3. Theory

3.1 Risk perception

Most risk perception studies that target natural hazards have chosen to focus on adults, and few among children and students (Bosschaart et al., 2013, p. 1662). Risk perception is a very subjective view of the environment either locally or in general, and it is determined by factors affecting the individual. It is the personal assessment of the probability of a hazard happening and the following consequences, in addition to possible actions that can be taken in such a situation (Scovell et al., 2022, p. 453). Personal risk and exposure to natural hazards can shape risk perception of their local area compared to the general perception of risk. The bias of never having been affected by any hazard despite it being a prevalent threat in an area can be referred to as “unrealistic optimism” (Scovell et al., 2022, p. 453). People think that they are relatively safe since nothing bad has ever happened to them. Personal risk assessment can also be shaped by trust in local authorities. If efficient measures against possible natural hazards that could affect them were adopted, then people would feel less at risk for such hazards to occur (Wachinger et al., 2013, p. 1051).

Experience with natural hazards is another factor that can affect risk perception. In general, experience can be divided into two dimensions: direct experience, and indirect experience (Wachinger et al., 2013, pp. 1052-1053). The former refers to seeing the hazard by themselves or being directly exposed to it, while indirect experience is a second-hand experience of natural hazards. This can be in the shape of witnessing close ones being exposed to natural hazards, reading about them on any sort of media, or learning about them in educational settings (Ge et al., 2021, p. 3122). The level of exposure, experience, trust, and fear as factors to influence risk perception and protective behaviors is still a debated topic in research, where results seem to vary wildly and not show a concrete answer. This can be the result of different methods being used, or different definitions or understandings of the concept risk perception.

3.2 Participatory mapping

Participatory mapping can be explained as a method and/or tool for collecting information about a chosen topic, in this case natural hazard risk perception (Burnett et al., 2023, pp. 3-4). Having the public participate in planning with these tools can be seen as a democratic way to influence city planning. It can be used to create a feeling of empowerment and that citizens are being included and valued (Burnett et al., 2023, pp. 3-4). New digital tools that have been developed over the past decades, and a changed how planning processes have included the publics' engagement with their opinions and knowledge in planning (Beauregard, 2020). New digital tools have made collecting such data much easier and it can be done over longer distances and include more people. GIS has contributed to the participatory mapping process by connecting location data to a map and visualizing statistics to monitor changes (Burnett et al., 2023).

Public participation is not only optional in Norway, but it is mandatory to different degrees dependent on who and to what degree they will be affected by something, according to the Norwegian Plan- and Building law (Rothschild & Ekberg, 2022, p. 10). Public participation can then be viewed as a right to be part of the process. Children are also part of the citizens that will be affected by municipality and city planning processes, and their needs should be accounted for. The term "Barnetråkk" is used for mapping what areas are used by children and is often used in relation to what routes they take to school to improve traffic security. A digital tool can also be used to map what areas that they like/dislike and what activities they use different areas for (Rothschild & Ekberg, 2022, p. 28). This data can then be used by the local authorities to continue analyzing the areas or implementing changes. The importance of implementing some change in accordance with collected results can be important for children to see that their voice has been heard and then gain more trust to local planning authorities.

3.3 Natural hazards risks Trondheim municipality

In this study there is a focus on risk areas of three types of natural hazards in Trondheim. Trondheim is a city that for the most part is situated on marine clay (Ottesen & Langedal, 2001, pp. 1-2). This makes some areas in the municipality susceptible to possible risk of quick clay slide hazards that can cause a variable level of harm upon people or infrastructure. Quick clay is the result of clay sediments that are deposited rapidly into salt water at a high concentration, thus the salt forms a sort of "skeleton" that keeps the stability of the clay intact. However, once too much water is added again later the concentration of salt is diffused and the "skeleton crumbles". The result is that the once solid soil turns to liquid in a moment (Rosenqvist, 1966, pp. 447-448).

Another natural hazard that Trondheim is prone to is floods. The areas and infrastructure close to Nidelva are at risk if the water level rises a few meters. A cause that is likely to raise the water level is the increase in precipitation intensity and amount because of changing climate and warmer temperature. An increase in precipitation over time can also cause a flood (Dykstra & Dzwonkowski, 2021). Intense precipitation periods can cause lakes to overflow and other smaller rivers to flood as well. Lakes up in higher elevations at the east side of Trondheim can be the source of a flooding event.

Additionally, a large amount of water can cause instability in the soil of slopes, potentially causing a landslide. A slope is held up by force and resistance. Flowing water can detach fragments of rock or soil, and therefore reduce the resistance for the slope to hold. With less grain and eventually smoothing out the resistance, the friction will get reduced so that gravitational forces will cause the slope to fail, resulting in a landslide. When the mass starts moving it can consist of primarily rock, as a rockfall landslide, soil that is pulled down on flowing water, or as a flow with primarily water (Kirkby, 2017, pp. 382-387).

3.3.1 NVE data and areas of caution

The data used to display the possibility and risk of natural hazards are downloaded from *Norges vassdrags- og enetgidirektorat (NVE).* The layers that were downloaded were the areas of caution for: flom-aktsomhet, flomsone, skred_JordogFlomskred, and skred_kvikkleire (NVE, 2024). This data is freely available to download and use in GIS analyses. Areas of caution can be explained as mapped areas in the shape of polygons in the dataset that display areas which are prone to any of the listed natural hazards. The degree of danger is also explained in the data for each polygon, but will not be used for this analysis, since my goal is to analyze if the pupils are aware of areas that may be at risk, and not in depth as to which risk or how large the risk could be The data that was downloaded was then later used for ArcGIS Pro to compare with the collected map data done with Sketch Map Tool (Sketch-Map-Tool.heigit.org, 2024a) (esri.com, 2024).

4. Methods

This framework to assess risk perception among pupils consists of two data collection tools and a didactic method for execution of the collection process in the classroom. To collect data, I used the Sketch Map Tool (Sketch-Map-Tool.heigit.org, 2024a) and an online survey to collect information regarding natural hazard risk perception through Nettskjema.no (Nettskjema, 2024). Initially the purpose of this project was meant to be more of a quantitative GIS analysis of the collected map data, but due to circumstances that I will address in the discussion section, the trajectory changed, focusing more on the method itself as a framework. A mass collection of data with maps containing data to be compared, and several answers that can be put in tables and figures for analysis is referred to as a quantitative method (Hammarberg et al., 2016, p. 498). In general, quantitative research is appropriate when factual data is collected to answer a research question. When variables can be identified and isolated and one already has some idea of what the answer might be (Hammarberg et al., 2016, p. 498). The answers can be used for statistical analysis to find answers in numbers or percentages of a target group, or to find relations between different variables and factors (Hammarberg et al., 2016, p. 498). In addition, I study the collected answers and maps for their information and try to assess a pattern in the frequency, though with just one school class the results will not be fully representative. Qualitative research is often related to small-group discussions or interviews where there is a focused topic. It can be used to collect personal data and experiences and go in depth and analyze the few samples of collected data (Hammarberg et al., 2016, p. 498). The two methods do not need to be applied separately but can be interchangeable (Hammarberg et al., 2016, p. 499). In this study, the survey is meant as a quantitative collection method to find where of a selection of participants have gotten their risk knowledge, and how they perceived the risk itself, and a qualitative analysis about the usage of a participatory mapping tool. Therefore, I argue that this project is a mixture of both a quantitative and a qualitative method.

In this chapter I will describe the two methods I have chosen for collecting data and how they were used in this project. I will describe how the Sketch Map Tool works and give an example of how the base map used in this project looks like. Afterwards, I will explain how the survey was designed and what purpose it has for the analysis. Then I will describe how the data has been collected in the classroom and what didactic considerations were considered for the planning process. Following the execution of the collection of maps and surveys, I go through how the data was processed and prepared for display and analysis. This chapter ends with the ethical considerations for this project and a discussion about the quality of this research.

4.1 Sketch Map Tool

The main tool used for this research is the Sketch Map Tool, which is a participatory mapping tool which uses OpenStreetMap data (Klonner, Hartmann, et al., 2021). In this section I will explain how the tool works, not in a very technical sense as it is outside the grasp of this analysis, and how I have used it for collecting data. An evaluation of how the tool worked and functioned in this case is discussed later, in conjunction with some other uses of this tool. The tool visualizes knowledge with a clear and updated map in the form of OpenStreetMap to make the communication of results easily understandable (Klonner, Hartmann, et al., 2021, p. 1). The concept of the tool is that you choose your area of interest - to collect data for, which I have chosen Trondheim. Then you create a map with the map generation feature (Klonner, Hartmann, et al., 2021, p. 3). This is the basis for the map that will be used, and it is generated as a PDF with a QR code that is necessary for georeferencing globes that are placed at the edges of the map to detect the boundaries (Klonner, Hartmann, et al., 2021, p. 3).

Generating a map on the tool's website is part of a three-step process. First, the area and scale must be chosen. The two rectangles in the map present how the product will come out as a PDF with the red outline as where the map will be and the black rectangle as where the paper itself is. See Figure 6 for reference. Then it is possible to choose some general format setting, I chose A4 as Paper format and to have the orientation as landscape.

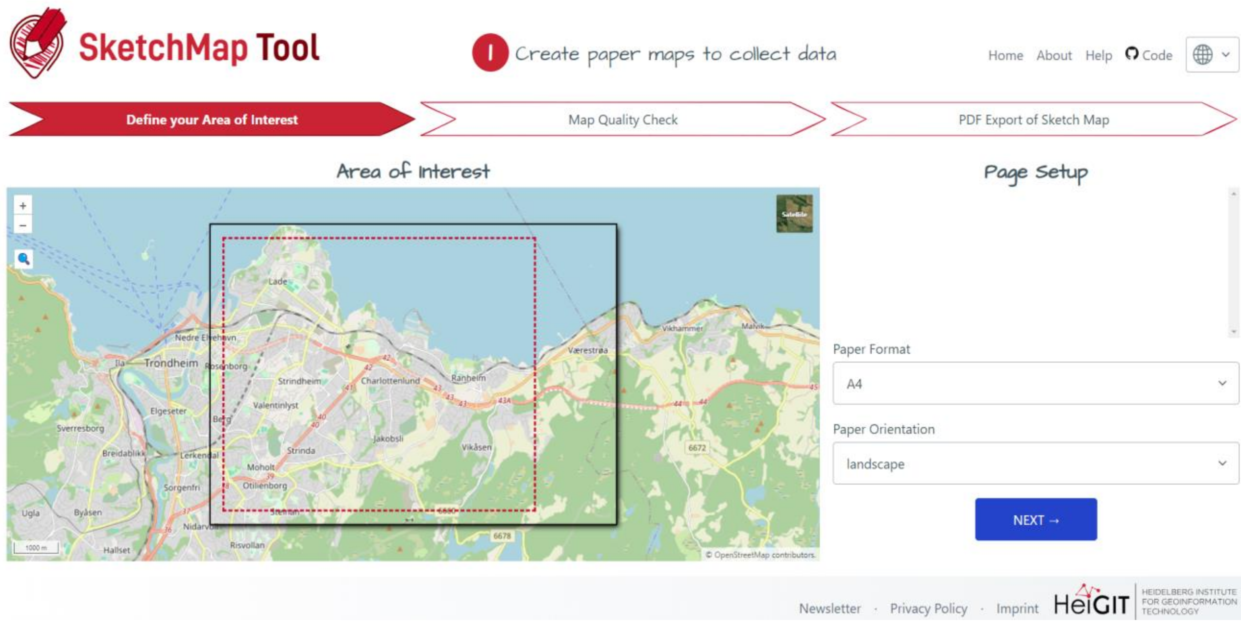

Figure 4 - Creation of paper maps to collect data (Sketch-Map-Tool.heigit.org, 2024a).

After a quality check, the actual Sketch Map Template is ready to download. The quality check allows for an assessment on the quality of the existing OpenStreetMap data for the area in a "traffic light" way to display it. There is information and recommendations that could be helpful for possible further analysis of the area and accuracy of the data (Klonner, Hartmann, et al., 2021, p. 10). For the Sketch Map Template there is the download option to get the georeferenced map as a PDF that is ready for data collection.

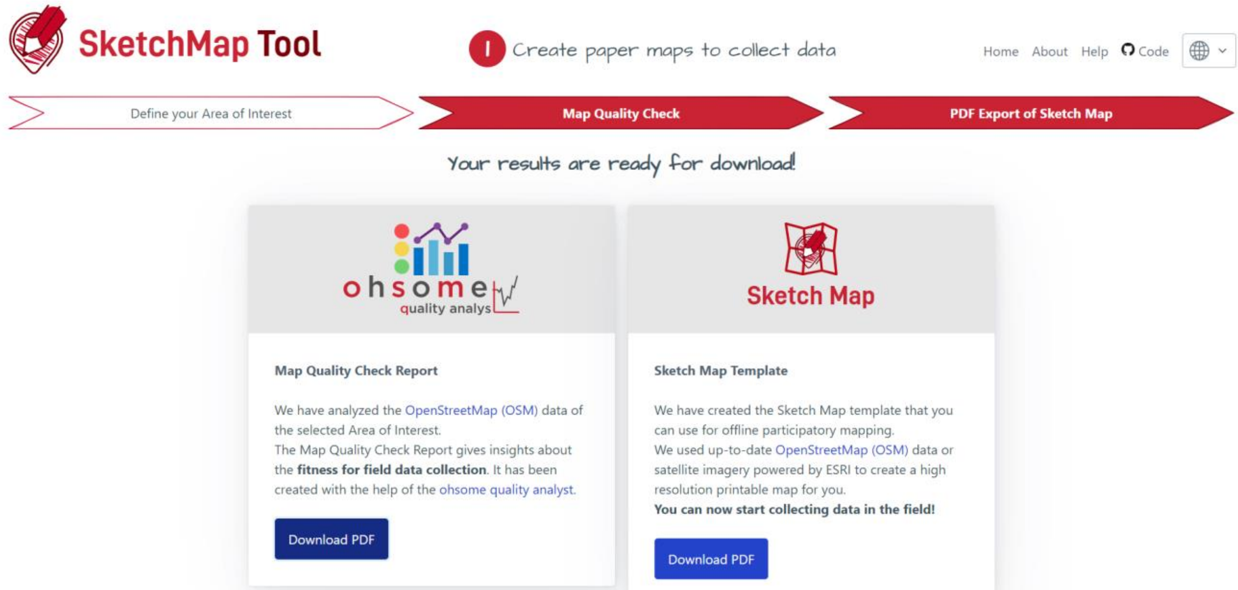

Figure 5 - Map quality Check and PDF export of the generated Sketch Map (Sketch-Map-Tool.heigit.org, 2024a).

Figure 6 – Map of Trondheim generated with (Sketch-Map-Tool.heigit.org, 2024a). It is an area of Trondheim where the black line at the top right of the map shows a distance of 1000 meters. The QR code is at the bottom right side and is necessary for georeferencing the globes that mark the outlines of the map.

I chose this scale and area as it covers the area in Trondheim around Charlottenlund high school and the area that pupils going to this school would be most likely to use for their day-to-day life. The reason as to why the scale did not cover all of Trondheim was that too much detail such as roads would be lost. The level of detail is also important for the used to be able to navigate the map and locate specific features (Klonner, Hartmann, et al., 2021, p. 8). With this generated map I captured the relevant area at a scale that would let markings cover specific roads and areas, since they would be relevant to what the participants should mark on the map.

For the practical part of collecting data, I needed to work with the tool and familiarize myself with it, in addition to deciding what I wanted to map and for what purpose. I wanted the pupils to map the areas they used to gather on a day-to-day basis and what areas they thought were at risk for one of the three hazard types: quick clay slide, flood, or landslide. The term "Barnetråkk" can be used for this process. The actual process of it is a bit more complex than what I have been performing in this case, but the concept remains the same (Rothschild & Ekberg, 2022, pp. 27-28). This term will be explained more in the theory section, see 13. Here I use a tool to map what kind of activities they do in certain areas, and then where they believe and/or know are at risk for the specified natural hazards. I decided upon three categories that the participant would mark on the map to show what areas they used. Then they would mark areas that they thought could be at risk for either of the three natural hazards mentioned earlier. Each of these were then to be marked with different colors in order to distinguish between them in the last step, the uploading of the maps and processing to GeoTIFF or GeoJSON files (Klonner, Hartmann, et al., 2021, p. 10). The first three categories are daily activities, which means areas where the participant spends a lot of time. In the analysis I want to see whether any of these marked areas are in the hazard risk sones or if they mark any areas that they use as a risk sone. The reason for why the three natural hazards is merged lies in the limitation of distinguishing between different colors. The choice of colors required some experimentation, to have them different enough from each other that they would not blend in the upload to GEOTIFF file process, which I will return to in the discussion. I eventually decided upon colors that met this qualification, and that are somewhat commonly available at schools:

Color on the map	What it represents
Black	My way to school
Green	Areas that I use for freetime activities
Blue	Areas where I meet friends and/or socialize
Red	Natural hazards risk areas (Floods, quick clay risk area, and areas at risk for landslides)

Table 1 - Categories for the Sketch Map Tool

After collecting the data, the last step of this process is to digitize the map by uploading pictures of them in either a .png or .jpg picture format. You can upload one or more files at the same time up to the maximum size of 500 MB, which is a considerable size for the picture format files. The option to upload these many files at once makes the process of digitizing the maps considerably easier. This makes the method more approachable for larger collections of physical participatory mapping. The relatively low cost, and high efficiency of digitizing larger quantities of maps, might make the threshold for the use of participatory mapping lower for municipalities or other shareholders. It is important to have proper lighting for the colors to be clear for the program to capture, and to include the entire map with the globes and QR-code (Klonner, Hartmann, et al., 2021, p. 10). This is more important for the use of GeoJSON files where the color of the sketched areas will be made as layers coded as the specific color. Even with unfavorable illumination conditions the tool can recognize the globes and QR-code for making the georeferenced GeoTIFF files (Klonner, Hartmann, et al., 2021, p. 3).

Figure 7 - Insertion of the pictures with data (Sketch-Map-Tool.heigit.org, 2024a).

The result can then be downloaded either as a georeferenced raster as GeoTIFF file, or as a vector GeoJSON file. In other words, a picture of the maps that is georeferenced, or a file where the marked lines and figures on the map appear as separate vector polygon layers. These files can then be directly uploaded and used in a GIS software. I have chosen to use QGIS (QGIS.org, 2024) as the source to upload the downloaded data, and transferred it to ArcGIS Pro (esri.com, 2024) to work with the downloaded files and display the results.

