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Ethics of Climate Change Adaptation—The Case of Torrential Rains in Norway

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Abstract: This article analyses adaptation to climate induced challenges in form of torrential rains hitting urban landscapes in Norway with increased frequency. Specifically, it investigates the influence of the industry structure on ethical challenges when the climate changes. A meta-analysis of the scientific output from a major multi-disciplinary research program is carried out. In addition, the methods include use of expert opinions, literature review and document studies. Climate change adaptation challenges disciplines within civil engineering and natural sciences. Following this, established practices need alteration as specialists face new ethical challenges. Practical climate change adaptation requires the ability to overcome silo mentality among the involved disciplines. Challenges involve acknowledging responsibility, transparency, and information quality. Engineering takes place in an environment of incomplete knowledge. In addition, there is a high degree of decentralised decision-making and directives, and laws and regulations are often lagging after the experienced challenges. Consequently, individual experts experience increased ethical challenges. Systemic circumstances apprehension is necessary for reducing societal risks within climate change adaptation. Both education of engineers and cooperation between specialists from different disciplines is needed to master the altered framework conditions.

Keywords: professionalism; silo-thinking; information asymmetry; problem of many hands; knowledge abuse

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1. Introduction

Climate change exposes societies to radical change [1]. Categorisations of the responses to the changes observed mostly vary between climate change mitigation and climate change adaptation (CCA) e.g., [2]. At the heart of CCA lies ethical concerns (ibid.) and responding to climate change is one of the gravest ethical challenges facing humanity today [3]. Indeed, these authors underline that CCA impacts not only a need for technical solutions, but also encompasses major changes in the way societies operate. Such major changes will inevitably have significant ethical implications. These include most notably questions about who will bear the burdens of the changes (that is, key ethical concerns such as equality issues, gender issues, geographical distribution issues, and socio-demographic issues).

The ethical concerns are multiple [4,5]. Ethical analysis concerning CCA needs to take place at several levels, since "[e]thics [within this context] encompasses evaluative thought that extends from noble visions and high ideals to the more immediate and constrained assessment of options that face people in the here and now" [6], p. 847. The literature indicates that within the field of CCA, more effort has been invested in ethical analysis on an overall level than in the here and now.

Climate change leads to a concern for the actors that carry out concrete CCA measures, in particular engineers within the architecture, engineering, and construction industry [7]. In this article, ethical challenges posed by CCA enforced by intense precipitation in the form of torrential rains affecting urban landscapes are scrutinized. In several regions, but in Norway in particular, torrential rains are pointed out as being a key challenge inflicted on the built environment by climate change. Torrential rains are also worth paying particular attention to, given that they are very challenging in terms of CCA [8]. The results outlined here are thus based on analyses of the Norwegian context; they are, however, applicable in regions where an increase in torrential rains is expected.

The literature review preceding the research presented in this paper showed, however, that little is known concerning the implications for the actors addressed—and in particular the ethical challenges that surface during this work. As such, the analysis presented pertains not only to CCA, but also to the more general question of adaptation to altered framework conditions by industry professionals such as engineers. The ambition is to illustrate how altered framework conditions expose engineers to ethical challenges by answering the following research questions:

1. What are the main systemic circumstances shaping CCA measures?
2. What ethical challenges do these measures entail for individual experts?
3. What measures can be envisaged to overcome these challenges?

2. Theoretical Framework

The definitions of ethics are notoriously diverse [9]. The contrasting features and overlapping of these definitions can be illustrated in several ways [10]. For instance, Davis ([11], p. 718) depicted three separate concepts labelled ethics, notably (1) ordinary morality, (2) a field of philosophy, and (3) special standards that go beyond ordinary morality. Engineering ethics fall into this third category, as it "applies only to members of the relevant group (engineers)" ([11], p. 719). While resembling aspects from other ethical perspectives, engineering ethics is generally more stringent. For instance, the National Society of Professional Engineers [12] is very specific in detailing ethical conduct and unethical practices, where the safety of others, truthfulness, trustworthiness, and a long list of similar topoi from the literature on ethics are listed.

