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Establishing the representativeness of available surface water scenarios for plant protection products in environmental risk assessment in Norway

Opinion of the Panel on Plant protection Products of the Norwegian Scientific Committee for Food and Environment

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Preparation of the opinion

The Norwegian Scientific Committee for Food and Environment (Vitenskapskomiteen for mat og miljø, VKM) appointed a project group to draft the opinion. The project group consisted of two VKM members, a VKM staff and an external expert. Two referees commented on and reviewed the draft opinion. The Committee, by the Panel on Plant Protection Products, assessed and approved the final opinion.

Authors of the opinion

The authors have contributed to the opinion in a way that fulfils the authorship principles of VKM (VKM, 2019). The principles reflect the collaborative nature of the work, and the authors have contributed as members of the project group and/or the VKM Panel on Plant Protection Products.

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Competence of VKM experts

Persons working for VKM, either as appointed members of the Committee or as external experts, do this by virtue of their scientific expertise, not as representatives for their employers or third-party interests. The Civil Services Act instructions on legal competence apply for all work prepared by VKM.

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Summary

The Norwegian Food Safety Authority (NFSA) requested the Norwegian Scientific Committee for Food and Environment (VKM) to assess the relevance of the surface water scenarios used in environmental risk assessment of plant protection products for the Norwegian conditions. This request was based on a letter from the Ministry of Agriculture and Food asking the NFSA to evaluate the current use of FOCUS surface water scenarios in the environmental risk assessment of plant protection products.

In the report from the FOCUS Surface Water Scenario group, the methodology and relevance of their run-off and drainage scenarios was analysed for the different regions in the European Union (FOCUS, 2001). In this study, a similar procedure was followed to analyse the relevance of the FOCUS EU scenarios and the Norwegian scenarios for the agricultural area of Norway.

Methodology

Thematic input maps. To quantify and identify the spatial distribution of areas in Norway represented by the ten FOCUS scenarios and the four Norwegian scenarios (ToR 1), thematic maps with information on land cover, annual rainfall, soil texture, organic matter in the topsoil, annual temperature and slope were used.

Agricultural area and land cover were based on Corine land cover data (EU Commission, 2005). Soil texture was based on the European soil data base (ESDB ver.2), and the raster library SGDBE (European Soil Bureau, 2006; Jones et al., 2005). Organic matter in the topsoil was based on the European soil data base OCTOP (Jones et al., 2005). Precipitation and temperature were based on WorldClim data and the interpolation was done based on (Hijmans et al., 2005). The slope parameters were taken from a map developed and used by the Julius Kühn-Institute Germany (JKI) as part of the SYNOPS-WEB application, a model which is able to assess environmental risk from pesticide use under realistic field conditions in Norway (JKI, 2013).

FOCUS Surface run-off scenarios. The exact procedure followed the methodology from the EU FOCUS group developed in 2001. From the land use map, the first step of the analysis was to consider the two key properties rainfall and texture and calculate the areas satisfying the criteria given in the FOCUS scenario. The second step was to consider the two less important properties, organic matter content and annual mean temperatures. The third step is related to the landscape and slope used for excluding flat areas (less than 2% slope).

FOCUS Drainage scenarios. After identification of agricultural areas, the analysis was also to consider the two key properties, recharge and texture. However, for this project respective recharge maps were not available. Therefore, annual rainfall was considered instead of annual recharge as (FOCUS, 2001) also connected rainfall categories to the drainage scenarios. Furthermore, FOCUS (2001) stated that "drainage occurs predominantly on areas

with slopes of 4 % or less". The second step considered the less important parameters, organic matter content and annual mean temperature to define variation of the scenarios. From this stepwise approach areas satisfying the EU FOCUS criteria were quantified by maps and tables. Agricultural areas in Norway represented by the ten FOCUS scenarios (ToR 1) and areas not represented by these scenarios (ToR 3) were calculated.

Norwegian scenarios. Distribution of the two Norwegian surface runoff scenarios and two drainage scenarios were quantified using the same procedure and criteria as for the analysis of the FOCUS scenarios.

Worst case areas. The agro-environmental characteristics were classified and quantified according to the relative worst-case nature of temperature, slope, rainfall, and soil texture (part of ToR 2) and protectiveness of additional area. The four Norwegian scenarios were classified according to the criteria from EU FOCUS scenarios.

Areas not covered by the scenarios (ToR 3). Areas not covered by scenarios were identified by the representativity analysis (ToR 1).

Assessment of aquatic exposure. Simulations with MACRO and PRZM was conducted with substances (9) with hypothetical parameters (annex 1) to predict the concentration in surface water ($PEC_{sw)}$) and in the sediment (PEC_{sed}). TOXSWA (TOXic substances in Surface WAters) was used for calculation of exposure in water according to a standard size of the recipient (stream, ditch, and pond) (FOCUS, 2001). This gives an estimate of the relative importance of the properties of the substances especially effect of temperature on the run-off, drainage, and drift (ToR 4). Aquatic exposure was calculated for the four Norwegian scenarios with WISPE and EXAM using selected pesticides based on former field experiments.

Results

Representativeness of FOCUS run-off scenarios. There are no agricultural areas that can be excluded due to rainfall alone as criterion. When applying the strict FOCUS definition of the soil texture and annual precipitation, all FOCUS scenarios can be relevant for Norway. Only 7.3 % of the vulnerable agricultural area in Norway can be assigned to one of the FOCUS run-off scenarios, including exact organic matter class. All representative locations (independent of organic matter type) are characterised by lower temperatures than the original FOCUS definition. The annual temperatures in Norway are between 2 °C to 8 °C lower than the respective FOCUS scenario. After temperature correction, many locations in Norway fulfil at least a part of the FOCUS run-off definitions. R2 (Porto) is the most representative for Norway. An overview of the spatial distribution of the level of protection when using the EU-FOCUS run-off scenarios is presented in figure 8-1.