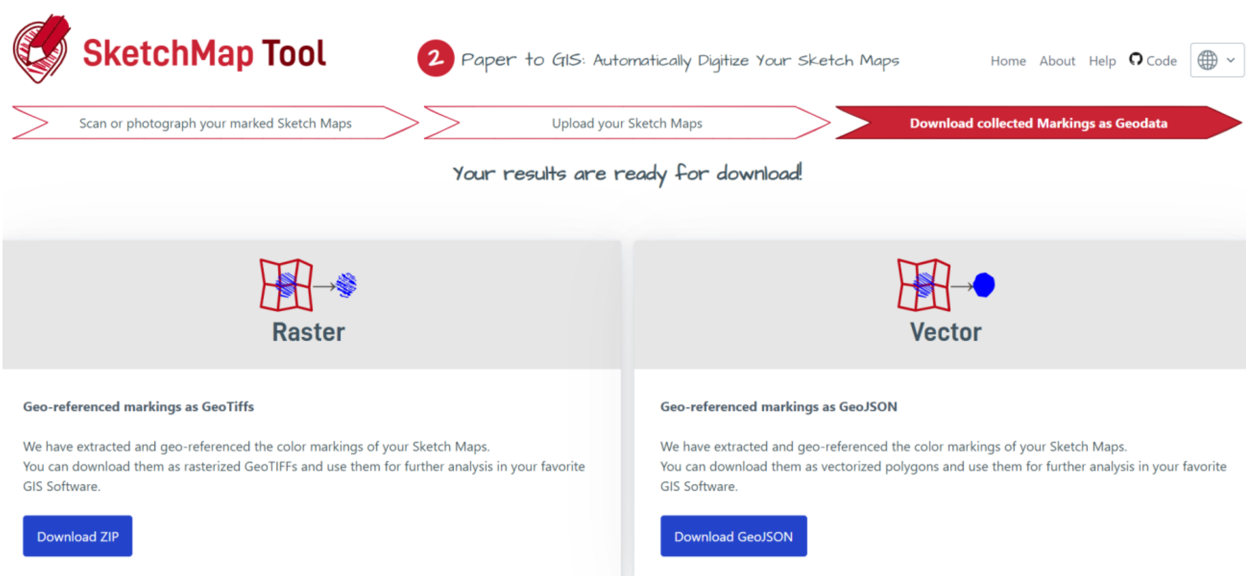

Figure 8 - The uploaded picture with data ready for download either as a georeferenced Raster or as a GEOTIFF file Vector (Sketch-Map-Tool.heigit.org, 2024a).

4.2 Survey

I have chosen to supplement the participatory mapping method with a survey to put some context for the map data, and to see where they got their knowledge about natural hazards. The survey is therefore used to complement the discussion of the Sketch Map Tool data, and will be used for the analysis, as well as the result from the analysis itself. With my thesis question "*What is the perception of natural hazard risk in Trondheim among high school pupils?*" I find that knowing some of the participants' background knowledge and experience is important in answering this question. The answers might help explain certain patterns that are found on the markings of the maps. With one of the first questions, it might also help in refining this process for later uses with their own opinion if the explanations were good enough, and they understood how to do the task. If many pupils say that they did not understand what they were doing, that would be an indication for me as the instructor that either I did poorly in explaining the task, or the task itself was hard to do. It could be that the map was too unclear to use or navigate or that the task was simply at too difficult a level. This is why the survey is an important part of analyzing the answer to my research question. I will now further explain my survey development process.

This is an analytical survey, which has the purpose of finding some correlation between the answers there and the results from the participatory mapping process. An analytical survey has something that it tries to find the answer to, this is the dependent variable. In this case the dependent variable is "risk perception". This dependent variable is affected by several independent variables. Such variables in this case are natural hazard knowledge and exposure. The connection between the dependent and the independent variables is then tested by control variables (Rød, 2017, p. 64). The questions for this survey are formulated as an attempt to see if there are any connections between them. There are not too many control questions in this survey, as one key focus was to keep it short and concise, as to my experience as a teacher the interest in answering and participating in a survey falls considerably if it becomes too long. Also considering that it is asked after the mapping exercise.

Another important consideration for the method is the implementation strategy. Since it is performed in the classroom, and not sent to them after the class, it is mostly conducted "face-to-face" despite them answering on a digital survey on their computer or phones (Rød, 2017, p. 66).

Some benefits of doing it this way is that it often creates a larger frequency of answers, and that misunderstandings can be detected and corrected (Rød, 2017, p. 66). The information text in the survey should still be clear to make sure that there are no misunderstandings. Should any confusion regarding the questions in the survey occur, I will have the opportunity to clear them up for the participants. My presence in the room may have some consequences (Rød, 2017, p. 66). They might feel inclined to answer "yes" in the first question (See Appendix A) to be nice to the person who is present, or "no" should they not like the one presenting it. More information on the survey collection process will be explained later.

I used Nettskjema.no to make and structure the survey and to collect the data for this part of the process. This is a tool that can be used to make surveys, gather and analyze data. It is developed and published by the University in Oslo (Nettskjema, 2024). The service also has good security for collecting and storing sensible data together with "Tjenester for Sensitive Data", and they have gotten approval from Regionale komiteer for medisinsk og helsefaglig forksningsetikk (REK) and Sikt – Kunnskapssektorens tjenesteleverandør (Nettskjema, 2024). Additionally, it provides an easy way to handle the collected data. Data can be downloaded as an excel file for further analysis or can be displayed with an automatically generated report of the answers that can be displayed in the preferred figure style. There are a few styles available dependent on the question type that was added for the survey for each question. Some of the results later will be displayed using this automated report later (Nettskjema, 2024). I did not have any sensitive data in my survey, but I find the service to be quite useful with all the other features included. The survey was in Norwegian, since the class was all Norwegian speakers, ensure most barriers were removed and to guarantee that anything in the survey was too difficult to understand. The removal of English as a language barrier was also done to make as many of the pupils as possible want to do the survey with focusing on the content with no additional distractions (Bernhardt, 1984). Most of the questions were marked as mandatory, but some follow-up or open answer question formats were optional with the same goal in mind. They were there in case the participant wanted to elaborate on their previous answer where it would make sense. The other answers options will be shown in results. The survey was structured to be several small pages than one long page with several questions. This decision was made so that the survey may seem shorter than a long document with several answers. It was possible to move back and forth between the questions, but only a few were visible on the same page at once. It was structured with a theme for the page and informational text about the theme and clarifications about the questions. This format should make the amount of information that they have before them at once more digestible (Rød, 2017).

Question 1-2 were there for the participation in the survey and their answers, and to gauge how well the response was for the participatory mapping task. The questions 3-6 and 9 are there as a control to check the background knowledge and where they could have gotten it from. In hindsight, question 9 should have come directly after 6 to keep them properly categorized. The last questions, 10-12 were there to see the exposure level. In total the survey consisted of 7 pages, each with a specific theme. Page 1 of the survey had a short summary of information about the project, that was elaborated when presenting the survey, and the first question where the participant could opt out of having their answers used for the project. The second page contained question 2 with a focus on if the task was understood. Pages 3 and 4 had the theme of finding social factors for natural hazard knowledge, and the pages had the corresponding number for the questions from the survey. Page 5 had the theme of natural hazard knowledge and school and contained questions 5 to 7. Next, page 6 was to collect information about interactivity with information about/from the municipality with question 8 and 9. Lastly, page 6 was about exposure with direct and indirect knowledge about natural hazards with questions 10 to 12 (Scovell et al., 2022, p. 463). The follow-up dialogue boxes were on the same page as the required question (See Appendix A). Finally, the survey ended with a *Thank you for participating* to show that their participation is appreciated.

4.3 The collection process in class

An important part of the data collection process was the performance in the classroom. The time I had in the classroom was used as a short education class as well, regarding the relevant topic of climate change, and some factors that could lead to some possible natural hazards in the local environment. To meet with this class, I had arranged the date with a teacher at the school so that I could use one school class for this project and the topic. The act of participatory mapping required a variation of colors to work as intended. Therefore, the teacher had prepared markers for the students in case they either did not have any available or forgot to bring them to school.

Another way this could have been done was of course for me to bring that many markers with me, but I did not have the needed amount available myself. If the necessary color markers are not present at the time, then a solution is for the participant to make markings on the map and a legend on the side. This way, the map can be corrected manually afterwards for color before a picture is taken and uploaded for generating the georeferenced data.

I started the class with an introduction with a short introduction of myself as a master's student from NTNU and a short introduction to my project. This was done to prepare the pupils for what they were going to do for this class, so they knew what to expect. Additionally, I informed them in a short summary what the data was going to be used for and the thematic and main goals for my project. Next, I started to introduce the participatory mapping exercise by showing a picture of the map that had been generated for the chosen area by using Sketch Map Tool's generation function. On the map I had examples of how the mapping could be done, as seen in Figure 9 and Figure 10. Each of them would mark on their own individual map, without working together in groups or with the person sitting next to them. What does such a task require of the pupil? The participants were first year students at high school. The collection process was done during the middle of spring, when they are closing in on the end of their first year with the common geography course (Kunnskapsdepartementet, 2019). Skills required for this exercise would first and foremost be to read and understand a map. The scale of the map was of such a quality that several noticeable locations are visible on the map to orient the position of where things are on the map. Some level of local knowledge is also required to be able to recognize the different markings on the map. The area is local to the school, and since getting to know your local environment is part of the curriculum, I go in with the assumption that they have got some knowledge of the local area.

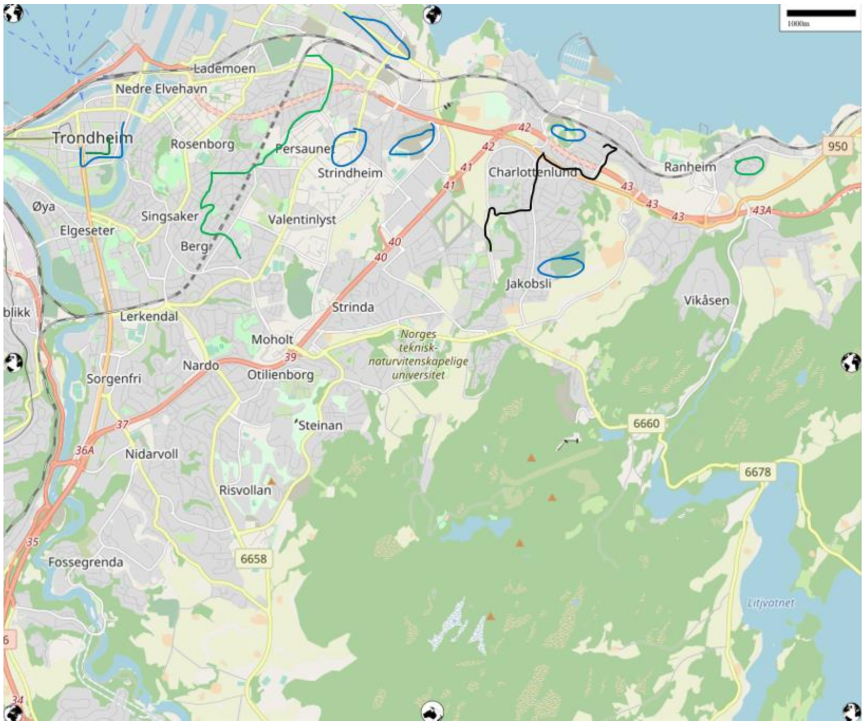

Figure 9 - The example map that was presented to the class. Where the green and blue lines are areas that are used for day-to-day activities and the black line is the way to school.

The task was presented and explained with some examples from me before the physical copies were distributed to the pupils. This is done to avoid and/or clear up any confusion on the task before they start marking on the map. The lines and circles on the map were marked as examples of how the marking could be done. Additionally, they were asked not to draw or write over the QR-code on the side of the map, as it is needed for the automatic digitalization recognition (Klonner, Hartmann, et al., 2021, p. 10). They were also told that if they did not wish for their map to be used as data for this project, they could drop out by marking a clear X on the right-hand side of the map. After the initial markings of these categories, I showed them a new example, and now they would mark areas that they thought were at risk for either of the three natural hazard types with a red color. I also asked the participants what they knew about the relevant natural hazards and made sure that we went through some causes and effects of them. To create a "common understanding" for the participants of what was meant by a risk area. I then collected the maps after the hazard risk areas were mapped.

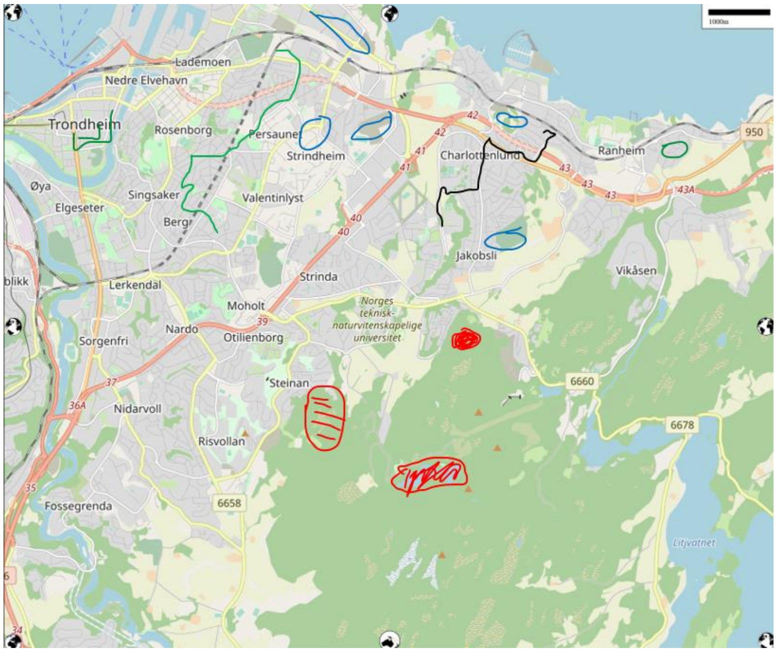

Figure 10 - Example for marking on map with the addition of red markings for natural hazard risk areas. Marked on map generated with (Sketch-Map-Tool.heigit.org, 2024a).

Before asking the student to answer the survey, I introduced the concept of risk perception. This was to make sure that they would know what the survey would be about. They were also informed that they could opt out of having their answers used in this study, by checking off the first question in the survey. The pupils then answered the survey individually. Once everyone had answered the survey, and the maps were collected, I showed them an authoritative map displaying the identified areas in Trondheim that are at different grades of risk for the relevant natural hazards with the map data from (NVE, 2024). The last bit of the process in class was used to explain how such free data could be accessed online, and some small discussions on how climate change is affecting frequency and strength of natural hazards.

4.4 Processing of the collected sketch map results

First, all the maps were collected from the participants in the classroom. After the maps were collected, I needed to sort out the maps that had any X markings on them, since this was the way for the participant to show that they did not want their sketched map to be part of the sturdy. No maps were marked so they were all brought forth to the next step of the process. To digitize the maps, I took a picture of all the maps in a room with good lighting. The pictures were taken with my own mobile phone, and I avoided getting my own shadow in the way to darken parts of the image. For the pictures it is important that the QR-code is visible and not sketched over for it to be properly georeferenced, and be recognized by the tool (Klonner, Hartmann, et al., 2021, p. 11). I then transferred the pictures to a pc to upload the files on the webpage.

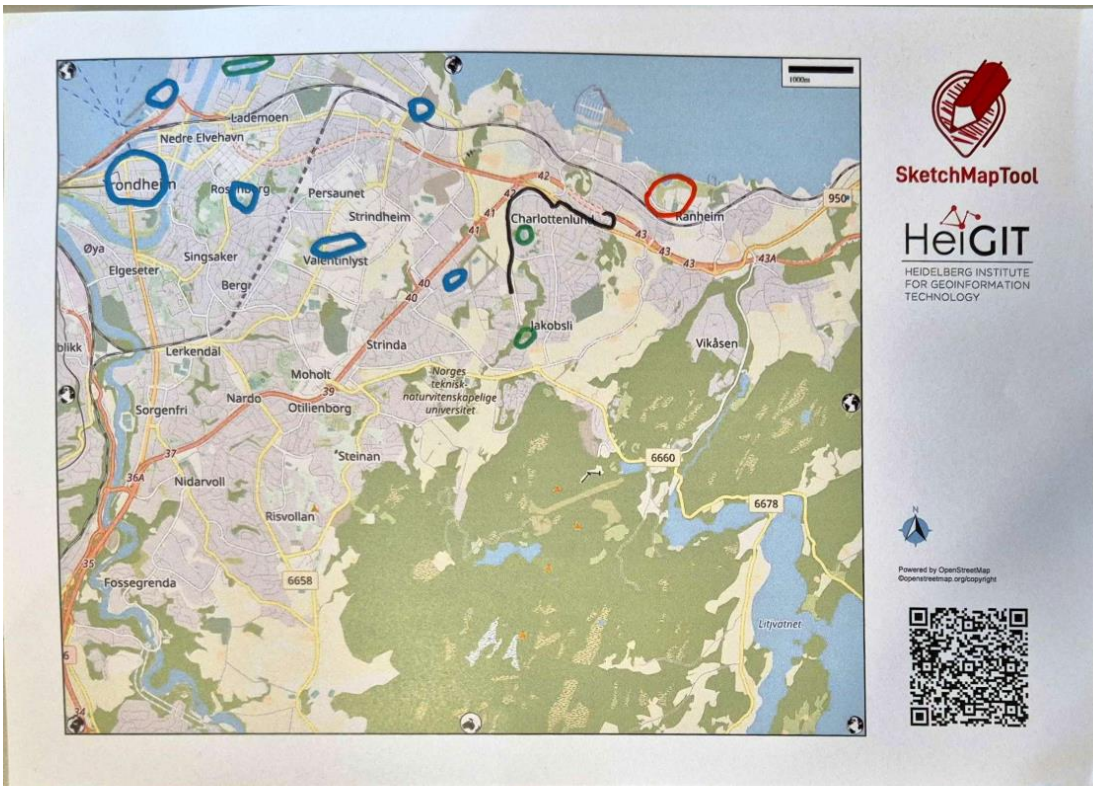

Figure 11 - Picture of map 2, taken with private mobile. The picture that will be uploaded to Sketch Map Tool for digitization (Sketch-Map-Tool.heigit.org, 2024a).