Even though occurrences of such practices are treated in the following, the present article rather treats the dynamics driving the occurrence of or potential for unethical practice.

2.1. From Ethics in the Built Environment to Ethics in CCA

Reviews aiming at mapping unethical practices within the built environment in general—be they broad in approach e.g., [13,14], focusing particularly on corruption e.g., [15,16] or particularly exposed individuals [17]—have remarked the small interest in questions related to ethics. As Walker [18] notices, there is no reference to ethics in the index of PMI's Guide to the Project Management Body of Knowledge [19] and generally "a dearth of papers related to ethics".

Associations such as the Project Management Institute (PMI), Royal Institute of British Architects (RIBA), American Institute of Architects (AIA), American Society of Civil Engineers (ASCE) and International Project Management Association (IPMA) have codes of conduct [20]. These codes are typically general in nature. In addition, studies of higher levels of education have shown that little if any ethics are included in the curriculum of engineers e.g., [21–23].

Exploratory studies reveal a widespread idea of professional ethics existing in the form of tacit knowledge [24,25]. Tacit knowledge is typically anchored in deep-rooted practices. As climate changes and the responding adaption measures change, pressure is put on established perceptions of ethics in the industry.

2.2. Ethics of CCA—Previous Analyses

Further, the approach of Heyward, for whom "adaptation aims to deal with the potential or manifested effects of the physical changes associated with global climate change. It does not attempt to reduce GHG concentrations [e.g., mitigation] or avert temperature increase" [2], p. 483, is followed. The main advantage of this definition is that it opens the question of CCA to all fields of potential interventions.

The moral worthiness of CCA has been contrasted with that of mitigation, resulting in that "[t]hose who advocated mitigation regarded talking of adaptation, variously, as (1) defeatist [. . .], (2) as an indication or creating unwillingness to participate in mitigation efforts, and (3) as a distraction from mitigation" [2], p. 475. Having such a promised cure should make us more likely to procrastinate and less likely to address the root problems causing climate change in the first place e.g., [26,27].

The need for adaptation has, however, been recognized more prominently in the 2010 Cancun agreement, maintaining that "adaptation must be addressed with the same priority as mitigation and requires appropriate institutional arrangements to enhance adaptation action and support" [28], p. 3.

Following this, ethical debates have been raised on analytic and political levels. Institutional arrangements e.g., [29], policy-making processes e.g., [30,31] and administrator role challenges e.g., [32] are typical examples of this. Thematically, these debates include concerns for indigenous populations particularly exposed to the effects of climate change e.g., [33]; vulnerable populations e.g., [34,35]; the implications of the use of global-reaching adaptation tools such as geoengineering e.g., [36]; climate diplomacy e.g., [37,38]; non-linear risk potentials, such as exceptional tipping-points e.g., [39], etc. Similarly, the identified approaches to ethics of adaption vary from normative e.g., [40] via framework-oriented e.g., [5] to exploratory e.g., [3]. The debates include terms such as justice (for a discussion hereof from a financing perspective, see e.g., [41]; transparency (e.g., [42]; responsibility (e.g., [43]; obligation to act (e.g., [44]), etc.). It seems, thus, that the main body of the literature addresses challenges occurring within the spheres of politics and policy-making.

Equally interesting is what is not debated. Questions about practical concerns such as conflict resolution [45], analyses porting on those carrying out practical CCA work, or crucial subjects such as project delivery methods are rare (a notable exception can be found in [46]; see also [47]). Considering this, it is easy to agree with Schmidtz [45], for whom "[e]nvironmental ethicists need to start with conflict on the ground rather than visions". Even more sharply, Holland [34] underlines that "adaptation efforts are largely treated as a technical enterprise [. . .] while marginalizing issues of social justice". It can be added to this that there is a real lack of the literature on what van de Poel et al. [48] and van de Poel et al. [49] denote the problem of too many hands. Within the Norwegian context, this "conflict on the ground" has several aspects, with challenges driven in particular by geographical factors that vary greatly.