Representativeness of FOCUS drainage scenarios. When only considering soil texture, 95% of the agricultural area in Norway can be attributed to the drainage scenarios. Considering slope and texture only 14.6 % of the agricultural area can be attributed to one of the drainage scenarios. Adding rainfall to the soil texture and slope, 3.6 % of the agricultural area can be linked to one of the FOCUS drainage scenarios. The influence of organic matter content in the topsoil is considered to be limited for the drainage scenarios. 86.5% of the agricultural area in Norway vulnerable to drainage is characterised by lower spring and autumn temperatures than the FOCUS definition. Only 13.5% of the respective locations show a similar temperature range as FOCUS. After having adapted the FOCUS scenarios to Norwegian temperature conditions, many locations in Norway fulfil at least part of the FOCUS drainage definitions. An overview of the spatial distribution of the level of protection when using the EU-FOCUS drainage scenarios is presented in figure 8-3.

Representativeness of the Norwegian run-off scenarios. In contrast to the European FOCUS scenarios, which did not fit completely to Norwegian conditions (mainly because of the scenario temperature), the Norwegian run-off scenarios are much better fits to the agricultural area in Norway. 3.4% of the agricultural area (515 km²) have the same properties regarding rainfall and texture. Furthermore, 58.8% of the fields (8883 km²) can be considered less vulnerable compared to the original scenarios. Nevertheless, a certain scenario can always be assigned to this area. Using the Norwegian scenarios in these fields should guarantee a higher level of protection than the FOCUS scenarios. For 28.6% of the area the situation is open because the soils in these agriculture areas are less vulnerable whereas the rainfall is higher. The scenarios do not cover 4.3 % of the agricultural area (651 km²). An overview of the spatial distribution of the level of protection when using the Norwegian runoff scenarios is presented in figure 8-2.

Representativeness of the Norwegian drainage scenarios. The two Norwegian drainage scenarios represent 95% of the agricultural area in Norway when considering the soil texture class as key parameter. 52% of the agricultural area have similar annual rainfall as the Norwegian drainage scenarios, whereas 39.8% of the areas are characterised by more rainfall compared to the original scenario. If the Norwegian drainage scenarios are considered for the risk assessment, 52% of the agricultural area in Norway are protected by a higher level than the situation described in the original scenario. This is caused by higher organic matter content and steeper slopes in these areas.

There are no areas which are definitely less protected than the level provided by the original scenario. However, for 43.1% of the agricultural area, it is not clear whether the high rainfall at these locations is compensated by steeper slopes and/or higher organic matter contents. In so far, the situation is open. In principle, this unfortunate situation could be solved by combining the soil with a station having more rainfall than the original scenario.

The remaining 5% of the agricultural area does not have drainage potential due to its soil texture class ("no soil texture", e.g., histosols). An overview of the spatial distribution of the level of protection when using the Norwegian drainage scenarios is presented in figure 8-4.

Worst-case

EU-FOCUS scenarios. Run-off. Of the EU scenarios, scenario R1 from Weiherbach (Germany) represents the worst case according to the temperature. Even though this is the worst case for temperature in EU, this scenario and none of the other scenarios cover the Norwegian conditions. 53.1% of the agricultural area were found to be in line with one of the FOCUS surface run-off scenarios assuming temperature correction has been employed. Additionally, 45.1% of the agricultural field can be assigned to R2 or R4, but these fields are characterised by less rainfall than the EU FOCUS scenarios. Thus, the EU-FOCUS scenarios can be considered more protective for the Norwegian agricultural fields. The area in Norway which is the analogue of the FOCUS scenarios R2 (Porto), is the area in Rogaland and the west-coast of Norway. More protected areas with less precipitation and same texture is the area outside the moreen ridge (raet) close to Oslofjorden and the northern part and valleys of South Eastern Norway and Trøndelag (table 3-2 and map figure 3-2).

EU-FOCUS scenarios. Drainage. According to the temperature, the drainage scenarios, D1 from Lanna (Sweden) is characterized as extreme worst-case. Based on the temperature criterion, three EU-drainage scenarios are recommended to be used in Norwegian risk assessment: D1 (Lanna, Sweden), D3 (Vredepeel, The Netherlands) and D4 (Skousbo, Denmark). The distribution of D1, D3 and D4 of the FOCUS drainage scenarios is summarized in table 3-11.

The Norwegian scenarios. All the Norwegian scenarios are considered as more worst-case than the EU FOCUS scenario because of colder conditions.

Run-off. The scenario Syverud (NR1) can be considered a worst-case assumption. 3.4 % of the agricultural area is having the same properties regarding rainfall and texture. Furthermore, 58.8% of the fields can be considered less vulnerable than the original scenarios. Nevertheless, a certain scenario can always be assigned to this area. Using the Norwegian scenarios in these fields should guarantee a higher level of protection than the original scenarios.

Drainage. 13.3 % of the agricultural area (2123 km²) is not covered by the two Norwegian scenarios because the soil texture class (medium) is not met. However, the Rustad scenario was considered as a worst-case approach for these areas. Nevertheless, neither Rustad (soil texture class "medium fine") nor Heia (soil texture class "coarse") can be considered representative for the soil texture class "medium". However, in this analysis the scenario Rustad with its "medium fine" soil texture was considered as a surrogate for the agricultural areas with "medium" soil texture. This choice can be considered a worst-case assumption.