On the webpage I uploaded pictures of the 22 sketched maps to the Sketch Map Tool website Figure 7, where all the pictures were .jpg files (Sketch-Map-Tool.heigit.org, 2024a). For GeoTIFF files I uploaded all the files at once, and individual raster files for each of them were generated, all together in one zip file. To add these files to my QGIS (QGIS.org, 2024) project, I used the add raster layer function and chose the files from the folder that I unzipped in the same folder location as my project. For the GeoJSON files I first downloaded the result and had the file prepared and stored it in my project folder. From QGIS (QGIS.org, 2024). I added the polygon layers by choosing the vector → add vector layer → then choosing the GeoJSON file. The result of uploading all the maps at once will be a merged raster with all the maps combined into one Figure 41. For individual polygon layers of the maps, one map must be uploaded at a time. I did this by uploading them one by one in the same order that I had numbered my maps, so that it would be easier to keep track of which vector layer file belonged to what map. All of these were added following the same procedure as the combined file.

The transition of the data from QGIS to ArcGIS Pro is not necessary should one not have access to the second or prefer the former (QGIS.org, 2024) (esri.com, 2024). I prefer working in ArcGIS Pro which I am more familiar with, so I transferred the files over to my project geodatabase there. The data itself did not display any difference between the two programs. The downloaded files were first uploaded to QGIS as ArcGIS pro does not recognize the file types. After uploading the GeoJSON files to QGIS, I opened a folder connection from ArcGIS Pro to the project folder where the QGIS project was stored. Then I added them to my map there by using the functions: layer → add vector layer → the GeoJSON files. The layers are then automatically given the same color for all the sketches. Correcting the colors for display of data was done by opening the attribute table and manually changing the colors to what the polygons were registered as, see Figure 12. This is not necessary if the purpose is only to conduct a spatial analysis with the other tools in the program, as they have the correctly coded names for the color. Some of the colors were not recognized fully and resulted in several colors, see Figure 13. This can be fixed by using reclassify to classify the other colors to what it was supposed to be. To make sure that the colors were registered correctly, I had to double check with the raster. In some cases, the colors registered in the color field in the attribute table did not match the color from the map. More on this issue will be discussed later.

Map1

Field: Add Calculate Selection: Select By Attributes

	FID	Shape	color	name
1	0	Polygon	red	Map_1.jpg
2	1	Polygon	red	Map_1.jpg
3	2	Polygon	red	Map_1.jpg
4	3	Polygon	red	Map_1.jpg
5	4	Polygon	black	Map_1.jpg
6	5	Polygon	green	Map_1.jpg
7	6	Polygon	blue	Map_1.jpg
8	7	Polygon	blue	Map_1.jpg
9	8	Polygon	blue	Map_1.jpg

Figure 12 - Attribute table of map 1. The FID is the ID that each polygon is given, and the color is the color that it is recognized as by the Sketch Map Tool digitization. Last is the name of the picture file. Picture taken in ArcGIS Pro (esri.com, 2024).

Map8

Field: Add Calculate Selection: Select By Attributes

	FID	Shape	color	name
1	0	Polygon	red	Map_8.jpg
2	1	Polygon	blue	Map_8.jpg
3	2	Polygon	black	Map_8.jpg
4	3	Polygon	pink	Map_8.jpg
5	4	Polygon	blue	Map_8.jpg
6	5	Polygon	blue	Map_8.jpg
7	6	Polygon	blue	Map_8.jpg
8	7	Polygon	green	Map_8.jpg
9	8	Polygon	green	Map_8.jpg
10	9	Polygon	yellow	Map_8.jpg

Figure 13 - Attribute table of map 8. How the colors of the map were captured by the Sketch Map Tool conversion to GeoJSON files. All the 10 sketching's were recognized and turned into polygons, but some of them did not get the correct color. Picture taken in ArcGIS Pro (esri.com, 2024).

Figure 14 - Map 8 raster file. The number 3 at the bottom and 9 at the top that are marked in orange is sketched by me to show which areas were registered as the FID for the polygons in the previous figure. Picture taken in ArcGIS Pro (esri.com, 2024).

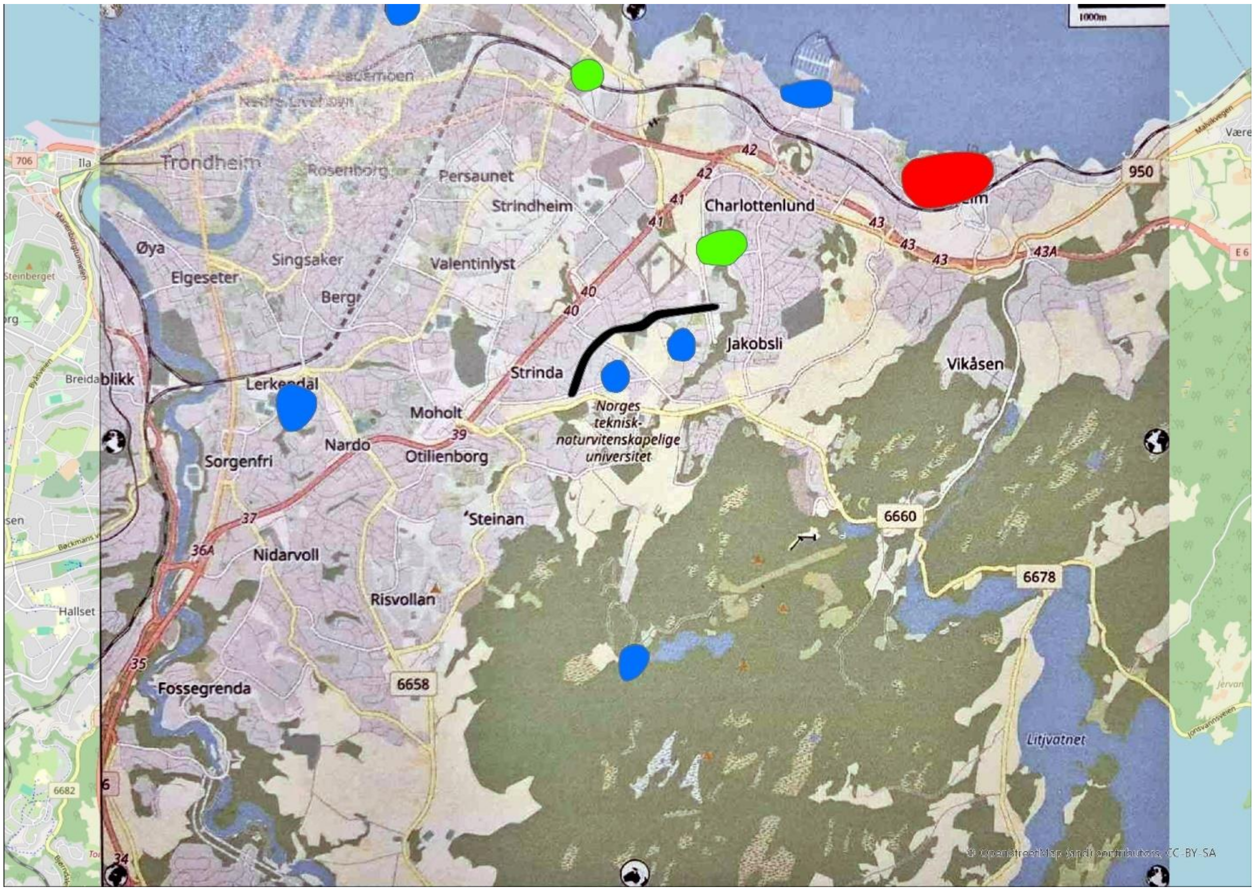

Figure 15 - The GeoTIFF result for map 8 after correcting the symbology for polygon 3 and 9. The raster for map 8 is used as the background. Picture taken in ArcGIS Pro (esri.com, 2024).

The GeoTIFF files were exported by choosing export – save as … - change the format to ESRI .hdr Labelled – choose a preferred name. This will result in three files for each of the maps. I then saved all these files in a new folder which I created a folder connection to through ArcGIS Pro (esri.com, 2024). From then I only needed to add the raster files to the current map, and the georeferenced maps were ready for analysis and comparison. When working with data from different sources in GIS one must make sure that the displayed projections match each other to avoid issues in displaying information correctly. The "Project" tool can be used to change the projection of the raster to align with the project.

Finally, I went to find data on natural hazard mapping in Trondheim municipality at NVE's website (NVE, 2024). I used the map data from the "skred" and "Jord- og flomskred – aktsomhetsområder" for landslides, "faresonder" then "kvikkleire" for quick clay, and "flom" and the "aktsomhetsområder" (NVE, 2024). After downloading the data, I moved the zipped folder to my ArcGIS Pro project folder and unzipped it (esri.com, 2024). Lastly, the layers were added to the map and the symbology changed to be distinct to the background.

4.5 Ethical considerations

When dealing with people as participants in research there are ethical considerations that must be considered. First is informed consent, which is explained by (Pietilä et al., 2020, p. 51) as "Informed consent promotes respect for the study subject's autonomous decision-making" where the autonomy of the subject is important. Participation should always be an informed choice, where the subject decides if they want to be part of the collection data and if their values aligns with that of the researcher (Pietilä et al., 2020, p. 51). For my research project, the participants had a document with information about my goals for the research and a summary of what it would entail. Additionally, they were informed about what I wanted to study and what the data would be used for, and who would have access and be responsible for the data. They had the option to opt out of having their answers used in the study in both methods used for collecting data. In the survey the first option is to opt out should they wish (See Appendix A), and for the mapping exercise they were informed that they could make a clear X mark on the right-hand side, or just made clearly visible, on the paper with the map.

The pupils that were participating were also informed that their data would be anonymous. Privacy and security of data is an important part of the data treatment, and anonymity itself is not enough to protect their privacy (Pietilä et al., 2020, p. 64). Especially when the data is stored online, it is important that it is well protected. Encryption and restricted access to the data keeps it secure and protected from unauthorized access (Clarke et al., 2001, p. 90). The encryption and security of data on Nettskjema has been approved by Regionale komiteer for medisinsk og helsefaglig forksningsetikk (REK) and Sikt – Kunnskapssektorens tjenesteleverandør *(Nettskjema, 2024).*

Ethical considerations that are important for participatory mapping is that the researcher is fully transparent with the participants in the study. The purpose of the mapping should be clearly stated to the participants in a language that is comprehensible to the specific age group involved (Klonner & Norze, 2023, p. 151). I made sure to describe my project and that the data would be used for evaluating a participatory mapping software and how it could be used to collect data on risk perception. A short introduction and simplified explanation of what both were given to adapt the terms for the age group, first year high school pupils. Additionally, Klonner & Norze state that "the participants should be made aware of how the information being collected will be used and that no harm will come to them because of their participation in the project or study" (Klonner & Norze, 2023, p. 151). I gave a short introduction to how the Sketch Map Tool worked; that you choose a site of study and print it out, so that participants can sketch on the map before it is taken picture of and uploaded and georeferenced for further use (Sketch-Map-Tool.heigit.org, 2024b). The data collection would take away some time from their usual schedule, so I also made an attempt to aim for the relevant curriculum goals for geography for the pupils to also get some learning out of the valuable time used of their geography class (Kunnskapsdepartementet, 2019) (Klonner & Norze, 2023, p. 152).

There was no collection of any personal data such as name, gender or date of birth. With no personal identifiable information and encryption of data, the participants in the study remained anonymous. Ahead of the date I collected data the participants were sent a short document with information about the project to know what they would be participating in. This document was first sent to, and approved by their teacher, before it further was shared with the class. In this information document there was also contact information for both me and my supervisor in case there were any further questions or if they wished to withdraw their participation. Additionally, they always had the option to withdraw from participating at any time. In the mapping exercise they were instructed to make a clear mark on the right-hand side, and the first option in the survey was to withdraw their answer from being part of this study. I made sure to inform them before both exercises of their rights to choose if they wanted to participate in the study.

4.6 Quality of this research

Initially, this was meant to be more of a quantitative analysis with a larger emphasis on using GIS analysis tools to compare the layers generated from Sketch Map Tool (Sketch-Map-Tool.heigit.org, 2024a). When I started inserting the GeoJSON files into QGIS (QGIS.org, 2024), some of the polygon shapes gave unexpected results. The shape that was sketched on the map did not correspond very well with the transition to a polygon. More specifically, this was primarily an issue with drawn lines that would form one large polygon by connecting the line in certain places. I will return to this issue I had in the discussion of how GeoJSON polygons could be used for participatory mapping. Additionally, this was meant as more of a quantitative study than a qualitative, but with the limitation of collected information I changed the focus to the method, developing a framework for analyzing and collecting data on risk perception among pupils.

Several unfortunate circumstances, many schedule clashes and some sudden changes in plans for either part, me or the teachers that I contacted to visit their class, led to a sample size of only one school class. This was unfortunate, but only changed the focus for the analysis to that of a more qualitative one where I look at the use of the tool for local city planning and participatory mapping instead of just a quantitative analysis of a pattern in overlap between natural hazards and active areas. I will still analyze the results that I got as an example of a small case study, though the answers won't be representative for pupils in this age group (Rød, 2017, p. 158). It is rather an example of what a class can look like in terms of risk perception. My study could rather be seen as a framework that could further be improved upon for future studies.

For research to be trustworthy, it must have credibility (Hammarberg et al., 2016, p. 500). This is especially important for my study, as it has the purpose of being a framework for other studies which seek to use the same tool or method with a larger sample size of participants, to find more generalizing data. How the research was conducted, procedural decisions and generation of the collected data should be properly explained and transparent for the reader (Hammarberg et al., 2016, pp. 499-500). With my detailed description of my methods used and how the research was conducted, I believe that this framework should have reliable replicability. The questions of the survey are laid out and explained along with the structure of it so that it may be used again. The sketching of the map and uploading the data to Sketch Map Tool is also detailed (Sketch-Map-Tool.heigit.org, 2024a). However, the collection process in the classroom, despite being explained here, may differ in some ways from how other people present themselves and their project. With the participants being pupils in the first year of high school, each class and individual will differ in some ways each time this method is conducted. It is hard to do an exact replica of how the research is conducted in the classroom when the presenter of the project, the school and the pupil may decide how the conduction of the method would be most applicable.

5. Results

In this section I will provide and display the results from the collected data. I first start with displaying the survey results. There will be several figures that I will present when showing the results. The complete survey can be found in and will be quoted in the caption of the figures. Next, I will display the results from using the Sketch Map Tool method. Here I will start by displaying the results using the GeoTIFF file method for a set of maps, and then how the GeoJSON files show the sketched markings as polygons for the given map selection.

5.1 Answers to the survey

There were 21 participants for the survey, where 4 of them checked off that they did not want their answer to be part of this study. This means that there are 17 collected answers for the survey in the answers that I will present. Due to the low number of participants, I have chosen to use the number of answers rather than a percentage to further indicate that this is a small case study (Burke et al., 2018, p. 168). Using percentages could make the results look more impactful and different than reality and shape a misconception of how representable the data is for generalization of the answers. The figures with Norwegian text in the answers are from the rapport function in Nettskjema and will be specified in the figure-text, while the other ones are structured from the answers through Microsoft Excel (Nettskjema, 2024). I am starting with question 2, as the first one was if the participant wanted their answer to be used for this analysis. Some of the dialogue-box answers have few answers and will be included in the following question. The discussion of the answers will be done in the next section.

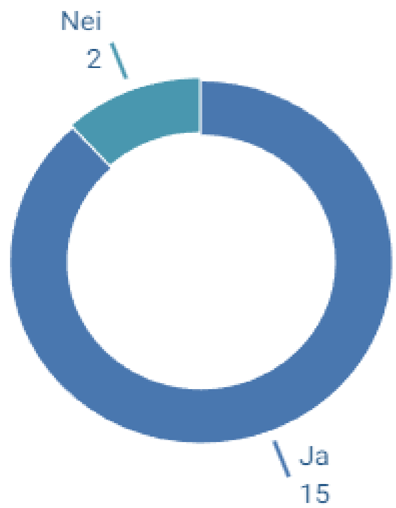

Figure 16 - Answers to question 2 "Was the task of filling in information on the map clear?" (See Appendix A). 2 answered no and 15 answered yes. Made with (Nettskjema, 2024).

This is the answer to the second question where 2 out of the 17 participants found the instructions for the task to be clear and understandable. However, in the follow-up dialogue-box answer that was tied to the "no" there were two answers: "How", and "How can our answers help you".

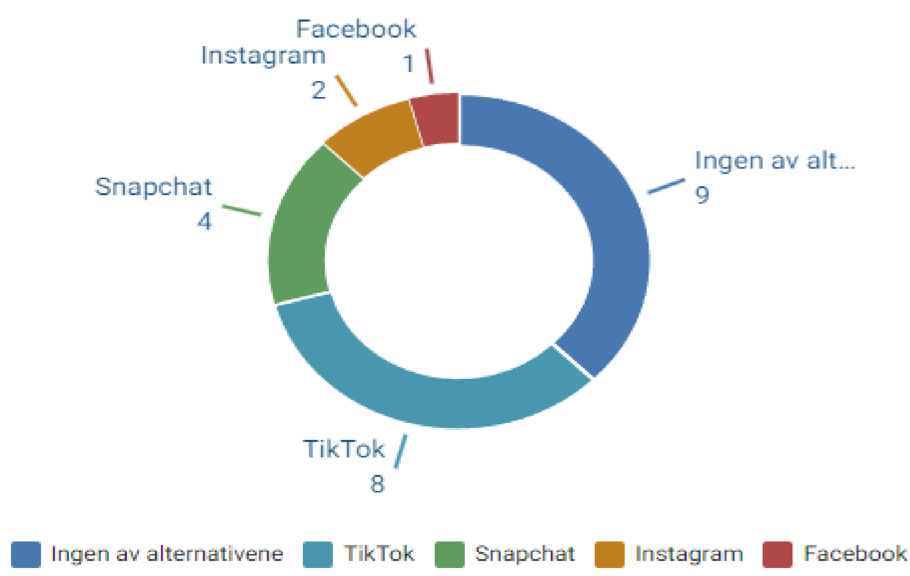

Figure 17 - Answers to question 3 " From what social media have you received information about natural hazards in Trondheim?" (See Appendix A). The answer alternatives are from left to right: None of the alternatives, TikTok, Snapchat, Instagram, and Facebook. Made with (Nettskjema, 2024).