2.3. Torrential Rains in Norway

Norway's varied topography, long north–south extent, and location at the edge of the North Atlantic result in highly variable climatic conditions over short geographical distances. The seasonal variations are significant. Generally, the climate is milder in Norway than in other areas at the same latitude, mainly because the North Atlantic Drift transports warm water from the Gulf of Mexico northwards along the Norwegian coast. Prevailing south-westerly winds carry warm, moist air towards the coast [50].

Annual precipitation in Norway has increased by ca. 18 % over the last ca. 100 years, and climate prognosis shows that average precipitation will increase by 10–18% through this century, relative to the reference period 1971–2000, depending on the emission scenario [8]. In addition, both the frequency and intensity of extreme precipitation events are increasing. The increase is seen for all regions and all seasons, causing large damage to infrastructure and buildings. The effects of heavy rainfall—most notably with high intensity over a few hours—are particularly challenging to adapt to, both due to their amplitude and the relative lack of predictability concerning where they will occur [8]. In addition, as buildings and infrastructure assets have expected lifetimes from 40 to more than 100 years, they are exposed not only to the climate at the time of construction but also to climate variations over decades [51,52].

The increase in torrential rains—both in frequency and impact—challenges existing systems established to tackle precipitation. In other words, altered framework conditions impose altered technical solutions and the new ethical challenges that come with them.

2.4. Industry Characteristics Moulding Ethical Challenges

As debated by several authors e.g., [53], projects carried out within the context of the built environment have certain characteristics that distinguish them from other industrial ventures. Vrijhof [54] has typified the industry as a "project-based industry with specific characteristics such as location-bound design, one-off production, changing production coalitions per project, outdoor and environmental circumstances, multiple clients and multiple suppliers involved in a single project. In comparison to many other industries, the production environment in building is relatively complex and unstable". This definition can with minor alterations be extended to all endeavours discussed here.

Not surprisingly, these characteristics reflect how the industry operates, so "actual operations in the industry can be interpreted as responses to its inherent complexity" [55], p. 3. A key point is that the characteristics foster decentralized decision-making. This means that executive powers and corresponding ethical responsibilities are put in the hands of those carrying out CCA-related work.

The challenges involved in decentralised decision-making are exacerbated by another characteristic of the contemporary AEC industry, notably that of information silos.

2.5. Silo Mentality

An information silo can be defined as an insular information system incapable of exchanging information with other systems. In a field characterised by information silos, information is not adequately shared.

The influence of industry structures on knowledge sharing between engineering disciplines within the built environment is a surprisingly little-scrutinized theme. Working within a fragmented structure, with project-based work and between different engineering disciplines involves results in information silos [56]. Challenges can—for instance—be directly observed in the lack of cohesion in the new teams that take on the different phases of a construction project [57].

Technologies such as BIM have for decades held the promise of enhancing integration and reducing the fragmentation of the industry [58]. Still, this development is far from reaching a point of maturity permitting for effective combatting of existing information silos [59].

For what concerns decision-making within the context of CCA, it seems that silo mentality will expose more actors that carry out concrete CCA measures, in particular engineers within the architecture, engineering, and construction industry [7], to ethical challenges. Not being able to involve other disciplines and actors with differentiating concerns in the decision-making will expose those making decisions to the dangers of not being able to fully appreciate the consequences of decisions.

2.6. Knowledge Gap

As commented by Nair and Bulleit, "[e]ngineering is a practice that must function in an environment of incomplete and uncertain knowledge" [7], p. 65. Alterations to complex adaptive systems predictably produce highly uncertain results. The incompleteness and uncertainty of knowledge manifests at two analytically distinct levels—practically, in that the engineering challenges encountered are new, and ethically, since the tacit knowledge developed over time will be outdated.