Areas not represented

There are no locations in Norway, which completely fulfil the FOCUS surface water definitions, insofar that it could be assumed that the complete agricultural area is not represented by any of the ten FOCUS surface water scenarios.

The Norwegian run-off scenarios do not cover 4.3 % of the agricultural area. The background is higher rainfall than in the run-off scenarios. For 28.6% of the area, the situation is open because the soil texture of these areas is less vulnerable whereas the rainfall is higher.

Regarding the Norwegian drainage (originally groundwater) scenarios, Rustad and Heia, there are no areas which are definitely less protected than the level provided by the original scenario. However, for 6511 km² (43.1%) of the agricultural area, the situation is not clear whether the high rainfall at these locations is compensated by steeper slopes and/or higher organic matter contents. Taken together, the situation is open and rather similar to the representativeness of the EU FOCUS scenario (after temperature correction). The spatial distribution of these agricultural areas is presented in figure 8-4.

Contribution of spray drift, drainage, and surface run-off

Simulation with the FOCUS scenarios and Norwegian scenarios give indication that the contribution from spray-drift, surface run-off and drainage can be assessed, based on the time of the peak concentration. The contribution of drift, surface run-off and drainage have to be evaluated on a case-to-case basis, dependent on crop, pesticide property and climate. Using FOCUS scenarios for Norwegian conditions, temperature correction is necessary. WISPE which is calibrated for the Norwegian conditions, can be a good alternative to the FOCUS SWASH scenario. The theoretical background is outlined in chapter 6.

Uncertainties

According to the FOCUS document (FOCUS, 2001), it is not possible to represent all agronomic situations that result in the transport of agricultural chemicals to the surface water bodies. To make the FOCUS scenarios as broadly applicable as possible, maps of geographic locations that are reasonably similar to the specific situation being modelled were developed. This strategy has been used to identify represented locations based on seasonal values for temperature which influence the degradation rate, average annual recharge for drainage scenarios and seasonal rainfall for run-off scenarios. Similarly, soil characteristics were used to identify areas susceptible for preferential flow and define the soil hydrology group. These characteristics have then been used to parameterize the model. Notably, two sources of uncertainty arise from the process: Spatial variability of environmental characteristics and (choice of) input parameters for the modelling.

Conclusions

FOCUS run-off scenarios. In this report the key parameters assumed to govern run-off are rainfall and soil type. Different temperature conditions do not directly influence run-off and erosion. The annual temperatures in Norway are between 2 °C to 8 °C lower than the respective FOCUS run-off scenario. To use the FOCUS scenarios for Norwegian conditions, a temperature correction is essential either by changing the respective pesticide information (DegT50 in soil) or by changing the original FOCUS climate files. The FOCUS scenarios tend to be more protective for the locations in Norway with more organic matter than the FOCUS scenarios. 53.1% of the agricultural areas were found to be in line with one of the FOCUS scenarios assuming temperature correction was employed. Additionally, 45.1% of the agricultural field are characterised by less rainfall than the EU FOCUS scenarios and can be considered especially protective for these Norwegian agricultural fields. An overview of the spatial distribution of the level of protection when using the EU-FOCUS run-off scenarios is presented in figure 8-1.

FOCUS Drainage scenarios. In this report the key parameters assumed to govern drainage are soil type and slope. Different annual rainfall and temperature would not directly influence the drainage process. Steep slopes in many Norwegian fields give cause for excluding the vulnerable areas for which drainage model scenarios are needed. The annual temperatures in Norway are between 0 °C to 10 °C lower than the respective FOCUS drainage scenario. To use the FOCUS scenarios for Norwegian conditions, a temperature correction is essential either by changing the respective pesticide information (DegT50, easy solution) or by changing the original FOCUS climate files (complicated solution). Assuming temperature correction, the EU FOCUS drainage scenarios cover 51.5 % of the Norwegian agricultural land with similar or a higher level of protection. An overview of the spatial distribution of the level of protection when using the EU-FOCUS drainage scenarios is presented in figure 8-3.

Norwegian run-off scenarios. The Norwegian run-off scenarios are much better fits, regarding the temperatures observed in Norwegian agricultural areas: 44% of the fields show differences below 1 °C, whereas 83% of the fields show differences below 2.5 °C compared to the scenario conditions. The Norwegian run-off scenarios are able to protect 62.2% of the Norwegian agricultural land. For 28.6% of the agricultural areas, the situation is open because the soils in these agricultural areas are less vulnerable, whereas the rainfall is higher. An overview of the spatial distribution of the level of protection when using the Norwegian run-off scenarios is presented in figure 8-2.

Norwegian Drainage scenarios. The two Norwegian drainage scenarios represent 95% of the agricultural area in Norway, when considering the soil texture class as key parameter. The most relevant is Heia, corresponding to about two-thirds of the area (67.7%). The other scenario Rustad covers 14% of the agricultural area. 13.3% of the agricultural area is not covered by the two Norwegian scenarios. 5.0% of the agricultural area have no drainage potential because the respective soils are characterized with no texture (e.g., histosols). 52% of the agricultural area have similar annual rainfall as the Norwegian drainage scenarios, whereas 39.8% of the areas are characterised by more rainfall than the original scenario and less protected. If the Norwegian drainage scenarios are considered for risk assessment, 7867 km² (52%) of the agricultural area in Norway are protected at a higher level than the situation described in the original scenario. This is due to higher organic matter content and steeper slopes in these areas. An overview of the spatial distribution of the level of protection when using the Norwegian drainage scenarios is presented in figure 8-4.

Key words: Plant protection products, pesticides, surface water, run-off, drainage, Norwegian scenarios, EU FOCUS scenarios, environmental risk assessment.