The purpose of this question was to understand what media platforms the pupils use to get information regarding natural hazards. Only one participant had gotten any information from Facebook. Two had received information through Instagram, and 4 using Snapchat. The two most picked options were Tik-Tok with 8 participants saying that they had gotten information by using such a platform and 9 voted for none of these alternatives.

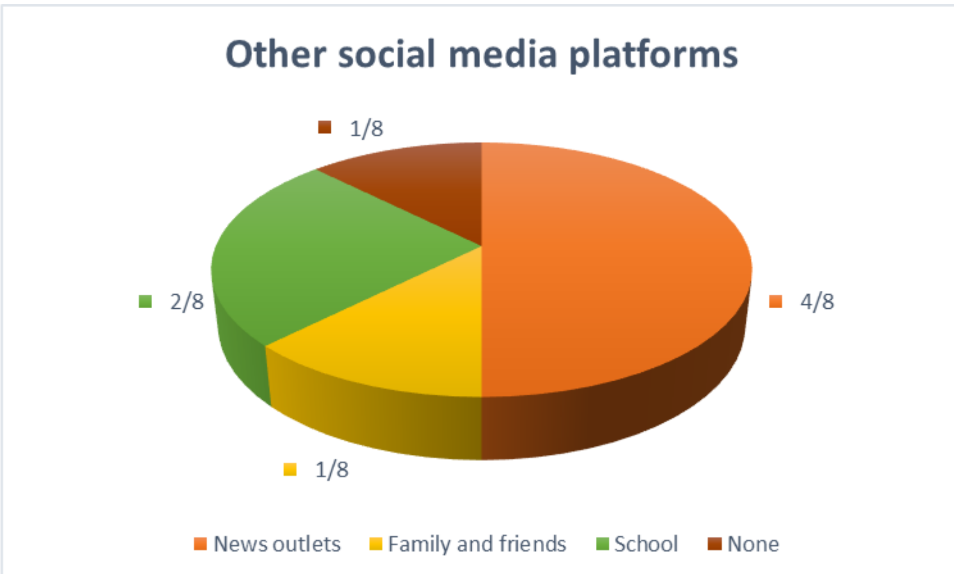

Figure 18 - Answers to question 3.1 "Should the platform you have received information from not be in the list, then you can write it here." (See Appendix A).

This optional alternative was available to all participants, not just those who chose the option of "none of the alternatives" (See Appendix A). It was also specified in the question description that they were not limited to only one alternative but could add more. The answer format for this question was a dialogue box. From the answers given I chose to categorize the other alternatives, where different names of news outlets, for example, were merged into one category. Four out of the answers in this section already aimed towards the category of the next question, with social factors for natural hazard knowledge.

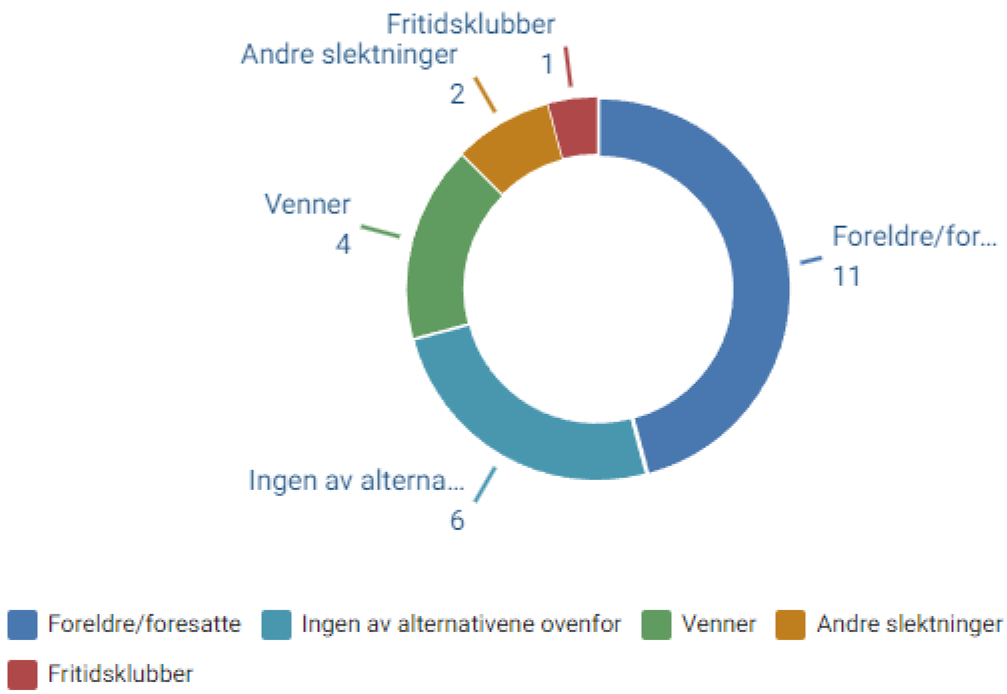

Figure 19 - Answers to question 4 "Have you received information about natural hazards in Trondheim from those around you?" (See Appendix A). With the answer alternatives from left to right: Parents/guardians, none of the alternatives above, friends, other relatives, free-time clubs. Figure made with (Nettskjema, 2024).

This question has the same structure as the previous one, where the participant could choose more than one option and write their own answers in a dialogue box if the alternatives did not cover it. 1 participant answered that got information from free-time clubs, 2 from relatives, 4 from friends and the majority, with 11 participants, getting it from their parents/guardians. 6 answered none of the alternatives above. There were 3 answers in the dialogue box where all of them said "school" or "teacher".

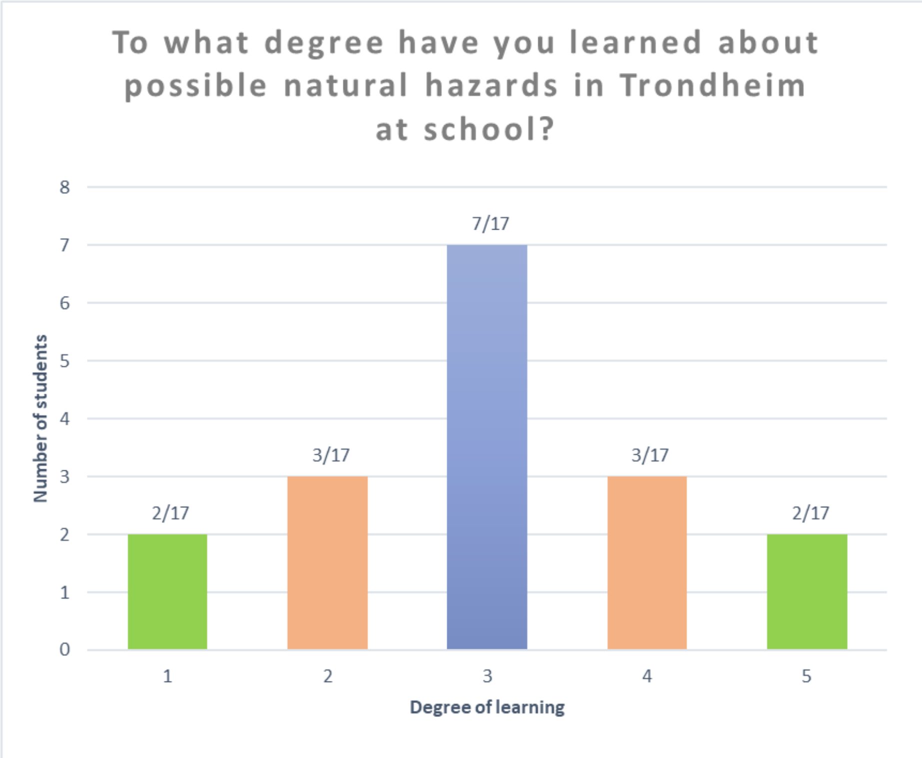

Figure 20- Answers to question 5 (See Appendix A). The number of answers is numbered by the amount of the total for each, and the numbers for the degree of learning were measured from left "small degree" to right "high degree" that were noted in the survey.

Figure 20 shows the answers to what degree the pupils felt that they had learned about natural hazards in Trondheim at school in general. The value of 1 means that the participant does not feel like they have learned much about it, and 5 that they have learned a lot about it at school. The answers show that a total of 5 participants did not feel like they had learned a lot about it at school. The majority, with 7 answers, said that they felt like they had learned something. And 5 pupils answered that they had learned about natural hazards to a medium high- or high degree.

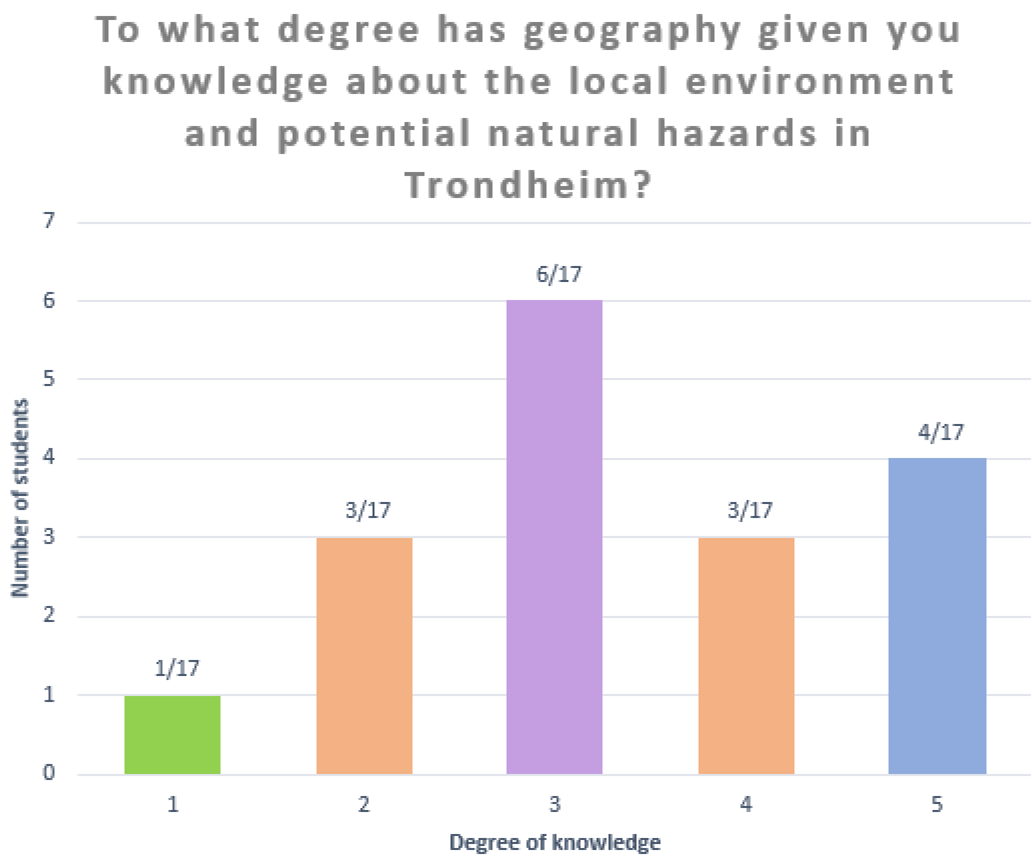

Figure 21 - Answers to question 6 (See Appendix A). The number of answers is numbered by the amount of the total for each, and the numbers for the degree of learning were measured from left "small degree" to right "high degree" that were noted in the survey.

This question specifies how the geography course has contributed to gaining knowledge about the local environment and potential natural hazards in Trondheim (Kunnskapsdepartementet, 2019). The same grading structure is used for this question. Only one participant answered 1, and three answered 2, saying that they did not learn much about it. The majority answered the medium option of 3. When it was specified to the course, more pupils answered that they learned about the topic than when it was asked about at school in general. Three participants answered option 4 and the second highest category was option 5, and they felt that the geography course had taught them a lot about the topic.

Figure 22 - Answers to question 7 "I wish we learned more about possible natural hazards in Trondheim, at school" (See Appendix A). 8 of the participants answered "no" and 9 of them answered "yes". Picture taken from (Nettskjema, 2024).

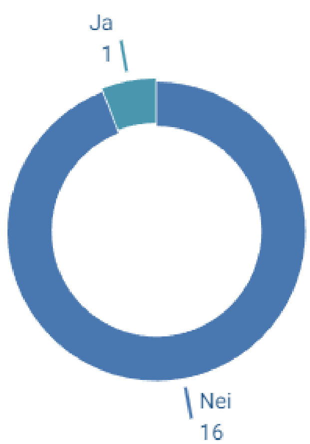

Figure 23 - Answers to question 8 "I have visited Trondheim's' websites to look for information about natural hazards" (See Appendix A). 1 of the participants answered "yes" and 16 answered "no". Picture taken from (Nettskjema, 2024).

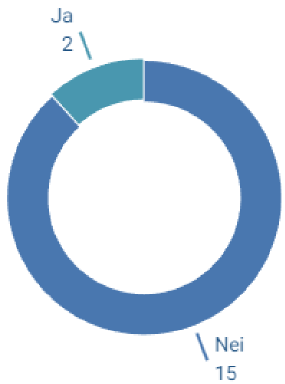

Figure 24 - Answers to question 9 "I have been informed by Trondheim municipality on social media about natural hazards." (See Appendix A). 2 answered "yes" and 15 answered "no". Picture taken from (Nettskjema, 2024)

Question 7, 8, and 9 are questions with a "yes" or "no" answer format. Figure 22 asked about the interest in learning more, where 8 answered "no" and 9 answered "yes". Almost half of the class did not have any interest in learning more than they did. For Figure 23 the question of seeking out information was asked and only one of the 17 participants had looked for information about natural hazards at their sites. When asked if they had gotten any information from Trondheim municipality on any of the social media they use, two out of the 17 participants answered "yes".

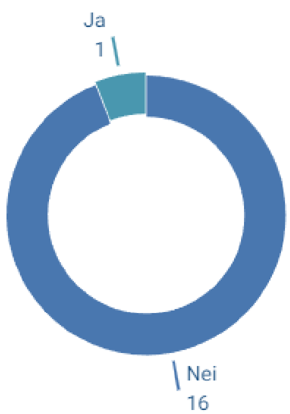

Figure 25 - Answers to question 10 "Have you ever felt exposed to a natural hazard?" (See Appendix A). 1 Answered "yes" and 16 answered "no". Picture taken from (Nettskjema, 2024).

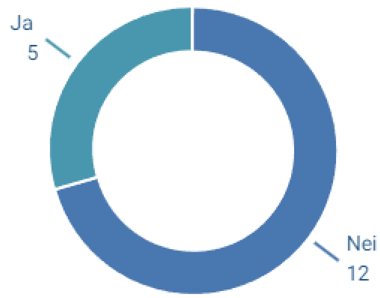

Figure 26 - Answers to question 11 "Have you been exposed to a natural hazard?" (See Appendix A). 5 answered "yes" and 12 answered "no". Picture taken from (Nettskjema, 2024).

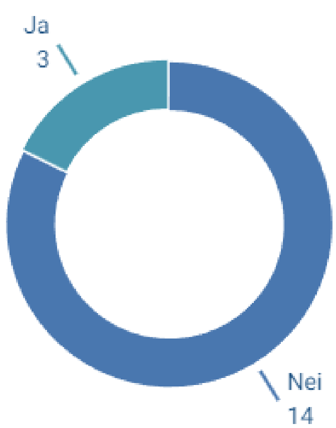

Figure 27 - Answers to question 12 "Has there been an event of a natural hazard that has made you more alert?" (See Appendix A). 3 answered "yes" and 14 answered "no". Picture taken from (Nettskjema, 2024).

Question 10, 11 and 12 asked about exposure to natural hazards. In Figure 25 only 1 participant had felt exposed to a natural hazard. On the follow-up question they answered that they had felt exposed to a hurricane, which was not relevant for this study. Next question was about direct exposure to natural hazards Figure 26. Five of the participants answered that they had been exposed to a natural hazard, and two of them followed up with that they had been exposed to floods. For the last question Figure 27 three answered "yes", but none of them specified which event had made them more alert.

5.2 Sketch map results

There were 22 participants for the participatory mapping. None of the participants marked on their map that they did not want their data to be used in the analysis. This is a visual analysis of the maps, so I have chosen to display them in a clear and efficient way for comparing them. I have put the GeoTIFF digitized maps together a few at a time to keep detail when using the transparency for symbolization of the raster layers. For displaying the figures, I have compared four maps in the three first map comparisons, and three maps for the last two map comparison figures. The raster layers are displayed with rising transparency for the different layers to compare them to each other, while still maintaining a certain clarity for the market areas of each map. For each of the resulting maps, I have chosen to display the results with these maps overlaying each other first, followed by a comparison with the natural hazard data (NVE, 2024), and finally with the GeoJSON files. The polygons have been corrected to show the intended color from the map that was digitized for the purpose of the risk perception analysis. The transparency for 4-map comparison was 70%, 60%, 40% 0%, starting from the top layer. For the 3-map comparison the transparency was 70%, 50%, 0%. The overlay of vector layers of natural hazards is set to 70% for the yellow, clay risk areas. 50% for the blue colored flood risk areas, and no transparency percentage on the dark umber-red markings for landslides. The colors were chosen to be distinguishable when looking at the map. OpenStreetMap has been used as the basemap for this analysis but will not be visible in most of the results (esri.com, 2024). First, I will show a result from Map 1 to demonstrate the accuracy of the georeferencing Figure 28. Then I will show the results for the maps that I grouped together in the display. First how the overlay looks, then with the natural hazard layer, and finally the registered polygons, all in a side-by-side comparison. The polygons for the grouped maps have been merged with the "merge" tool in ArcGIS Pro and chose the "color" field (esri.com, 2024). Colors registered as another color than black, blue, green or red will be displayed as "other values" in grey. This is done to show accuracy with the use of the tool and color recognition.

Figure 28 - Georeferencing accuracy showing result from the GeoTIFF file result from the Sketch Map Tool. The small globes that shape the edges of the map show the extent of the map from the printed paper. Displayed in ArcGIS Pro with the OpenStreetMap as the basemap (esri.com, 2024).