Such consequences of systemic alterations need, as illustrated above, to take into account the nature of the system that is changing—in this case, the AEC industry exposed to climate change. As illustrated above, climate changes will inflict major stress on the built environment. To meet future climate conditions, CCA efforts need to be made. These efforts, however, need to be conceived of within constraints that are very much present in the AEC industry, notably its project-based nature and the information silos characterising the industry. To a certain extent, the consequences of this have been discussed at a policy level.

Yet, neither the consequences of alterations to practical solutions nor the consequences this will have for the ethical deliberations of those carrying out work on a practical level are properly understood.

3. Methods

3.1. The Research Object

The research object under investigation here is the built environment at large as this is influenced by changes in climate that necessitate CCA measures. Emphasis lies on water-triggered landslides, stormwater management, blue–green solutions, building structures, socio-economic incentives and decision-making processes.

3.2. Research Design

The present article results from a meta-analysis of the outcomes of an eight-year research project, Klima 2050, with the main objective of "risk reduction through climate adaptation of buildings and infrastructure". Meta-analysis is here not to be taken in any very technical sense, but rather in its original meaning, as the "analysis of analyses" [60].

The analysed studies were based on laboratory and field measurements, simulation techniques, as well as semi-structured interviews and observation studies. This covers the entire width of the centre activities and therefore a broad range of methods and techniques within building sciences, geosciences, hydrology, civil engineering, and social sciences [61–66].

In addition, pilot projects have constituted a main arena for product and process development, as well as for validation of previous research. Collaborative research through PhD projects, master theses, partner participation and stakeholder groups constitutes the core of all research activities.

3.3. Literature Review

The main search engine used was Google Scholar. Complementary searches were conducted in the Norwegian library database Oria. Search words included "ethics", "virtue", "professionalism", "silo mentality", "urban landscapes", "information asymmetry", "problem of many hands" and combinations of these using Boolean operators.

3.4. Document Study

In addition to the published research, the centre has produced a series of documents such as strategy documents, communication plans and summaries of the research conducted. These form part of the background material for the analysis, following Bowen's [67] prescriptions for document analysis.

4. Results

4.1. Precipitation and Awareness in Norway

Over the last decades, several extreme weather events have been observed in Norway. The common denominator of these events is water. As described by Sandberg et al. [68], the chronological development of CCA strategies in Norway from 2009 to 2019 illustrates that extreme events have led to increased awareness of climate change consequences.

The national budget for 2009 marked the commencement of the Government's adaptation-related work [69]. This resulted in a report outlining the consequences of climate change (i.e., [52]). In 2013, a government report on the status of CCA in Norway [50] recommended addressing surface water flooding in particular. The ensuing report was published in 2015 [70].

Reporting to the Intergovernmental Panel on Climate Change (IPCC) entails the continuous assessment of risk factors and adaptation needs [71]. As part of the Paris Agreement, all countries are committed to preparing a climate change adaptation plan [72]. In 2018, a governmental report [73] was published setting out climate-related risk factors and their significance for the Norwegian economy. The year 2018 also saw the publication of adaptation guidelines for use in planning, directed at the municipalities, county councils and national authorities. These were subsequently incorporated into the statutory provisions accompanying the Municipal Planning Act [74]. However, climate change adaptation was only referred to in Norway's national budget in 2020 under the items research and foreign aid [75].

With two exceptions, the documents described above do not mention ethical issues. The first exception [52] refers twice to the need to respect the inherent ethical value of nature, whilst the second exception [73] refers to moral hazard in the context of actor behaviour. No mention can be found of CCA-related ethical challenges.

4.2. Ethical Challenges following the Effects of Torrential Rains

The following sections illustrate on a practical level that challenges stemming from the increase in torrential rains have ethical implications for individual experts.

4.2.1. Torrential Rains Lead to Landslides

Most debris slides and flows in Norway are triggered by precipitation. The precipitation occurs mostly in the form of rain, but sometimes it occurs in combination with the melting of snow [76–78]. Milder winters with more frequent rain-on-snow events lead to an increased frequency of slush flows, which often develop into debris flows as the flows entrain debris and sediments downslope. Increased levels of human activity, such as uncontrolled land use, urbanization and deforestation increase the probability of release and the consequences of landslides. The changing precipitation patterns may also lead to landslides in areas not usually affected by landslide activity.