Sammendrag på norsk

Mattilsynet ba Vitenskapskomiteen for mat og miljø (VKM) om å vurdere hvor relevante overflatevannsscenarioene som brukes i miljørisikovurdering av plantevernmidler, er for norske forhold. Forespørselen var basert på et brev fra Landbruks- og matdepartementet, som ba Mattilsynet om å evaluere den nåværende bruken av FOCUS-overflatevannsscenarioer i miljørisikovurdering av plantevernmidler.

I rapporten fra FOCUS Surface Water Scenario-gruppen (Forum for Coordination of pesticide fate models and their Use) ble metodikken og relevansen av avrennings- og dreneringsscenarioer analysert for de forskjellige regionene i EU (FOCUS, 2001). FOCUS-gruppen ble etablert på bakgrunn av et initiativ fra EU-kommisjonen og industrien om å utvikle retningslinjer for å bruke matematiske modeller i forbindelse med introduksjon av nye plantevernmidler på markedet. I denne vurderingen har VKM fulgt en lignende prosedyre for å analysere relevansen av ti FOCUS drenering- og avrenningsscenarioer og fire norske scenarioer for jordbruksområder i Norge.

Metodikk

Tematiske kart. For å kvantifisere og identifisere fordelingen av områder som er representative for Norge i de ti FOCUS-scenarioene (TOR 1) og de fire norske scenarioene, ble det brukt tematiske kart med informasjon om årlig nedbør, jordstruktur, organisk materiale i toppjord, årstemperatur og helling.

Landbruksareal og fordeling av vekster i Norge er basert på Corine-databasen (EU Commission, 2005). Jordtekstur er basert på data fra Den europeiske jorddatabasen ESDB og jorddatabasen SGDBE (European Soil Bureau, 2006; Jones et al., 2005). Organisk materiale i matjorda er basert på den europeiske jorddatabasen OCTOP. Nedbør og temperatur er basert på data fra WorldClim, og interpolasjonen ble basert på Hijmans et al. (2005). Parameterne for helling er basert på et kart utviklet av Julius Kühn Institutt i Tyskland (JKI). Hellingsberegninger er en del av SYNOPS-WEB-applikasjonen, som er en modell som kan benyttes for å vurdere miljørisiko ved bruk av plantevernmidler under realistiske feltforhold i Norge (JKI, 2013).

FOCUS Overflateavrenningsscenarioer. Analysen fulgte metoden fra EU FOCUS-gruppen som ble utviklet i 2001. Fra arealkartet var det første trinnet i analysen å vurdere de to nøkkelegenskapene nedbør og tekstur, og beregne arealene som tilfredsstiller kriteriene som er gitt i FOCUS-scenarioet. Det andre trinnet var å vurdere de to mindre viktige egenskapene, innhold av organisk materiale og årlige middel temperaturer. Det tredje trinnet er relatert til landskap og helling, som ble brukt til å ekskludere flate områder (mindre enn 2 % skråning).

FOCUS Dreneringsscenarioer. Etter identifisering av jordbruksområder, var analysen å vurdere de to viktigste egenskapene nedbør og tekstur. Helling betraktes som en nøkkelparameter i områder med betydelig helling. Det andre trinnet vurderer organisk materiale og årlig gjennomsnittstemperatur for å definere variasjon. Fra denne trinnvise tilnærmingen ble områder som tilfredsstiller EU FOCUS-kriteriene kvantifisert med kart og tabeller. Både landbruksområder i de ti FOCUS-scenarioene som er representative for Norge (ToR 1), og arealer som ikke er representative (ToR 3), ble beregnet.

Norske scenarioer. Utbredelse av de to norske overflateavrenningsscenarioene og to dreneringsscenarioer ble kvantifisert ved hjelp av samme prosedyre og kriterier som for analysen av FOCUS-scenarioene.

Worst-case områder. Landbruk og miljøegenskapene ble klassifisert og kvantifisert i henhold til temperatur, helling, nedbør og jordstruktur (del av ToR 2), samt beskyttelsesgraden for ytterligere arealer. De fire norske scenarioene ble klassifisert i henhold til kriteriene fra EU FOCUS-scenarioer.

Arealer som ikke dekkes av de ulike scenarioene (ToR 3), kommer fram ved hjelp av analysene i ToR 1.

Vurdering av eksponering i vann og sediment. Simuleringer med MACRO og PRZM ble utført med stoffer (ni tidligere brukt i FOCUS-simuleringer) med hypotetiske parametere (vedlegg II) for å forutsi konsentrasjonen i overflatevann (PEC_{sw}) og i sedimentet (PEC_{sed}). TOXSWA (TOXic substances in Surface Waters) ble brukt til beregning av eksponering i vann i henhold til en standardstørrelse av resipienten (bekk, grøft og dam) (FOCUS, 2001). Dette gir et estimat på den relative betydningen av stoffenes egenskaper, spesielt effekten av temperatur på avrenning, drenering og drift (ToR 4). Akvatisk eksponering ble beregnet for de fire norske scenarioene med MACRO og PRZM ved bruk av utvalgte plantevernmidler basert på tidligere feltforsøk.