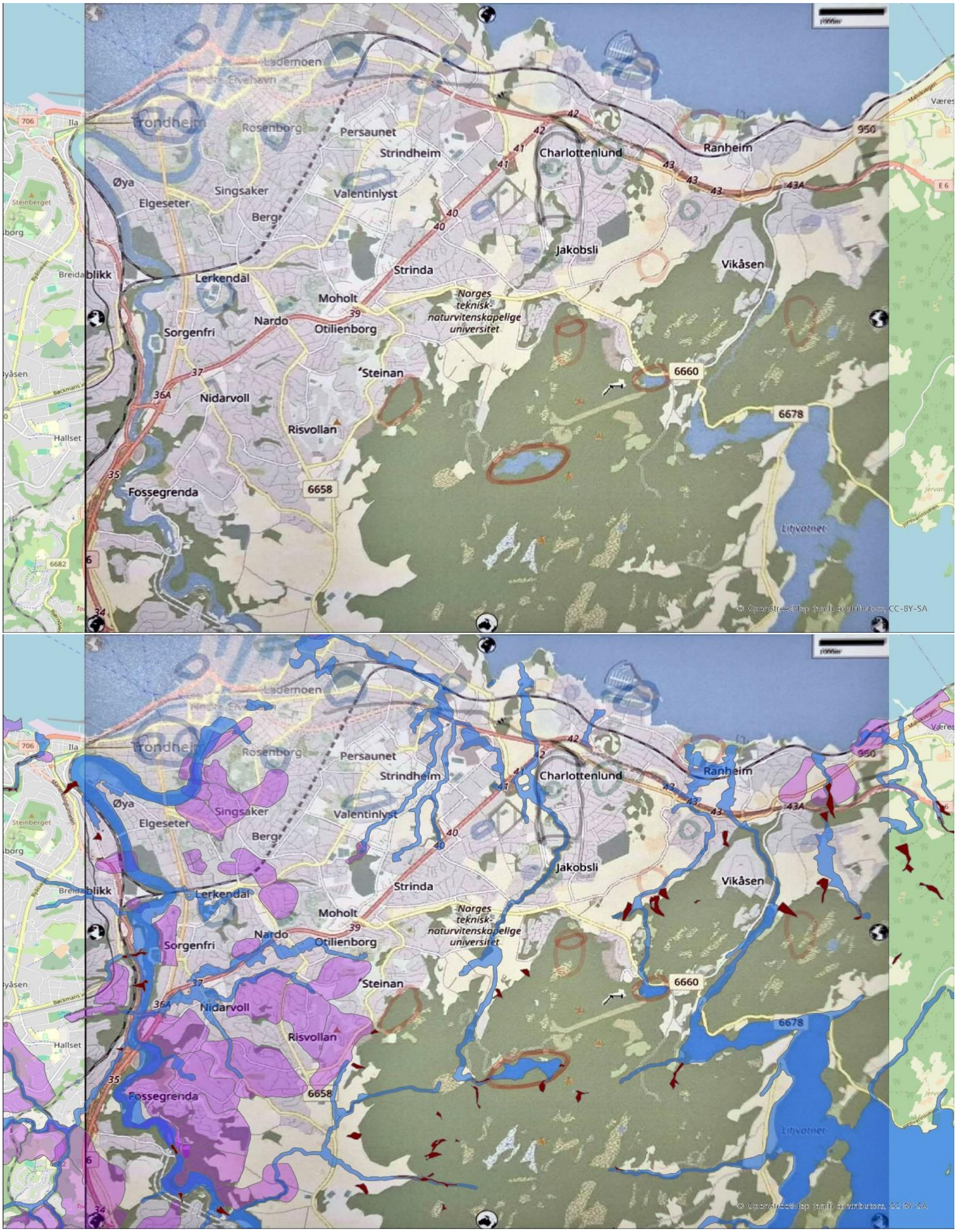

Figure 29 - Map 1 to 4 displayed with the natural hazard layers , where purple represent quick clay, translucent blue represent flood, and the dark red areas represent landslides, from (NVE, 2024). Picture exported from ArcGIS Pro (esri.com, 2024).

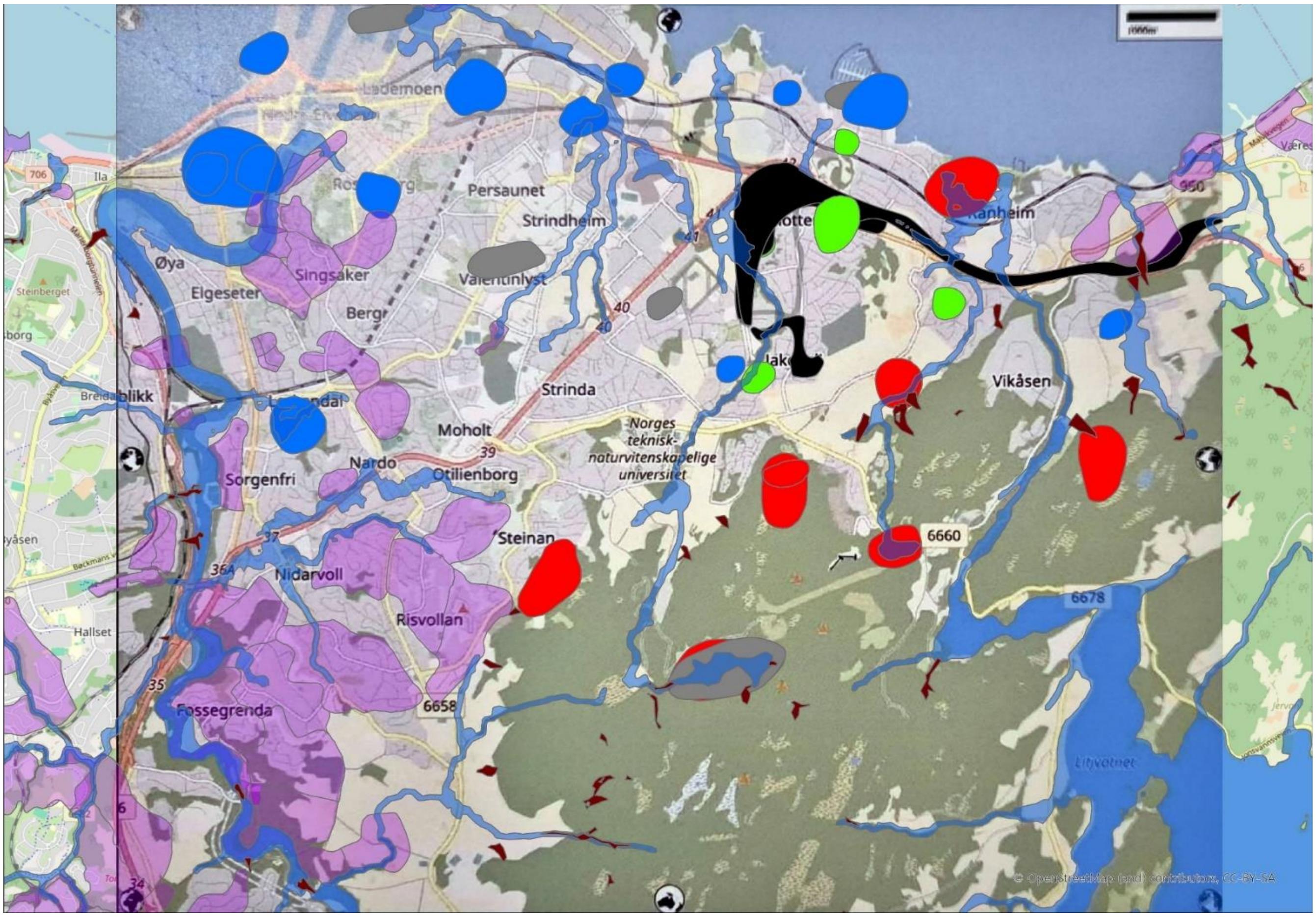

Figure 30 - Map 1 to 4 displayed with polygon layers of the digitized GeoJSON files colored after the categories in Table 1 and natural hazard layers from (NVE, 2024). The grey polygons represent areas where the color was registered as any other than the intended from Table 1. Picture exported from ArcGIS Pro (esri.com, 2024).

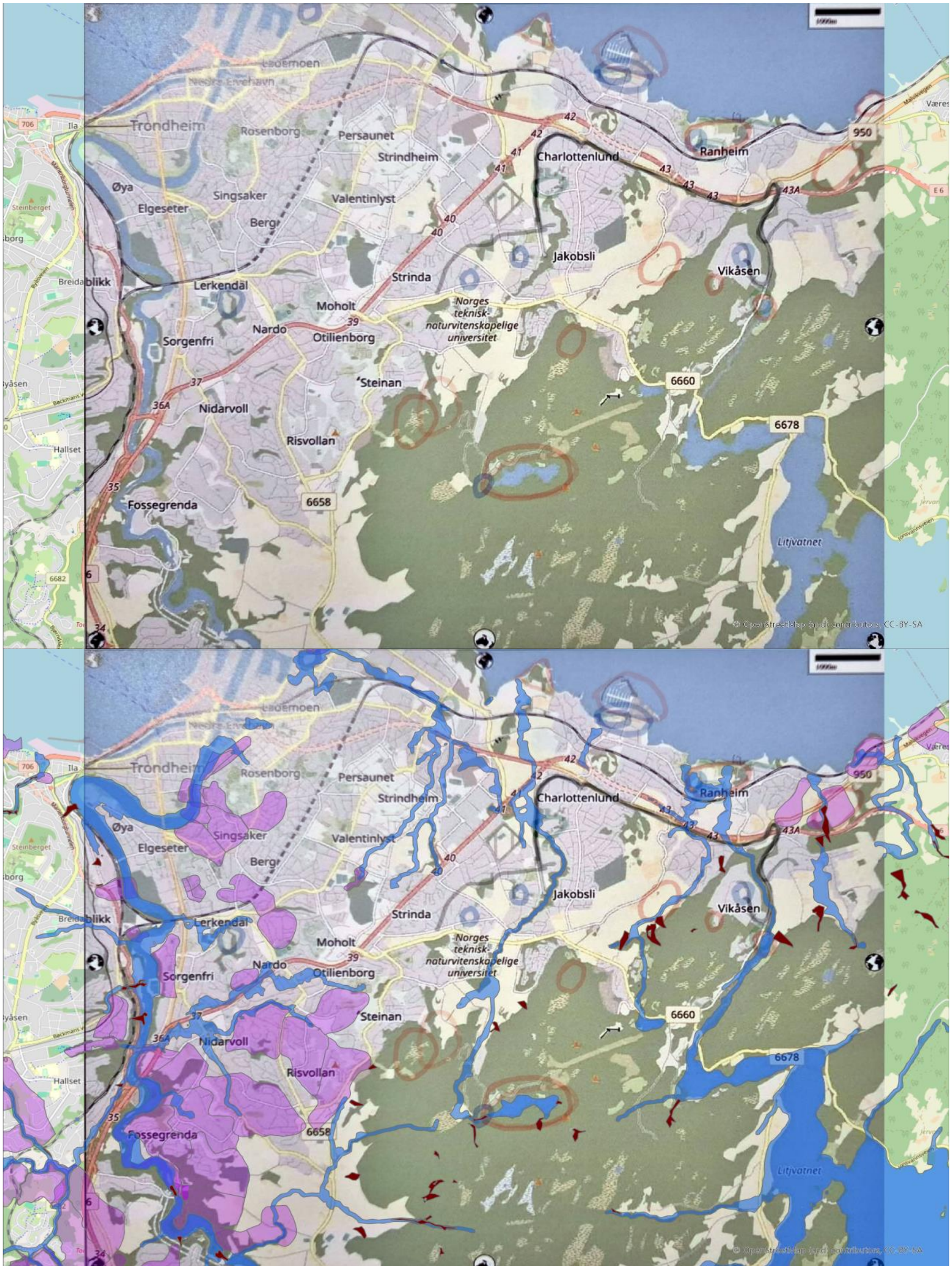

Figure 31 - Map 5 to 8 displayed with the natural hazard layers , where purple represent quick clay, translucent blue represent flood, and the dark red areas represent landslides, from (NVE, 2024). Picture exported from ArcGIS Pro (esri.com, 2024).

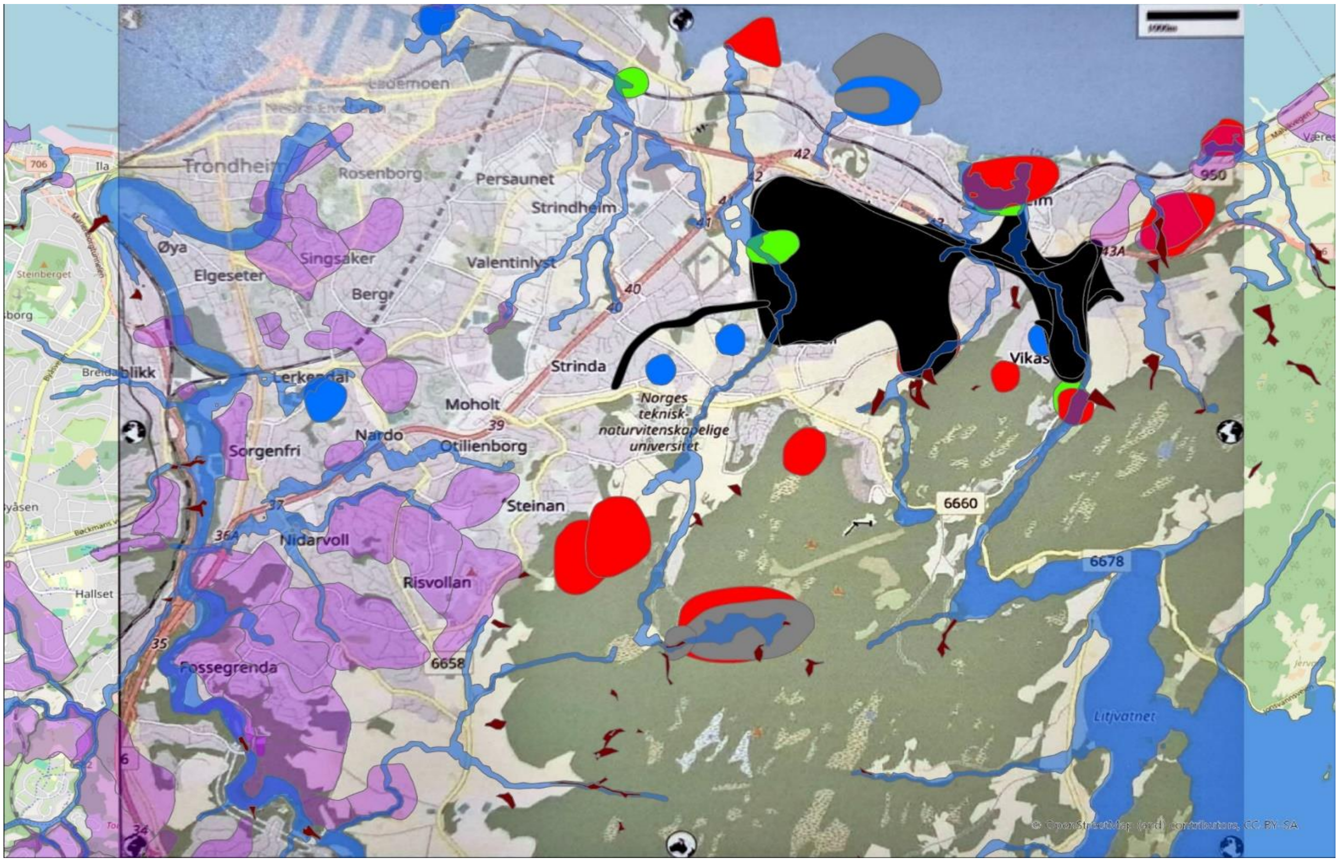

Figure 32 - Map 5 to 8 displayed with polygon layers of the digitized GeoJSON files colored after the categories in Table 1 and natural hazard layers from (NVE, 2024). The grey polygons represent areas where the color was registered as any other than the intended from Table 1. Picture exported from ArcGIS Pro (esri.com, 2024).

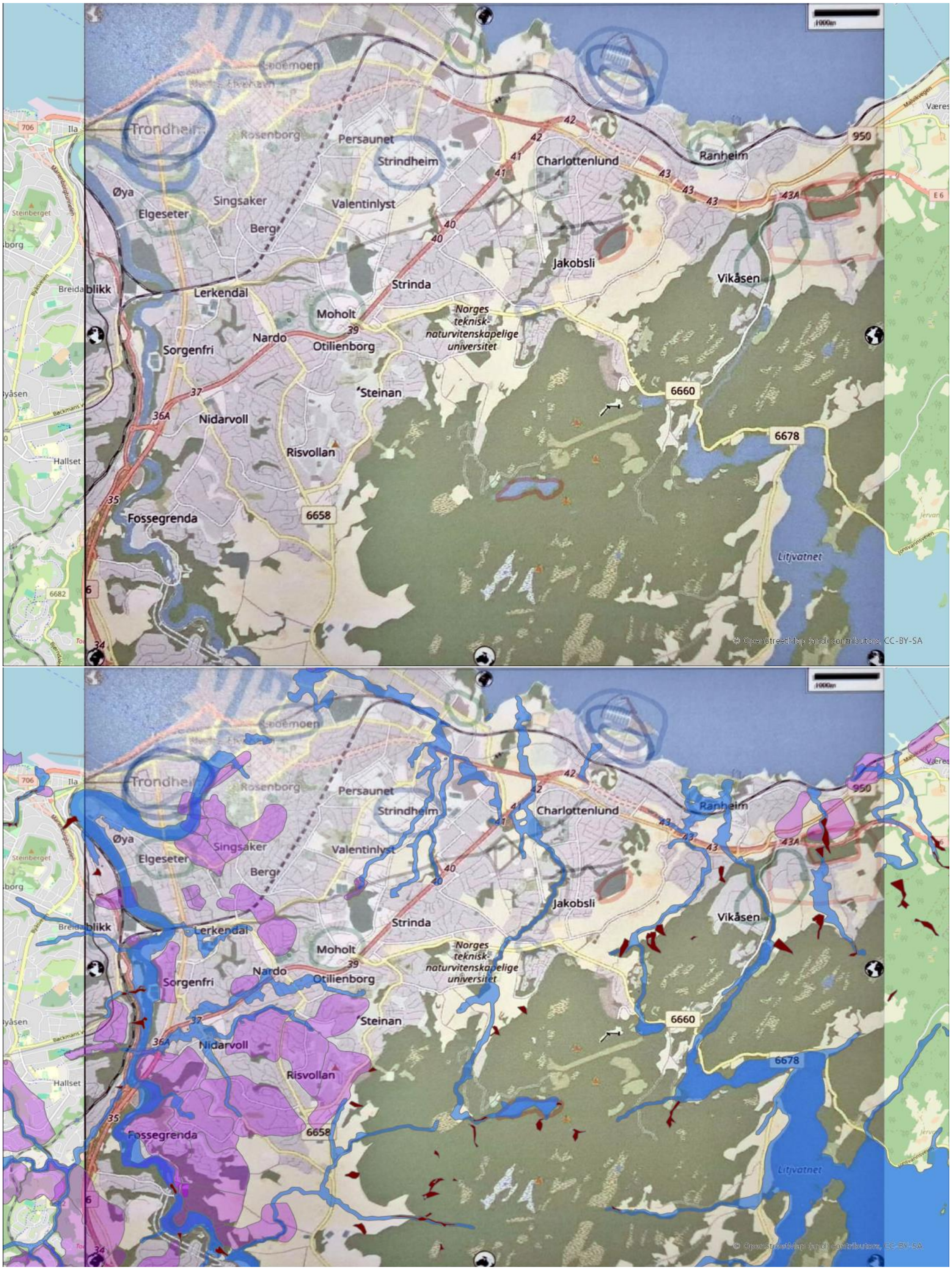

Figure 33 - Map 9 to 12 displayed with the natural hazard layers , where purple represent quick clay, translucent blue represent flood, and the dark red areas represent landslides, from (NVE, 2024). Picture exported from ArcGIS Pro (esri.com, 2024).