The development exerts increased pressure on infrastructure. Transport infrastructure such as roads and railways are particularly vulnerable to landslides. Climate change is identified as one of the main challenges to the safety of transport infrastructure [79]. Examples of this appeared in the village of Kvam in central southeast Norway in both 2011 and 2013, when main roads and railroads were closed for long periods due to flooding and debris flows, with huge economic losses as a result.

Structural risk-reducing measures for landslides include barriers and check dams. Non-structural measures include early warning systems, evacuations, and road/railroad closures. Lately, nature-based solutions that usually involve vegetation have gained importance. Proper land use planning is however crucial for the establishment of new infrastructure and buildings. This planning is regulated by the Norwegian Planning and Building Act (Plan-og bygningsloven) [80].

For existing buildings and infrastructure, however, the challenges are multifaceted. Many houses and much infrastructure are built in areas which already are, or will be, exposed to landslide hazards. The hazard is difficult to assess, and the assessments are often based on the expertise and judgement of individual specialists. Furthermore, the knowledge of landslide hazards is largely missing in the general public.

Assessments of landslide hazards require frequently updated knowledge and frequently updated directives, laws and regulations. In addition, the hazards entail ethical challenges, for instance, pertaining to political decision-making, the responsibility for variations in insurance premiums, and questions regarding the balance between individual and collective responsibilities. A hazard assessment by a specialist may lead to dramatic changes in property values. Today, specialists already face ethical challenges in addition to traditional engineering challenges, and these ethical challenges do not disappear when ignored.

4.2.2. Torrential Rains Lead to Pluvial Floods

The construction of traditional drainage systems (mainly underground) will not suffice to address the challenges ahead. Nature-based solutions and floodways are proposed as measures for tackling such challenges [70].

Following this line of thought, the overarching strategy for tackling flood water stemming from torrential rains in Norway today is outlined by Lindholm [81]. The main approach described there consists of a three-step strategy for infiltration, delaying, absorption and safe flood roads. The principle is that the first subsection in most cases manages to infiltrate or withhold the water in all rains with a smaller amount of precipitation than a defined threshold value. When precipitation above this threshold falls, the excess drains to open facilities that delay and absorb runoff. In a few events, the volumes of water are so extensive that the normal systems cannot handle runoff alone. For these, floodways can be constructed to safely divert the resulting pluvial floods [81]. The above illustrates what challenges those responsible for reducing the effects of flood water are facing.

One challenge stems from the system boundaries for Norwegian urban streams. Paragraph 20 in the Natural Damage Act (Naturskadeloven) [82] requires downstream protection against flood-triggered landslides [nedstrøms sikring er påkrevd]. It is unclear how far downstream measures are to be implemented. The text of this act leaves a fuzzy boundary between measures protecting against floods and downstream measures protecting against landslides caused by such floods. This fuzzy boundary is particularly felt in urban areas, where effects on the built environment can be substantial. In areas with quick clay, which are common in Norway, the balancing between measures poses significant ethical challenges.

Another challenge concerns the overlap between disciplines when it comes to the use of maps. Several frameworks for tackling parts of the challenge exist, but there is a limited exchange of information between users of these different frameworks. Good maps are available for flood and landslide hazards, respectively, but they are rarely combined. As such, the problem of the engineer—typically coming from one of the disciplines involved, such as hydrology or geotechnics—is to understand what to do within one's field of expertise without resulting in an action that conflicts with the concerns of those involved in other disciplines.