Resultat

Representativitet av FOCUS avrenningsscenarioer. Det er ingen jordbruksområder som kan utelukkes på grunn av nedbør alene som kriterium. Når en bruker den strenge FOCUS-definisjonen av jordtekstur og årlig nedbør, kan alle FOCUS-scenarioer være representative for Norge. Bare 7,3 % av sårbare jordbruksarealer i Norge passer et av FOCUS-avrenningsscenarioene når det gjelder organisk materiale. Alle representative jordbruksområder har lavere temperaturer enn den opprinnelige FOCUS-definisjonen. Ingen steder hadde temperatur som svarte til FOCUS-definisjonen. De årlige temperaturene i Norge er mellom 2 °C og 8 °C kaldere enn det respektive FOCUS-scenarioet. Etter temperatur-korreksjon oppfyller mange steder i Norge minst en del av FOCUS-avrenningsdefinisjonene. R2 (Porto) er den definisjonen som er mest representativ for Norge. En oversikt over dekning og beskyttelses-nivået av EU-scenariet er presentert i figure 8-1.

Representativitet av FOCUS dreneringsscenarioer. Når man bare vurderer jordtekstur, kan 95 % av jordbruksarealet i Norge tilskrives ett av de seks dreneringsscenarioene. Inkluderes helling og tekstur, kan 14,6 % av jordbruksarealet tilskrives dreneringsscenarioene. Ved å legge til nedbør til jordens tekstur og helling, kan 3,6 % av jordbruksarealet knyttes til noen av scenarioene. Innflytelse av organisk materiale i dreneringsscenarioene anses å være begrenset. Av jordbruksarealet i Norge som er sårbart for drenering, har 86,5 % lavere vår- og høsttemperaturer enn FOCUS-definisjonen. Bare 13,5 % viser et lignende temperaturområde som FOCUS. Etter å ha tilpasset FOCUS-scenarioene til norske temperaturforhold, oppfyller mange steder i Norge en del av FOCUS-definisjonene. Oversikt over dekning og beskyttelsesnivået på jordbruksarealene i Norge er presentert i figure 8-3.

Norske overflate-avrenningsscenarioer. I motsetning til de europeiske FOCUS-scenarioene, som ikke passet helt til norske forhold (hovedsakelig på grunn av temperaturen), passet de norske avrenningsscenarioene mye bedre til jordbruksområdet i Norge. 3,4 % av jordbruksarealet (515 km²) har de samme egenskapene til nedbør og tekstur. Videre kan 58,8 % av feltene (8883 km²) betraktes som mindre sårbare enn de opprinnelige scenarioene. Likevel kan et bestemt scenario alltid tildeles dette området. Bruk av de norske scenarioene i disse feltene bør garantere et høyere beskyttelsesnivå enn de opprinnelige scenarioene. Scenarioene dekker ikke 4,3 % av jordbruksarealet (651 km²). En oversikt over fordelingen og beskyttelsesnivået ved bruk av de norske avrenningsscenarioene er presentert i figure 8-2.

Norske drenerings-scenarioer. De to norske dreneringsscenarioene representerer 95 % av jordbruksarealet i Norge når man vurderer jordstruktur som nøkkelparameter. 52 % av jordbruksarealet har tilsvarende årlig nedbør som de norske dreneringsscenarioene, mens 39,8 % av områdene er preget av mer nedbør enn det opprinnelige scenarioet. Hvis de norske dreneringsscenarioene vurderes til risikovurderingen, er 52 % av jordbruksarealet i Norge bedre beskyttet enn det opprinnelige scenarioet. Dette skyldes høyere innhold av organisk materiale og høyere helling. Det er ingen områder som er mindre beskyttet enn nivået som ble gitt i det opprinnelige scenarioet. Imidlertid er 43,1 % av jordbruksarealet uavklart om den høye nedbøren på disse stedene kompenseres av høyere skråning og / eller høyere innhold av organisk materiale. Så langt er situasjonen åpen. I prinsippet kan denne uheldige situasjonen løses ved å kombinere jorda med en stasjon som har mer nedbør enn det opprinnelige scenarioet. De resterende 5 % av jordbruksarealet har ikke dreneringspotensiale på grunn av sin jordteksturskla sse ("ingen jordtekstur", f.eks. Histosoler). En oversikt over utbredelse og beskyttelsesnivå ved bruk av de norske dreneringsscenarioene er presentert figure 8-4.

Worst-case

EU-FOCUS-scenarioer. Overflate-avrenning: Av EU-scenarioene representerer scenario R1 fra Weiherbach (Tyskland) det verste tilfellet i henhold til temperaturen. Til tross for at dette er det verste tilfellet for temperatur i EU, er dette scenarioet og ingen av de andre scenarioene dekkende for de norske forholdene. 53,1% av jordbruksarealet ble funnet å være i tråd med et av FOCUS-avrenningsscenarioene, basert på antagelser om at temperaturkorreksjon er gjennomført. Ytterligere 45,1% av jordbruksfeltet kan dekkes av R2 eller R4, men disse feltene er preget av mindre nedbør enn EU FOCUS-scenarioene. Derfor kan EU-FOCUS-scenarioene betraktes som mer beskyttende for de norske jordbruksmarkene. Området i Norge som er analogt med FOCUS-scenarioene R2 (Porto), er området i Rogaland og vestkysten av Norge. Mer beskyttet med mindre nedbør og samme tekstur er området utenfor Morenryggen (raet) nær Oslofjorden og den nordlige delen og dalene på Sørøst-Norge og Trøndelag (table 3-2 og kart figure 3-2).

EU-FOCUS-scenarioer. Drenering: I henhold til temperaturen er dreneringsscenarioene, D1 fra Lanna (Sverige) karakterisert som ekstrem worst case scenario. Basert på temperaturkriteriet anbefales det å bruke EU-dreneringsscenarioer i norsk risikovurdering: D1 (Lanna, Sverige), D3 (Vredepeel, Nederland) og D4 (Skousbo, Danmark). Fordelingen av D1, D3 og D4 av FOCUS dreneringsscenarioer er oppsummert i table 3-11.