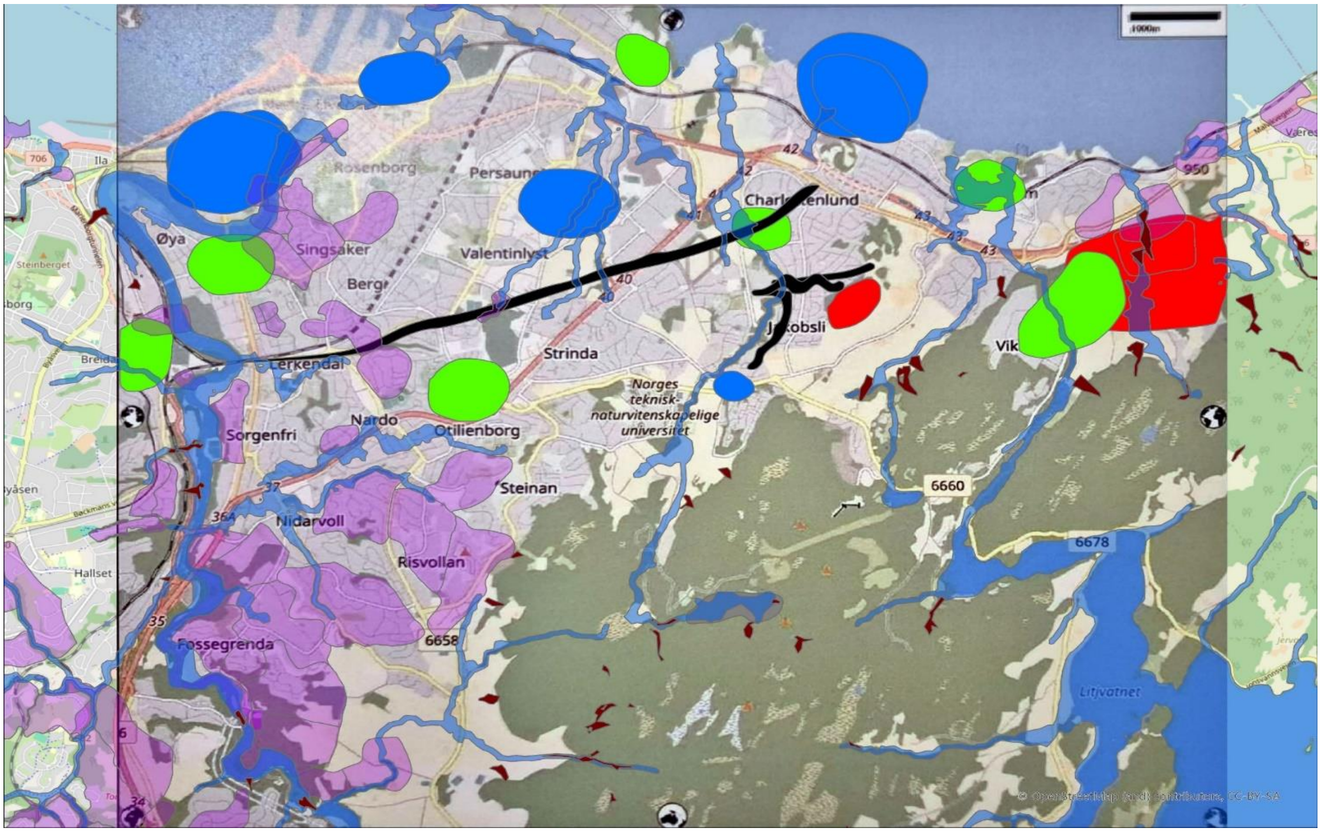

Figure 34 - Map 9 to 12 displayed with polygon layers of the digitized GeoJSON files colored after the categories in Table 1 and natural hazard layers from (NVE, 2024). The grey polygons represent areas where the color was registered as any other than the intended from Table 1. Picture exported from ArcGIS Pro (esri.com, 2024).

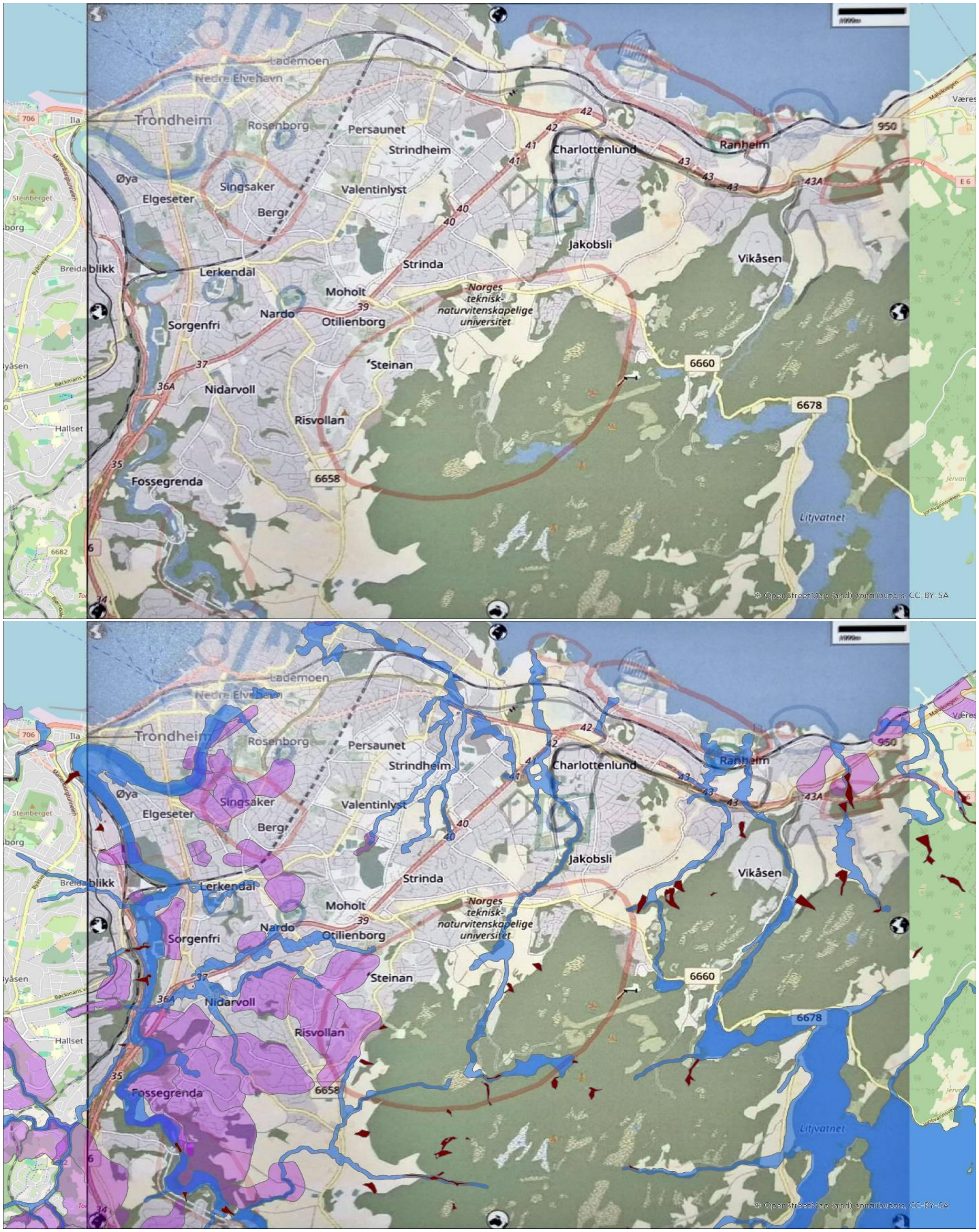

Figure 35 - Map 13 to16 displayed with the natural hazard layers , where purple represent quick clay, translucent blue represent flood, and the dark red areas represent landslides, from (NVE, 2024). Picture exported from ArcGIS Pro (esri.com, 2024).

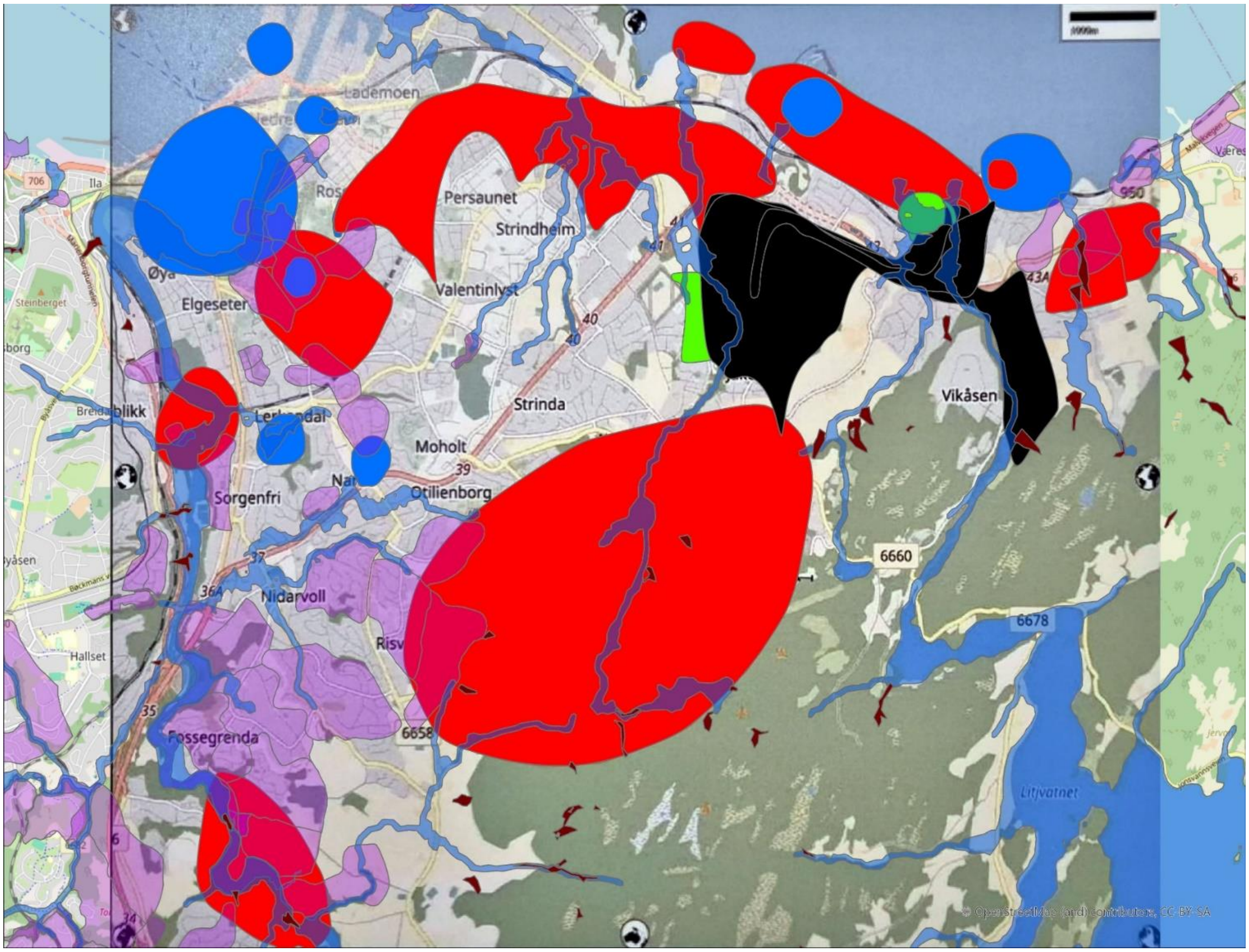

Figure 36 - Map 13 to 16 displayed with polygon layers of the digitized GeoJSON files colored after the categories in Table 1 and natural hazard layers from (NVE, 2024). The grey polygons represent areas where the color was registered as any other than the intended from Table 1. Picture exported from ArcGIS Pro (esri.com, 2024).

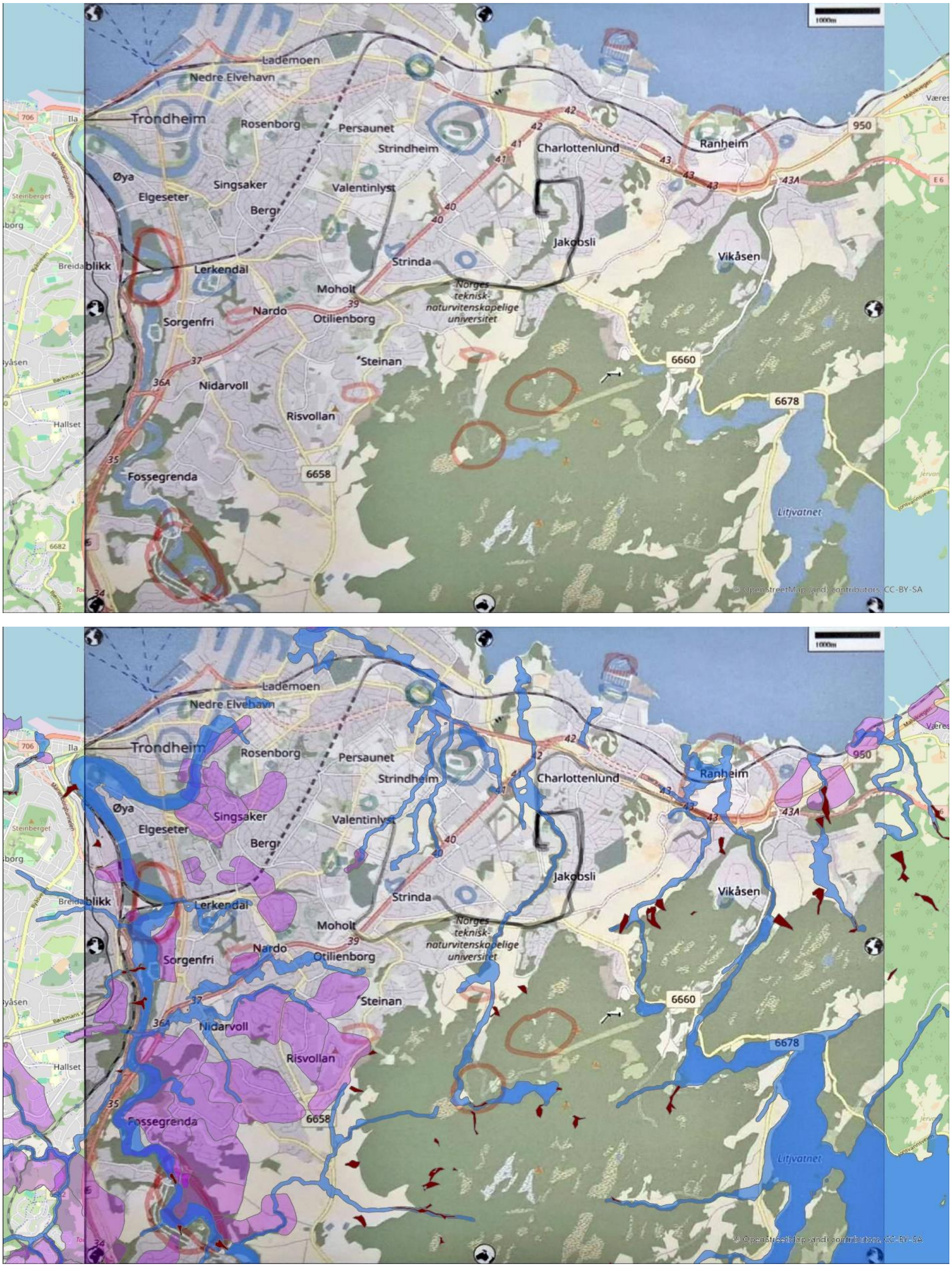

Figure 37 - Map 17 to19 displayed with the natural hazard layers , where purple represent quick clay, translucent blue represent flood, and the dark red areas represent landslides, from (NVE, 2024). Picture exported from ArcGIS Pro (esri.com, 2024).