The third challenge comes with the dimensioning of the intervention. As outlined by Skrede et al. [83], the use of streets as floodways is an illustrating example. Streets as floodways require additional hydraulic performance criteria and safety criteria. They are demanding structures to establish. Skrede et al. [83] determined that, when planning safe floodways, planners must choose between the level of safety and the hydraulic performance of the floodway. As such, steep urban streets as floodways cannot be recommended without substantial flood safety measures, such as levees, elevated pedestrian crossings, and elevated curbs. The balancing acts are left to the actors carrying out work on the ground to address. This dimensioning challenge is especially valid when deciding what maximum level of flood events should be accounted for; there is a large difference between planning for events with a 5-year return period and those with a 100-year return period.

For all three challenges, the question of who should act remains open. This is a typical problem of too many hands, and this problem is enforced by the plurality of actors from different disciplines. The lack of judiciary boundaries proves problematic. As of the writing of this article, no concrete cases illustrating the above challenges have been put to test before a Norwegian court of law.

All solutions have consequences, such as restricting usable area and high costs. Goal incongruities are almost guaranteed to arise between those who abide the measures and those who do not. The recourse to new floodways is telling; whose street is to be exposed to what levels of torrents of water is no innocent decision. In the end, many such deliberations should be determined on a political level; yet the technical analyses and other documents on which decisions are based need to be elaborated by engineers. These analyses are to a significant degree left to individual judgement.

In the examples discussed above, one of the main characteristics is the difference in specific knowledge by the engineer (the agent) compared to that of the commissioning party (the client). The recourse to the individual judgement of the engineer facing concrete problems exacerbates the potential for the inhibited use of this—and as such, opens the potential for dishonourable behaviour. In the Project Management literature, information asymmetry has been identified as one of the “hot spots” for potential corruption or analogous challenges. With the advent of increased intensity and frequency of torrential rain following climate change, it is predictable that the challenges will be greatly exacerbated.

4.2.3. Torrential Rains Lead to Damage to Buildings and Infrastructure

Two major sources of information concerning damages to buildings and infrastructure in Norway provide grounds for analysing both trends in and root causes for water-related damages. These are data from Finance Norway, concerning trends in insurance pay-out for water-related damages and the SINTEF Building defects archive [Byggskadearkivet], mapping building damages and their causes.

Finance Norway is the organization for the financial and insurance businesses in Norway, and their figures show that the trend in insurance payments is on the rise. The consumer price indexed figures increased from NOK 1.032 billion in 2008 to NOK 1.831 billion in 2019 [84].

An overview of the cost development of insurance paying outs after damages on buildings/inventory as a consequence of precipitation in the years 2008–2020 in Norway shows that urban stormwater damage is the most expensive factor, more so than floods and other natural disasters [84]. Data shows a drastic increase in the number of stormwater damages, from 18.000 in 2008 to 26.000 in 2016. According to Finance Norway [85], this increase cannot be explained by a significantly higher number of buildings nor infrastructure; it rather expresses the increased climate loads.

The SINTEF Building Defects Archive documents cases of building defects for the past 60 years. Since 1964, more than 5000 cases have been investigated. Detailed information regarding these investigations has been collated and filed in this building defects archive. A thorough investigation into the process-induced building defects collected in this archive revealed that few new types of damage occur, but they occur more often and with larger consequences [86].

This aggravation of damages leads to a need for more robust constructions. Buildings are, for instance, exposed to maceration over longer periods than before. Adaptation measures must address such concrete challenges. Masonry is a good example here, where research shows that an alteration in the wetness of the concrete employed can provide a more resilient masonry [87,88]. In addition, the altered precipitation patterns following frequent occurrences of torrential rains lead to novel needs for maintenance, e.g., where gutters formerly needed cleaning each autumn, they now ought to be cleaned before the rains of the summer season as well. Such small details typically have significant consequences for the built environment. Rather than the problem consisting of defective assemblies on a large scale, small parts of the construction might be exposed to stress levels exceeding their potential. CCA through the addressing of such small details challenges the ethical stance of individual experts.