Alle de norske scenarioene betraktes som verre enn more worst case EU FOCUS-scenarioet på grunn av kaldere forhold.

Arealer som ikke dekkes av noe av scenarioene

Det er ingen steder i Norge som helt oppfyller definisjonene av FOCUS overflatevann. Derfor kan man anta at det norske jordbruksarealet ikke er representert av noen av de ti FOCUS-overflatevannsscenarioene.

4.3 % av det norske jordbruksarealet blir ikke dekket av de norske overflate-avrenningsscenarioene. Bakgrunnen er høyere nedbør enn i avrenningsscenarioene. For 28,6 % av området er situasjonen åpen fordi jordstrukturen i disse områdene er mindre sårbar, mens nedbøren er mer sårbar.

I de norske drenerings-scenarioene er det ingen områder som er mindre beskyttet enn det opprinnelige scenarioet. Imidlertid er situasjonen uklar på 6511 km² (43,1 %) av jordbruksarealet om den høye nedbøren på disse stedene kompenseres av høyere skråning og / eller høyere innhold av organisk materiale.

Relativt bidrag fra sprøyteavdrift, avrenning fra overflate og drensvann.

Simulering med FOCUS-scenarioer og norske scenarioer gir indikasjon på at bidraget fra sprøyteavdrift, overflate- og dreneringsavrenning kan vurderes basert på tidspunktet for toppkonsentrasjonen. Toppkonsentrasjon like etter sprøyting antas å være bidrag fra avdrift. Overflateavrenning på et senere tidspunkt antas å være overflateavrenning, mens drensavrenning har større forsinkelse. Bidraget fra drift, overflateavrenning og drenering må vurderes fra sak til sak avhengig av kulturplante, jordtype, plantevernmidler og klima. For å bruke FOCUS-scenarioer for norske forhold er det nødvendig med temperaturkorreksjon. WISPE som er kalibrert for de norske forholdene, kan være et godt alternativ til FOCUS SWASH-scenarioet. Den teoretiske bakgrunnen er beskrevet i kapittel 6.

Usikkerhet

Ifølge FOCUS-dokumentet (FOCUS, 2001) er det ikke mulig å beskrive alle agronomiske situasjoner som resulterer i transport av landbrukskjemikalier til overflatevann. For å gjøre scenarioene så anvendelige som mulig, ble det utviklet kart over geografiske steder som er rimelig like den spesifikke situasjonen som modelleres. Denne strategien ble brukt til å identifisere steder basert på sesongverdier for temperatur som påvirker nedbrytningshastigheten, gjennomsnittlig årlig utlekking for dreneringsscenarioer og sesongmessig nedbør for avrenningsscenarioer. På samme måte ble jordegenskaper brukt for å identifisere områder som er utsatt for rask gjennomstrømning (preferential flow) og hydrologisk gruppe. Alle disse egenskapene har da blitt brukt til å forsyne modellen med parametere og spesielt to kilder til usikkerhet er viktig: Romlig variasjon av miljøegenskaper og valg av input for parametrene i modelleringen.

Konklusjoner

FOCUS Overflate avrenningsscenarioer. Det er ingen jordbruksområder som kan utelukkes på grunn av nedbør alene som kriterium. Ved bruk av den strenge FOCUS-definisjonen for jordtekstur og årlig nedbør, kan alle FOCUS-scenarioer være lokalisert i Norge. Bare 7,3 % av det sårbare jordbruksarealet i Norge kan tildeles et av FOCUS-avrenningsscenarioene inkludert eksakt organisk innhold. Alle representative steder (uavhengig av organisk materiale) har lavere temperaturer enn FOCUS-definisjonen. De årlige temperaturene i Norge er mellom 2 ° C og 8 ° C lavere enn det respektive FOCUS-scenarioet. Etter temperaturkorreksjon oppfyller mange steder i Norge minst en del av FOCUS-avrenningsdefinisjonene. R2 (Porto) er definisjonen som er mest representativ for Norge. En oversikt over den romlige fordelingen av beskyttelsesnivået ved bruk av avrenningsscenariene EU-FOCUS er presentert i figure 8-1.

FOCUS Dreneringsscenarioer. De viktigste parameterne for drenering er jordtype og helling: Forskjellig årlig nedbør og temperatur påvirker ikke dreneringsprosessen direkte. Bratte bakker i mange norske felt gir grunn for å ekskludere disse fra sårbart areal og dette gjør det unødvendig å benytte modellscenarioer for drenering i mange områder. De årlige temperaturene i Norge er mellom 0 ° C og 10 ° C lavere enn det respektive FOCUS-scenarioet. For å kunne bruke FOCUS-scenarioene for norske forhold, er temperaturkorreksjon viktig, enten ved å endre informasjonen om det respektive plantevernmiddelet (halveringstid, enkel løsning), eller ved å endre de opprinnelige FOCUS-klimafilene (komplisert løsning). Hvis steder i Norge har mer organisk materiale enn det respektive FOCUS-scenarioet, kan det antas at modellsimulering med FOCUS-scenarioet gir økt beskyttelse for det spesifikke stedet ved vurdering av aktuelle plantevernmiddelkonsentrasjoner i drenering.

De norske avrenningsscenarioene passer bedre til temperaturene som er observert i norske landbruksområder: 44 % av feltene viser forskjeller under 1 ° C, og 83 % av feltene viser forskjeller under 2,5 ° C sammenlignet med scenarioene. De norske avrenningsscenarioene er i stand til å beskytte 62,2 % av det norske jordbruksarealet. For 28,6 % av området er situasjonen åpen fordi jorda i disse jordbruksområdene er mindre sårbare, mens nedbøren er høyere. En oversikt over den romlige fordelingen av beskyttelsesnivået ved bruk av de norske avrenningsscenarioene er presentert i figure 8-2.