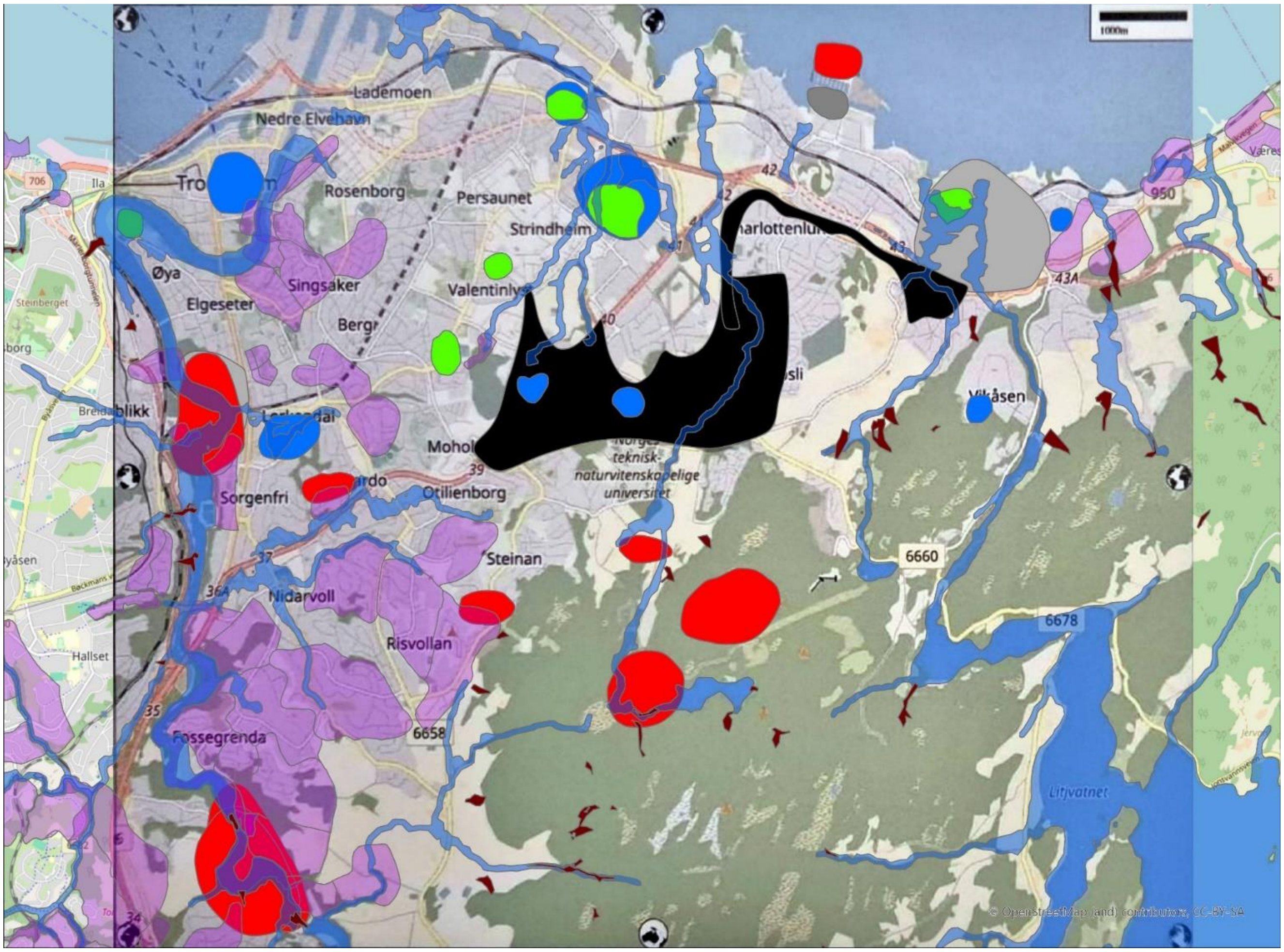

Figure 38 - Map 17 to19 displayed with polygon layers of the digitized GeoJSON files colored after the categories in Table 1 and natural hazard layers from (NVE, 2024). The grey polygons represent areas where the color was registered as any other than the intended from Table 1. Picture exported from ArcGIS Pro (esri.com, 2024).

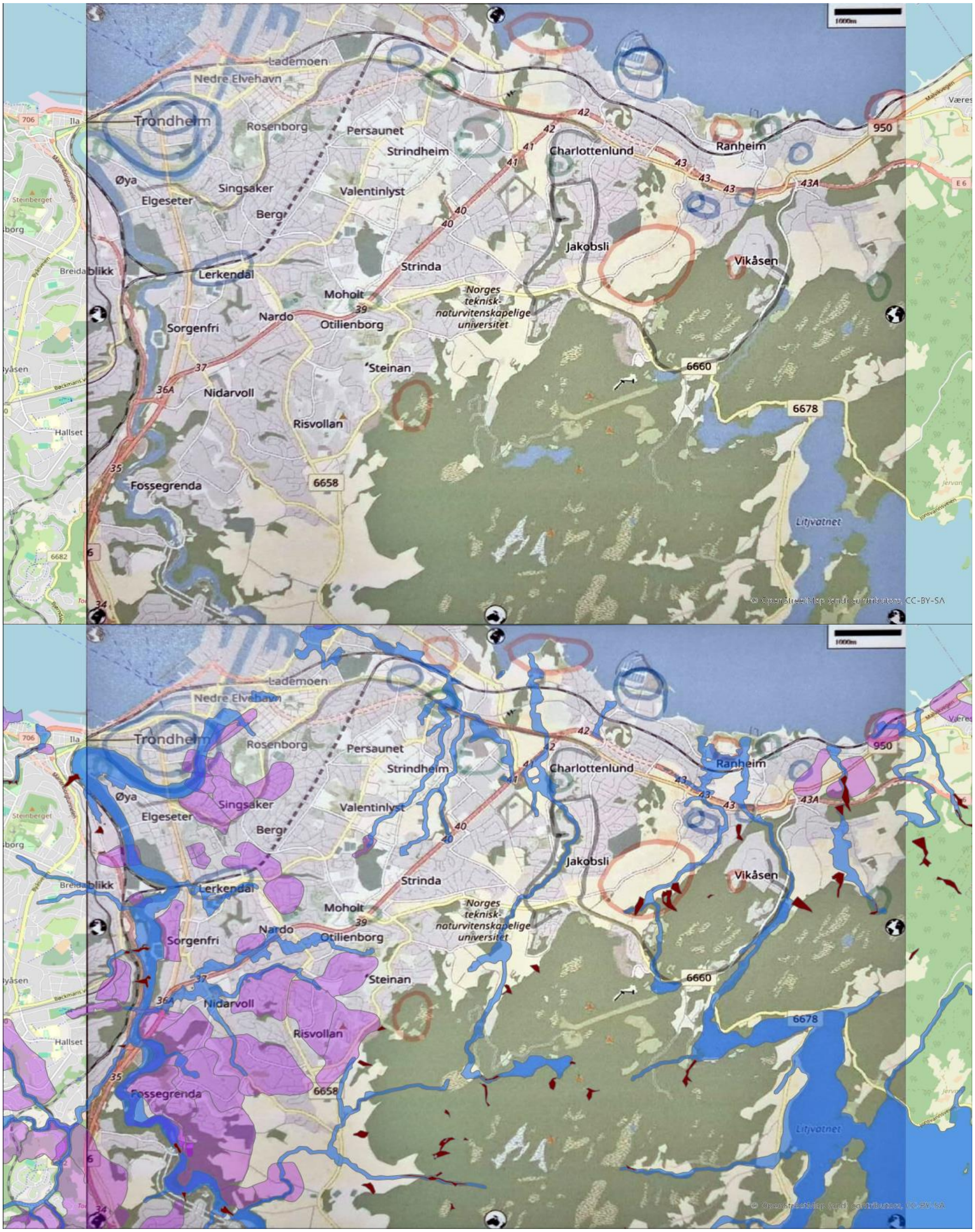

Figure 39 - Map 20 to 22 displayed with the natural hazard layers , where purple represent quick clay, translucent blue represent flood, and the dark red areas represent landslides, from (NVE, 2024). Picture exported from ArcGIS Pro (esri.com, 2024).

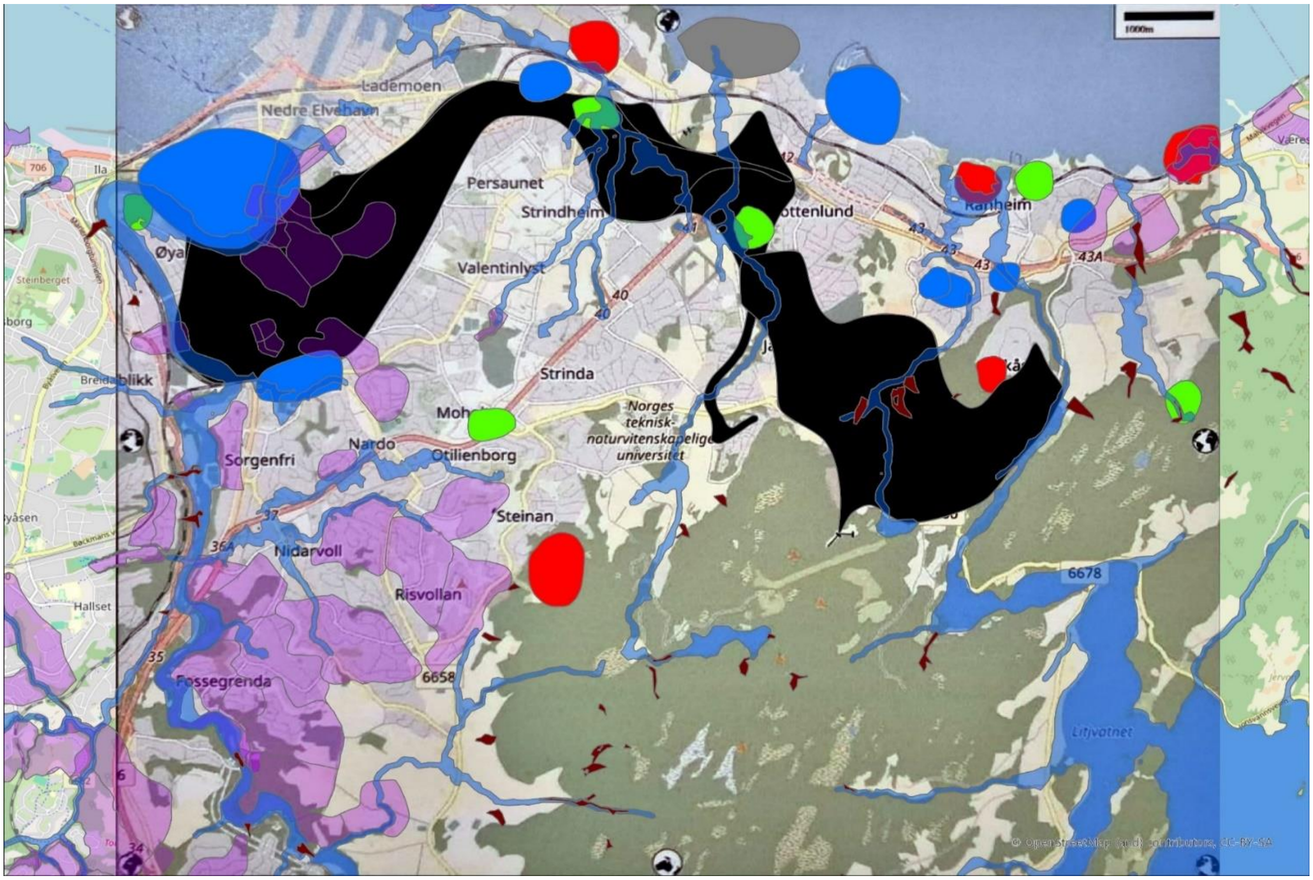

Figure 40 - Map 20 to 22 displayed with polygon layers of the digitized GeoJSON files colored after the categories in Table 1 and natural hazard layers from (NVE, 2024). The grey polygons represent areas where the color was registered as any other than the intended from Table 1. Picture exported from ArcGIS Pro (esri.com, 2024).

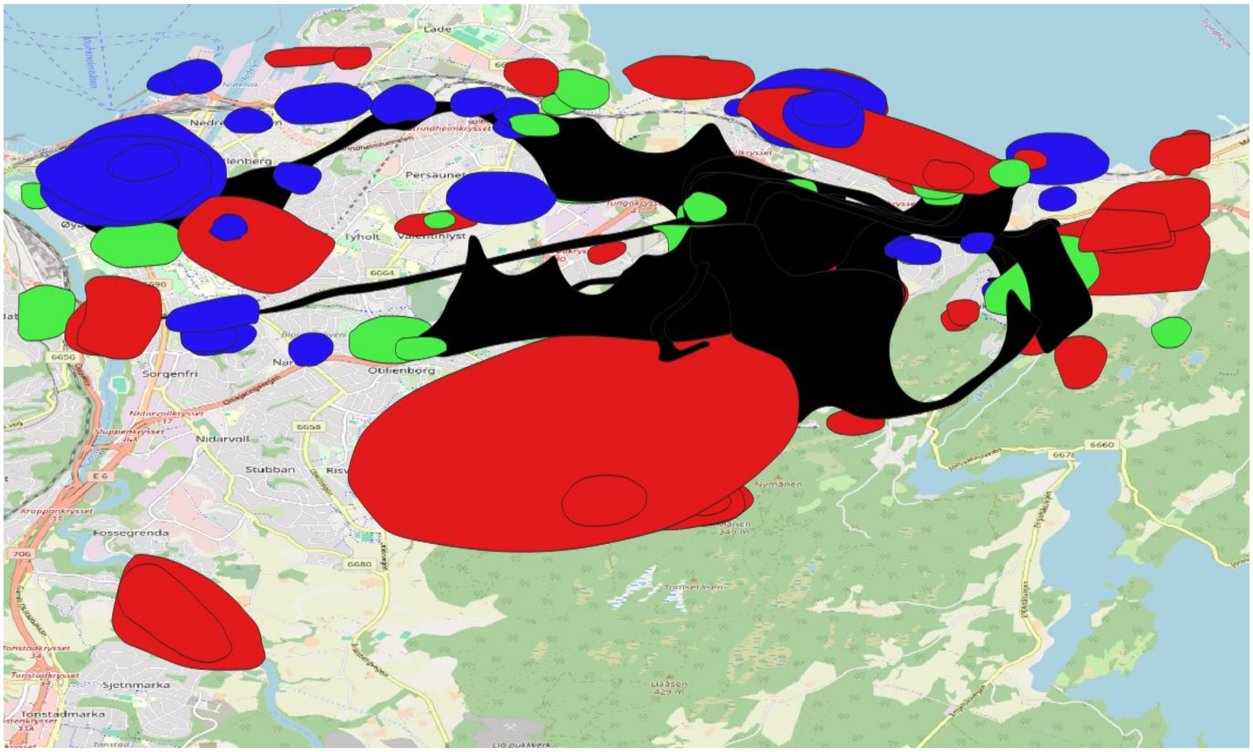

Figure 41 - The GeoJSON result of uploading all the maps at once. The polygons shown here have been corrected to their intended color. OpenStreetMap has been used as basemap. Picture exported from (esri.com, 2024).

The georeferencing of all the 22 maps were precise, so that they could be overlayed with each other for direct comparison. In this regard, the GeoTIFF raster result (map pictures) of the digitization retains high accuracy. Other digitalization considerations for the maps are the recognition of the sketches made of the map for producing the GeoJSON layer result. First, the recognition of shapes of the sketches has a very high accuracy, both in quantity and in quality. The recognition of the black line for Table 1 did not match well with polygon digitization, which I will return to in the discussion. Only for two instances the Sketch Map Tool software did not register the sketches (Sketch-Map-Tool.heigit.org, 2024a). The first instance was a green circle for map 18 from Figure 37 to 38, where it was not digitized. The second instance was for a black line in the same figure. The rest of the features got recognized by the software and digitized to polygon features.

The registered color for the features is found in the attribute table under the color field Figure 12. The colors that the participants used for the participatory mapping exercise were black, blue, green and red Table 1. In 13 of the 22 maps, one or more occurrences with wrong color recognition for the features. One example of such occurrences is map 8 in Figure 13 where some of the sketches had been categorized as pink or yellow. These misreading of the colors created a pattern that remained consistent for all the maps. Blue would sometimes register as pink, green as yellow and red as orange. Though not ideal, this still makes recategorizing them to the intended color much easier.

6. Discussion

I will start by discussing and analyzing pupil risk perception and how it can be interpreted from the survey results. Here I will look at how this corresponds with the background and theory for this study and see how these answers can explain or show any impact on the participatory mapping exercise results. Then I will discuss if Sketch Map Tool has been an effective participatory mapping method for collecting data on pupil risk perception, and improvements for both conducting studies with the method and what improvements would be needed for accurate results (Sketch-Map-Tool.heigit.org, 2024b). To do this I will look at the two different digitization options for visualizing data, GeoTIFF and GeoJSON. Finally, I will discuss how the results for this study could be used for further studies.

6.1 Conducting the survey and participatory mapping exercise

Before discussing the results, I want to discuss the first question in the survey regarding the participatory mapping exercise Figure 16. It is central for the results of this method that the tasks are explained in such a way that they will be understood by the participant, and therefore using a language that is adapted for the age group and knowledge background. Most of the participants answered that they understood the task, but two answered no and five chose not to have their answers used in this study. The maps were collected before the survey was conducted, but none of them asked for their map answers to be revoked afterwards. The two answers for what could have been explained better were “how” and “how can our answers help you?”. These two answers in addition to five pupils choosing not to have their answers for this study proved that the explanations of the task may have been understandable, but how their answers might help me could have been unclear. Since some of the participants did not understand what their answers were going to be used for, then it is possible that this is the reason as to why they did want them used for the study. In this case, the noise, see Figure 1, for communication could have been how I explained my project and how their data would help me test out the Sketch Map Tool as a software to collect data on risk perception (Sketch-Map-Tool.heigit.org, 2024a). The complication of several categories that would be mapped could also have been improved on to reduce the noise. That would make the task easier to perform with fewer colors and categories to follow, so that it would seem less overwhelming. Additionally, the time and date for collecting data could be planned long beforehand with a school or teacher so that the pupils are better prepared for the theme of the participatory mapping.

For the variables for pupil risk perception in this analysis I took inspiration from Adwin Bosschaart et al. and the variables of knowledge (Bosschaart et al., 2013), and from Yi Ge et al. and Päivi Lujala et al. for exposure to natural hazards (Ge et al., 2021) (Lujala et al., 2015). The discussion and analysis of the collected data will be discussed as relative to this class and will not be representative for pupils in their age group because of the low number of participants. The answers can however give an idea of what the general class "may" look like.