Kvande and Time [89] maintain that current building regulations do not treat CCA measures as an ensemble, but rather as dispersed entities. Whether an area is suitable for development purposes is assessed in the form of a risk and vulnerability analysis, in accordance with the Plan and Building Act and Chapter 7 in the Building Regulations TEK17 [90].

For land to be developed, there are requirements concerning groundwater and flood water in both the Plan and Building Act and the Building Regulations TEK17. For the building's ability to withstand moisture, wind and snow, the relevant requirements are discussed specifically in the Building Regulations TEK17. Chapter 7 of Building Regulations TEK17 describes the effect of climate change and the fact that this may have consequences for the localisation of buildings and for loads. An increased risk of flooding and landslides is described. After this, it is pointed out that "the Planning and Building Act with regulations shall contribute to ensuring that new buildings and structures are adapted to a changed climate". The Plan and Building Act specifically states that "to ensure that any measure has a proper and intended lifespan, special consideration shall be given to geographical differences and climatic conditions on site" (our translation). However, how the future climate is to be considered is not specified.

For an actor planning or carrying out actual work on site, assessing the implications and interplay of these regulations will prove inherently challenging. The level of detail can pose problems. Andenæs et al. [91] outline that unsurmountable levels of dispersed information in SINTEF building design guides relevant to blue–green roofs are inducing a selective reading of design guides. The SINTEF Building Research Design Guides are a series of reputed and widely used building technical recommendations in Norway. The selective reading leaves a significant and largely unaddressed human factor in play, and with corresponding risks and responsibility issues following thereof. Sticking to well-proven solutions will thus be highly tempting, even if these solutions are not the recommended ones.

This penchant for choosing well-proven solutions is exacerbated by questions pertaining to goal incongruity. Economic factors are at play, since altering the modus operandi of operations typically inflicts extra costs. Equally important, however, are temporal aspects. According to The Housing Construction Act (Bustadsoppføringsloven) [92], for instance, the warranty time for dwellings in Norway is limited to five years. Many of the damages inflicted by altered climatic conditions occur in a temporal horizon significantly longer than this. This means that the contractor has a strong incentive to consider the construction according to another timeframe than the client, who typically uses the built object over a period of decades.

Finally, adapting to new climate conditions typically leads to increased complexity in projects. As outlined by Engebø et al. [93], to meet the challenges of projects with high sustainability ambitions, new collaborative working processes need to be implemented, with the explicit ambition of breaking down discipline silos. To achieve this, emphasis is placed on heightened levels of trust among participants. Furthermore, according to Engebø et al. [46], achieving the requisite collaboration depends on contractual, cultural, and organisational elements, of which the latter two are under the direct influence of individual experts. Trust is of the essence, yet questions about responsibility and blame for breaching trust remain [47]. It seems reasonable that the actors most in contact with the other project parties—that is, the individual experts—will be most exposed to blame.

The numbers show that insurance payments are quickly raising. The knowledge about ways to make the buildings and infrastructure more robust partly exists, but the dissemination of this knowledge requires more effort than is provided today. The result is that those carrying out work on the ground are tempted to apply well-proven solutions suited for previous climate conditions before the more costly and robust solutions.

4.2.4. A Reactive Rather Than Active System

The above has identified ethical challenges following the effects of torrential rains as relatively discrete entities. Such an approach may hide possible cascading effects of the events. Flooding can, for example, lead to landslides, increased risk for landslides can influence the security classification of building sites, and runoff from buildings challenges the capacity of the urban drainage systems.

The possible cascading effects imply ethical challenges at an aggregated systems level. From the research carried out within the context of Klima 2050, at least three systems with challenges can be identified.

First, network activities are needed for practical dissemination of knowledge about the reactive nature of CCA measures. In a series of papers, Hauge et al. [94–96] discuss the nature of existing guidelines for CCA and the need for knowledge network activities as a strategy for dissemination.

Second, the directives, laws, and regulations within the context of CCA are dispersed and not holistic. For an actor planning or carrying out actual work on site, assessing the implications and interplay of building regulations will prove inherently challenging. The level of detail in the regulations can pose problems as well.