De to norske dreneringsscenarioene representerer 95 % av jordbruksarealet i Norge når man vurderer jordstrukturklassen som nøkkelparameter. Det mest relevante tilsvarer omtrent to tredjedeler av området (67,7 %). Det andre scenarioet dekker 14 % av jordbruksarealet. 13,3 % av jordbruksarealet dekkes ikke av de to norske scenarioene. 5,0 % av jordbruksarealet har ikke noe dreneringspotensiale fordi de respektive jordene er preget uten tekstur (f.eks. Histosoler). 52 % av jordbruksarealet har tilsvarende årlig nedbør som de norske dreneringsscenarioene, mens 39,8 % av områdene er preget av mer nedbør enn til det opprinnelige scenarioet og mindre beskyttet. Hvis de norske dreneringsscenarioene vurderes for risikovurderingen, er 7867 km² (52 %) av jordbruksarealet i Norge beskyttet av et høyere nivå enn situasjonen beskrevet i det opprinnelige scenarioet. Dette skyldes høyere innhold av organisk materiale og brattere skråninger i disse områdene. En oversikt over den romlige fordelingen av beskyttelsesnivået ved bruk av de norske dreneringsscenarioene er presentert i figure 8-4.

Abbreviations and glossary

Abbreviations

ADAS	Agricultural Development and Advisory Service
ESDB	European Soil Database
EFSA	European Food Safety Authority
ETRS89	European Terrestrial Reference System 1989
EXAMS	The EXposure Analysis Modeling System
FOCUS	FOrum for Co-ordination of pesticide fate models and their USe
JRC	Joint Research Centre (EU)
LAEA	Lambert Azimuthal Equal Area
OCTOP	Topsoil Organic Carbon Content for Europe
PEC	Predicted environmental concentration
PRZM	Pesticide Root Zone Model
SGDBE	Soil Geographical Database of Europe
STU	Soil Typological Unit

ToR	Terms of reference
TOXSWA	TOXic substances in Surface WAters etc
WISPE	World Integrated System for Pesticide Exposure
WRB	World Reference Base of Soil Resources

Glossary

DegT50: Description of time taken for 50 % of substance to disappear from a compartment as a result of degradation processes.

OCTOP: European soil data base with information on organic matter in the topsoil etc.

CORINE: Coordination of information on the environment program

Tiered approach: A stepwise risk assessment of a surface water pesticide exposure estimation

MACRO: A preferential flow model to simulate pesticide leaching

SYNOPS-WEB: A pesticide risk indicator model combined with GIS

WorldClim: Global Climate data for ecological modelling and GIS

15.06.21

Background as provided by the Norwegian Food Safety Authority

The Norwegian Food Safety Authority (NFSA) requests an evaluation of the relevance of the surface water scenarios used in environmental risk assessment of plant protection products. The evaluation is needed as part of a review of the current risk assessment methodology.

Background

In a letter from the Ministry of Agriculture and Food dated 28 January 2020, the NFSA was asked to evaluate the current use of FOCUS surface water scenarios in the environmental risk assessment of plant protection products. The NFSA was also asked to examine the feasibility of approving use of certain plant protection products for limited areas only, in those cases where they cannot be approved for the entire country due to risk of contamination of the aquatic environment.

Assessment of risk to the aquatic environment in the EU evaluation of active substances

Prior to approval for use in plant protection products under Regulation (EC) No 1107/2009[1] (EU Commission, 2009), active substances are required to undergo an environmental risk assessment. A key element of this process is the assessment of risk to the aquatic environment. Potential exposure of surface water in agricultural areas (ponds, ditches and streams) to active substances and their metabolites must be assessed using a modelling approach developed within the European Commission FOCUS framework (FOCUS, 2001).

Several risk evaluation steps are incorporated into the FOCUS scheme. Steps 1 and 2 in FOCUS are screening level steps based on conservative assumptions of surface water exposure potential. Step 3 employs 10 realistic worst-case scenarios representing combinations of crops, pedoclimatic regimes and routes of loss of pesticides to surface water (spray drift, run-off and drainage) across the EU.

Data on the physico-chemical properties of the active substance and environmental fate and behaviour data in soil, sediment and water are used in combination with the scenarios and the FOCUS models to estimate loadings of active substances and metabolites to surface water and their distribution and fate in aquatic systems, resulting in predicted environmental concentrations (PECs) that can be compared with appropriate ecotoxicity endpoints in the risk assessment for aquatic organisms.

Aquatic risk assessment in the national registration of plant protection products

Post-approval registration of plant protection products at a national level can include the use of standard FOCUS scenarios and/or national/region specific scenarios.

The project *"National Scenarios – Norway. Introduction of national scenarios for approval of new pesticides in Norway"* (Bolli et al., 2011), financed by the Action Plan for the Sustainable Use of Pesticides, was initiated with the aim of improving the risk assessment of pesticides in Norway by establishing scenarios from experimental fields which could be representative for Norwegian conditions. Four scenarios were developed. None of these scenarios are currently used for the surface water exposure assessment due to the limitations of the model tool in which they are parametrised. The Norwegian Institute of Bioeconomy Research (NIBIO) has received funding over the Action Plan for the Sustainable Use of Pesticides to address this issue.