6.2 Pupil natural hazard knowledge

The survey started off asking the participants about where they have received information about natural hazards in Trondheim, from social media and from those around them. Only one pupil answered that they had not received any information about natural hazards on social media. One answered Facebook, two answered Instagram and four Snapchat. The largest out of the specified categories was Tik Tok with nearly half the participants answering that they had received information about natural hazards in Trondheim from that platform Figure 17. Tik Tok surpassed both Facebook and WhatsApp with more than a billion downloads in 2018, and has about 800 million active users with a large portion of them being in the age group for this study (Cervi, 2021, p. 199). The platform allows for anyone to create short videos with edits, and a user can find any type of video due to the artificial intelligence that analyses the users' interests and preferences (Cervi, 2021, pp. 199-200). With this platform being such a large portion of the social media from where the participants say they have received information, it is important for teachers and schools to have a significant focus on critical thinking of sources (Kunnskapsdepartementet, 2017). Since the information can be shared by anyone, there is no guarantee that it is correct. For the remainer of the answers about social media there were five answers for news outlets, where four out of them said Adressa, which is a news outlet that covers news for mid-Norway. This shows that some of the participants do use a local information source. When asked who they received information about natural hazards in Trondheim, the majority, with 11 participants answering, was parents/guardians. Four answered friends, and three of those who answered none of the options above, said that they had learned about it at school.

Next, the participants were asked about how much they felt that they had learned about natural hazards in their local environment, Trondheim. There were two questions with a scale from 1 to 5 that they answered, one about at school in general and the other about the geography course at first year high school in Norway (Kunnskapsdepartementet, 2019). The answers show a small trend of the participants feeling like they learned more about natural hazards in the geography course, but the difference was still less than I had expected. The majority answered that they learned some, which was the middle option with value 3 for the survey, for both the questions. Despite most of the participants answering that they only felt like they learned something about natural hazards in Trondheim, 8 out of 9 answered that they were not interested in learning more about it Figure 22. Additionally, when asked if they had sought out information about natural hazards on Trondheim's own websites, or if they had received information directly from them only 1 and 2 out of 17 answered yes. The interest in learning more is at about 50% of the class, yet few of them had sought out Trondheim municipality directly. This question should have been reformulated to "Have you actively sought out local information about natural hazards?" to get a better picture of their interest and feeling of responsibility for seeking out this information. In the study from Loredana Antronico et al. 76% of the participants felt that they were directly involved in the responsibility of getting informed about natural hazards (Antronico et al., 2023, p. 6).

Lastly, the feeling of personal exposure among the pupils were low, with only 1 out of 17 saying that they felt exposed to a natural hazard Figure 25. But when asked if they had been exposed to a natural hazard, 5 out of 17 answered yes, with two of them having been exposed to floods. The first proves a point that Mitchell Scovell et al. made about personal risk and "unrealistic optimism" with the mindset that "it won't happen to me" (Scovell et al., 2022, p. 453). Similarly, the last question Figure 27 has three participants saying yes, which indicates that if they have heard of other natural hazard happenings, they do not see events happening other places to other people as something that might affect oneself. “One of the most important findings from this study was the strength of the relationship between risk perception variables and preparedness intention”(Scovell et al., 2022, p. 463). If the preparedness intention is low, then the overall risk perception may be lower than if they had a larger interest in seeking out information. With the participants’ answers average a value of 3 on the grade-scale Figure 20, while also being about equally split on the interest to learn more, can seem to follow the pattern that Corina Höppner et al. mentioned in their article (Höppner et al., 2010). Where a person’s risk perception influences the willingness/motivation to seek out or receive information (Höppner et al., 2010, p. 36).

6.3 Sketch Map Tool as a participatory mapping method for collecting data on natural hazard risk perception

With the context of the pupils’ natural hazard knowledge, I will now discuss how that may explain some of the sketches, and how successful the use of Sketch Map Tool as a participatory mapping tool for risk perception has been. When looking at risk perception, I will be looking at areas that the participants have marked red Table 1 on the map and see if they had marked any of the areas seen as natural hazard risk areas for landslides, floods or quick clay slides (NVE, 2024). One pattern that I noticed was that for several of the maps, the participant had marked the exact same areas in red as I did to demonstrate how they should make the markings on the map, see Figure 10. This could be the result of them being somewhat unsure of what areas could be categorized as natural hazard risk areas. Should the pupil feel like they did not know too much about specific areas and felt like they wanted to answer “correct”, then following the markings shown to them could be a conclusion. To improve on this part of conducting the data, I would not show the markings in red directly on the map, as done here, but rather just on the blackboard/whiteboard, or at the side of the map. With this, my presentation of the task has to some degree affected the answers.

An interesting outcome was that only on three of the maps did a participant mark an area that only one out of the 22 participants marked an area as used for everyday activity as an area at risk. Additionally, none of the participants marked any area local to the school as at risk for any natural hazard. This strongly emphasizes how people think that they are safe from hazards that may cause others harm (Scovell et al., 2022, p. 453). It also shows how the pupils answered the question about feeling exposed to a natural hazard Figure 25, where only one of the participants answered “yes”. Two out of the participants answered that they had been exposed to floods, and only two of the map answers have marked Nidevla as a source for a natural hazard. Those two might be coincidences, as I have not tied a name or number to the participants to see which answer is connected to what map, something that could be a point of interest for using this method again. Still, the point being that frequently used areas are generally not mapped as hazardous. Some of the areas that were most frequently marked as a areas used by the pupils were Trondheim Torg, Ranheim, areas in close proximity to Charlottenlund, and the pier north of Charlottenlund. To further emphasize the previous point, Ranheim and the pier were also areas frequently marked as an area at risk, but not by the pupils who actively used those areas. When looking at how the red markings overlapped with areas that are categorized as risk areas by NVE, the participants did not show high accuracy of what areas could be affected. The natural hazard areas with fewest markings were for quick clay, closely followed by landslides. Flood risk areas were the feature that was most marked. This could be because it would be easier to recognize directly on the map where a rise in water level could have an impact.

6.3.1 GeoTIFF files

I will now discuss the use of the tool as a method for collecting the data and visualizing it, with a focus on the two different digitization methods, GeoTIFF and GeoJSON files (Sketch-Map-Tool.heigit.org, 2024a). One of the greater strengths of the software is the choosing of a location and the OSM data analysis to check if the area and the scale of it would be suitable for participatory mapping (Klonner, Hartmann, et al., 2021, p. 4). The quality check can help the person or institute conduct participatory mapping of what improvements or measurements that need to be made for the chosen area. This is a great way of making the software more accessible to users, which is important for such a software (Kyem & Burnett, 2023, p. 246).

The GeoTIFF files are georeferenced raster picture files of the maps. This is the first of the options for downloading data of the digitized maps. Many maps can be uploaded at the same time, up to the limit of 500 MB size of files. Pictures of the maps can be recognized even under unfavorable light conditions (Klonner, Hartmann, et al., 2021, p. 10). This makes the software very efficient in handling a large quantity of data at the same time. All the maps get their own raster files. The accuracy of georeferencing with the maps was near perfect. This makes comparing the different maps for the sketched features an easier task. To compare the maps, one can either make them somewhat transparent, or look at them one by one while comparing them to other features. The GeoTIFF file variant is good for just visualizing and comparing data but is a more qualitative method of analyzing the data. This method could work for a smaller sample of maps but would be a lot of work when analyzing larger quantities of data.

6.3.2 GeoJSON files

A GeoJSON file is a georeferenced vector file that recognizes the sketches made on the map generated with Sketch Map Tool, and creates polygons which are coded for the color of the mapped feature, in the attribute table (Sketch-Map-Tool.heigit.org, 2024a). For the creation of GeoJSON files, the upload process is one to keep in mind for what result is needed for analysis. When uploading all the maps at once, the result will be one layer with the registered features from all the input maps in one layer, see Figure 41. This is a way to look for trends and can be a solid way of conducting a quantitative analysis of a large quantity of maps. The polygons can also be displayed with "no fill", meaning that they do not necessarily overlap with each other or cover other sketched markings, and have their edges colored instead. The maps can also be uploaded one by one to digitize one vector layer for each of the maps, that can be used for analysis, though this method requires more work.

The software is still under development, and though many of its recognition features are very accurate, the color recognition is not accurate enough for handling the four different color categories used in this project Table 1 (Sketch-Map-Tool.heigit.org, 2024b). The colors for each shape were displayed under the "color" field in the attribute table for the layer Figure 12. In the pilot testing for using this method, a lot of work went into finding colors that were recognized by the software, and did not blend with each other, especially if in proximity. The colors that I ended up using for this project were black, blue, red and green Table 1. If the colors are not "solid" enough, then the background will also affect how it will be recognized since it will slightly change the color. The colors were also recognized as yellow, pink and orange, and with at least one of these errors in recognition appearing in 13 out of the 22 maps. The pictures were taken in an environment with favorable light as well, to avoid shadows or any darkness in the picture affecting the outcome (Klonner, Hartmann, et al., 2021, p. 10). For this method to be easily accessible in an average school classroom, this part of the software needs some more improvement. Though the colors can be adjusted for the polygons manually later, this is not preferable. Another way to work with this issue in mind can be to use fewer categories. For example, with only black to show where the areas where pupils usually spend their time, and red to signify natural hazard risk areas. When using only one-color category, this will not necessarily be a concern, as there is no need to distinguish between the color coding of the polygons. For the digitization of GeoTIFF files, the color recognition is also not

The recognition of shapes and polygons had high accuracy, with only two instances of the sketch not appearing in the digitized form of the GeoJSON files. The first was a green circle and the latter was a black line that went through two other circles, which might be why it was not recorded. The shapes of all the circles were also accurate and aligned well with the GeoTIFF raster when compared. The big issue for visualizing the data with GeoJSON for this study lies in too little pilot testing in the shapes for this method. The digitization process will create polygons of the shapes in the maps, and with line features. So, the first category of "my road to school" did not translate well with this method, and should not be included as a line sketch for using the Sketch Map Tool (Sketch-Map-Tool.heigit.org, 2024a). The result of this was line features that were connected by the closest possible points to create polygons that covered up far more space than anticipated, and something that made a further analysis in GIS an issue.

7. Conclusion

Understanding the public risk perception is important for authorities to make decisions for mitigation and adaptation of consequences from natural hazards (Lujala et al., 2015, p. 3). The climate changes have had notable effects on precipitation in Norway, and shows a trend that the occurrence of heavy precipitation events will cause a projected flood level increase by 40% by the end of the century (Amundsen & Dannevig, 2021). Increased precipitation intensity and frequency will also increase the probability of other natural hazards, such as quick clay landslides and other landslides. Trondheim has a large amount of quick clay in the soil composition and could be prone to quick clay hazards (Ottesen & Langedal, 2001). Nidelva and the mountains in Trondheim municipality are in proximity with, or areas that are in use by the population. Until now, the majority of risk perception studies related to natural hazards have largely focused on adults (Bosschaart et al., 2013, p. 1662). As a geography teacher student, I find it important to include the younger part of the population as well, since they are an important part of the population and will grow up in a world with the results of climate change. An important part of including the area use of the younger population can be done by the use of "Barnetråkk", where they can map what areas they use and for what purpose, for authorities to use for city planning (Rothschild & Ekberg, 2022). Another way to visualize patterns of area use or local knowledge can be done using participatory mapping. In this study, I have used the participatory mapping tool Sketch Map Tool to map risk perception among high school students (Sketch-Map-Tool.heigit.org, 2024b). Some scheduling conflicts resulted in a low number of participants, which makes the results from this study not representable to generalize the results for first year high school students. The focus of this study was instead changed to test a framework for collecting data on natural hazard risk perception, with discussing the results in the context of what the patterns of a class may look like. The mapping of risk perception is also affected by knowledge, so I included a survey to see where the pupils got their knowledge from, and how much they felt that they had learned at school in addition to their interest in the topic. They were also asked about their experience. The answers from the survey were used as a context for discussing the sketch mappings with a visual analysis.

7.1 What is the perception of natural hazard risk in Trondheim among high school pupils?

Learning about the local environment, and about causes and consequences of natural hazards are part of the geography curriculum for geography. Natural hazard knowledge plays a part in risk perception, as well as both direct and indirect experience Figure 2 (Bosschaart et al., 2013, p. 1667) (Wachinger et al., 2013). According to the answers from the pupils, their natural hazard knowledge was average, and less than half the class was interested in learning more about the topic. In addition to the medium interest in the topic, most of the participants felt safe from natural hazards. Despite the pupils using many of the areas that are mapped as potential natural hazard risk areas by NVE, few of them mapped the areas that they used as areas that could be affected by one. Only one participant marked one of the areas that they used frequently as an area at potential danger. This shows a very clear "unrealistic optimism", where a hazard will only affect others and not happen to oneself (Scovell et al., 2022, p. 453). The same pattern repeated itself with the area in proximity to the school, where none had marked it as a potential natural hazard area, when there is a river running by. Only two of the participants marked Nidevla as a potential hazard zone. These results in addition to many of the participants answering that they received information about natural hazards from Tik Tok, emphasizes the importance of critical thinking of sources as a basic skill (Kunnskapsdepartementet, 2017). In these results, the pupils showed a low grade of risk perception. Interest in the topic can be a factor in developing risk perception. For schools and educational institutions, this could be an indication that there is a need to spark more interest for climate changes and the local environment through more interdisciplinary activities (Bosschaart et al., 2013, p. 1664).

7.2 Is Sketch Map Tool an effective participatory mapping method to measure natural hazard risk perception among high school pupils?

The Sketch Map Tool can be an effective participatory mapping tool for mapping risk perception if implemented properly. The accuracy of the georeferencing is reliable from the samples used in this study, which is important for the data quality (Kyem & Burnett, 2023, p. 249). The categories that I chose to use in this study could have been shortened down to two: areas they use for daily activities and areas they believe are at risk for any potential natural hazards. This is with the current state of the color recognition of the software and to minimize the manual correction of the data. The Sketch Map Tool is still in development, and can be improved with more users and samples to work with for the color recognition (Sketch-Map-Tool.heigit.org, 2024b).

The digitization can be done with either GeoTIFF files, which are georeferenced picture versions of the maps, or GeoJSON files that are polygon vector layers. The results can be used to visualize data in a GIS software like QGIS or ArcGIS Pro for further analysis (QGIS.org, 2024) (esri.com, 2024). With these options, the Sketch Map Tool allows for both qualitative visualization of the collected data and for quantitative spatial analysis of scanned layers (Sketch-Map-Tool.heigit.org, 2024a).

7.3 Can the output be used for city planning?

The result from this study shows that there is a lack in both natural hazard risk perception, and somewhat in interest among pupils. Since these results are not representative, this study has had the focus on testing the Sketch Map Tool as a method for participatory mapping (Sketch-Map-Tool.heigit.org, 2024b). The relative low cost in time and resources for using the tool can help overcome some Norwegian barriers in implementing climate change adaptation tools (Amundsen & Dannevig, 2021, p. 2). It is designed as an easy-to-use tool and is meant to be more accessible by using printed out maps that can be digitized later, so that the participants are not reliant on having access to or technical skills to be a part of the process. The high accuracy of data and the informative analysis with the OpenStreetMap quality check lowers the barriers for the user experience of the software (Kyem & Burnett, 2023, p. 246). The data on what areas pupils use frequently, and how aware they are of any possible natural hazard the area may be prone to, may give Trondheim municipality guidance in how and where to allocate resources for hazard mitigation. Information on where pupils receive information from could also be helpful in providing insight into how to spread important information to them. Greater communication and inclusion of public knowledge in city planning may lead to greater community resilience.

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9. Appendix

Appendix A

Survey questions

Nr.	Questions	Answer format
	I will first write the original Norwegian question, and then an English translation of it. The questions will be numbered, where a .1 question is a follow-up question to the previous one.	The answer formats that were used for this survey were: Multiple choice A grade scale from 1-5 Dialogue boxes for writing your own answer
1	Dersom du ikke ønsker at dine svar skal brukes i dette prosjektet kan du krysse av her. Should you not wish for your answers to be used in this project you can tick here.	One choice checkbox
2	Var oppgaven med å fylle inn informasjon på kartet tydelig? Was the task of filling in information on the map clear?	Multiple choice

2.1	Var det noe spesifikt som skulle vært forklart tydeligere? Was there something specific that should have been clearer?	Optional follow up to answering “Yes” Dialogue box
3	Fra hvilke sosiale medier har du fått informasjon om naturfarer i Trondheim? From what social media have you received information about natural hazards in Trondheim?	Multiple choice
3.1	Dersom platformen du har fått informasjon fra ikke er på listen kan du skrive den her. Should the platform you have received information from not be in the list, then you can write it here.	Optional Dialogue box
4	Har du fått informasjon om naturfarer i Trondheim fra de rundt deg? Have you received information about natural hazards in Trondheim from those around you?	Multiple choice
4.1	Hvis du har fått informasjon fra andre enn alternativene ovenfor kan du skrive det her.	Optional (With a notice to not write any specific names)

	If you have received information from others than the alternatives above, you can write them here.	
5	Til hvilken grad har du lært om mulige naturfarer i Trondheim på skolen? How much would you say that you have learned about natural hazards in Trondheim, at school?	A grading from 1-5
6	Til hvilken grad har geografifaget gitt deg kunnskap om naturen og mulige naturfarer i Trondheim? How much has the geography course given you knowledge about nature and possible natural hazards in Trondheim?	A grading from 1-5
7	Jeg skulle ønske vi lærte mer om mulige naturfarer i Trondheim på skolen. I wish we learned more about possible natural hazards in Trondheim, at school.	Multiple choice
8	Jeg har sjekket Trondheim sine nettsider for informasjon angående naturfarer. I have visited Trondheim's' websites to look for information about natural hazards.	Multiple choice

9	Jeg har blitt informert av Trondheim kommune på sosiale media angående naturfarer. I have been informed by Trondheim municipality on social media about natural hazards.	Multiple choice
10	Har du noen gang følt deg utsatt for en naturfare? Have you ever felt exposed to a natural hazard?	Multiple choice
10.1	Hvilken type naturfare har du følt deg utsatt for?	Optional Dialogue box
11	Har du blitt utsatt for en naturfare? Have you been exposed to a natural hazard?	Multiple choice
11.1	Hvilken naturfare har du blitt utsatt for? What natural hazard have you been exposed to?	Optional Dialogue box
12	Har det vært en hendelse du har hørt om som har fått deg til å være mer oppmerksom?	Multiple choice

	Has there been an event of a natural hazard that has made you more alert?	
12.1	Hvilken hendelse? What event?	Optional Dialogue box

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