Third, damage of data in the form of insurance payouts has been of interest to the researchers involved in Klima 2050 (e.g., [97]. Previous research has shown that municipalities benefit from damage of data on an address level from the insurance companies [98]. Data contribute to an improved understanding of the risks involved, and consequently to prioritizing measures. As described by Hauge et al. [95], the data provided made possible a public–private cooperation between regulatory bodies and insurance companies. The Norwegian Directorate for Civil Protection (Direktoratet for samfunnssikkerhet og beredskap) and Finance Norway implement common measures to prevent undesirable nature events. The closer one gets to those responsible for CCA, the clearer it becomes that such increases in data quantity and quality imply ethical challenges. If the insurance companies provide the municipalities with detailed loss data, claiming a lack of knowledge is challenging. The latter thus increases their exposure to impoverishing regress claims. The question is if small municipalities can manage such responsibility for access to loss data. As such, questions of responsibility arise on a systems level.

In sum, the pattern of action is reactive rather than proactive. The regulation of measures carried out does not adapt well to the challenges encountered and the question of who is taking on risk when information flows are altered is not well understood. The reactive systems leave the individual experts with ethical challenges when carrying out their work.

5. Discussion

The Results section addressed (1) the main systemic circumstances shaping CCA measures, (2) ethical challenges these measures entail for individual experts and (3) what measures can be envisaged.

First: A general insight from the results presented is that reactions to climate change adaptions (CCA) within the Norwegian context are largely pushed forward through major natural incidents such as hurricanes, floods, etc. This implies a certain lag in regulatory responses to such events. Directives, laws and regulations do not keep pace with the needed changes in the built environment that the physical conditions impose.

Second: Concrete CCA is highly specialised. Such specialisation is prone to foster silo mentality among the involved engineering disciplines. The specialisation underlines the need for decentralised decision-making, as the specialists are best in place for deciding what to do with encountered challenges. The specialists will typically have superior knowledge to the regulator about CCA issues, and there is a corresponding risk of abuse of knowledge.

Third: As Coecklebergh [99] suggests, there are two mutually exclusive ways to manage challenges within contexts similar to the ones discussed here; "by imposing external constraints on engineers or by engendering their feelings of responsibility and respect their autonomy". The results presented above suggest that the latter of these two ways is the most viable. The individual expert needs to rely more on professional virtues than directives, laws and regulations. There is a clear need for working towards less silo mentality and increased cross-disciplinary work. This, in effect, underlines the need for professional virtues.

6. Conclusions

On basis of the analysis, the following conclusions can be made:

- CCA challenges boundaries between civil engineering disciplines.

- Established practices need to be altered, and individual experts face new ethical challenges.
- On-the-ground CCA requires an increased ability to overcome silo mentality among the involved disciplines.
- Prevalent challenges concern acknowledging responsibility, transparency, and information quality.

The key point underlying the above points is that engineering with a high degree of decentralised decision-making occurs in an environment with incomplete knowledge and regulations. It follows that knowledge and regulations lag after the experienced challenges. As a consequence, individual experts experience situations that challenge their ethical judgements. The analyses presented above illustrate the concrete challenges met by actors within several contexts.

Systemic circumstance apprehension is necessary for reducing societal risks within climate change adaptation. To master the altered framework conditions, both education of engineers and cooperation across disciplines is needed. Education and professional standards must respond to these alterations. Increased attention to ethics in engineering education will be a good start.

Several directions of future research can be envisaged in light of the analysis presented here. It seems, however, that concern exists for the actors that carry out concrete CCA measures, in particular engineers within the architecture, engineering, and construction industry [7]. The role of these—be they consultants, project managers, technical experts, etc.—can be expected to increase in the near future. Given the limited literature on the field, observations of actual practices with recommendations for the improvement of these should be carried out. CCA is in its nature very concrete and tangible; future analyses ought consequently to be more oriented towards operational challenges and the ethical concerns these entail than towards solely desktop studies.

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