At present, Norway requires simulation with 9 of the standard FOCUS scenarios for the surface water exposure assessment. The reasoning behind this, is that based on the pedoclimatic characteristics of each FOCUS scenario (i.e., soil and climate properties) as described in FOCUS (2001), none of the scenarios have a combination of characteristics that seem to be a realistic worst-case for the Norwegian agricultural landscape as a whole. It was questioned whether the FOCUS scenarios would be protective[1] enough of the Norwegian agricultural landscape, and it was thought that this uncertainty would decrease with an increasing number of scenarios.

More knowledge on the relevance of available surface water scenarios is needed

Currently, no overview exists of which agricultural areas are represented (or protected) by the national scenarios or FOCUS scenarios. To decide on the appropriate use of the national and/or FOCUS scenarios in future regulatory risk assessment, it is necessary to investigate in more detail the range of relevant environmental characteristics within the Norwegian agricultural landscape and to what extent these characteristics are defined by the existing scenarios.

As regulatory submissions for approval of plant protection products are prepared for specific crop uses, it is important to consider the proportions of a national crop that are directly represented by each scenario. It is also important to evaluate what proportion of the national crop is grown in areas where the pedoclimatic conditions may be considered more challenging (in terms of pesticide loss and degradation) than those represented by the available scenarios that are relevant for Norway. If directly relevant surface water scenarios only encompass negligible areas associated with cultivation of an important crop, other information would need to be considered, for example in the form of an assessment based on indirectly relevant scenarios.

[1] "Representativeness": a scenario is representative of agricultural areas that have similar soil and climate conditions as the scenario. "Protectiveness": a scenario is protective of an area when it represents either similar soil and climate conditions or a more vulnerable situation in terms of pesticide loss and degradation.

Protection goal set in the legislation

There are no clear, specific protection goals for surface water set in Regulation (EC) 1107/2009, to aid in the selection of appropriately protective surface water scenarios. One must therefore consider the general protection goals set in Article 4 (3e): A PPP shall have no unacceptable effects on the environment, having particularly regard to the following considerations: i) its fate and distribution in the environment, particularly contamination of surface water, including estuarine and coastal water ii) its impact on non-target species and iii) its impact on biodiversity and the ecosystem. Further, it is important to consider that Regulation (EC) 1107/2009 is underpinned by the precautionary principle, as set down in Article 1(4). It is also relevant to consider the Norwegian Water Regulation. The environmental objective given in § 4 is that the state of surface water shall be protected against deterioration, improved and recovered with the aim of achieving good ecological and chemical status of the waterbody[2].

Terms of reference as provided by the Norwegian Food Safety Authority

Based on currently available data sets and literature, the NFSA asks the Norwegian Scientific Committee for Food and Environment to investigate the following objectives:

1. To identify agricultural areas in Norway that are «represented» by soil and climate conditions in the ten FOCUS surface water standard scenarios or the four national scenarios and quantify the size and spatial distribution of these areas.
2. To determine how worst-case the areas identified in objective 1 are in terms of surface water exposure potential compared to agricultural land across Norway, and if they could be considered protective of additional areas, even if they are not directly representative. Please see section 3.2 and 3.5 in FOCUS (2001) for an example «worst case assessment».
3. To identify the characteristics and spatial distribution of all agricultural land in Norway that is not represented by any of the ten FOCUS surface water scenarios or the four national scenarios.
4. To assess the relative importance of surface run-off (both dissolved and particulate phases), drain flow and spray drift as routes of aquatic exposure to pesticides in Norway based on pedoclimatic characteristics.

The NFSA would also like the Scientific Committee to give their opinion these questions:

[2] Please see the Water Regulation. (FOR-2006-12-15-1446) Forskrift om rammer for vannforvaltningen. 2006. Retrieved from: https://lovdata.no/dokument/SF/forskrift/2006-12-15-1446. for further details.

a) Considering the protection goals for human health and the environment set down in relevant legislation, as well as the findings of this study, which FOCUS scenarios and/or national scenarios should companies use when calculating predicted environmental concentrations (PECs) for Norwegian risk assessments?
b) How confident is the Scientific Committee that the scenarios recommended in question a) provide a sufficiently high level of protection for Norwegian agricultural areas as a whole?
c) For areas that are not sufficiently protected, or if risk assessments are uncertain, what supplementary information could be requested from companies to support PEC calculations?
d) In the context of approval of plant protection products for certain areas only, in those cases where they cannot be approved based on the regular risk assessment: Based on VKM's findings in this assessment, are there any clearly defined areas (either based on administrative units such as municipalities, or areas with a certain soil and climate) that are very well covered (with a high level of protection for health and environment) by one scenario or a combination of scenarios?

Expected outputs include:

- A report containing the information described in objectives 1 to 4 and evaluations of questions a) to d), based on sources including national soil, land use and climate data sets. The basis of evaluations or recommendations should be described in detail.
- Tables showing percentage area of individual crops grown in Norway that is covered by risk assessments using directly relevant FOCUS scenarios or national scenarios. See ADAS (2005) for example tables.
- Simplified maps illustrating objectives 1, 3 and 4. See DLO-Alterra Wageningen UR (2013) for example figures.

Assessment

1 Introduction

1.1 Agro-climatic scenarios in Europe and pesticide fate modelling

In 1996, the FOCUS (Forum for the Co-ordination of pesticide fate models and their Use) Steering Committee decided to establish the FOCUS Working Group on Surface Water Scenarios which should develop a series of standard agricultural-relevant scenarios for the European Union (FOCUS, 2001). By use of these scenarios, a uniform procedure for assessing the predicted concentration of pesticides in surface water (PEC_{sw}) and sediment (PEC_{sed}) in the surface water entered via run-off, drainage and spray drift was achieved. To identify vulnerable areas, a realistic combination of climate, slope and soil was assessed. Description of vulnerable areas follow the methodology of realistic worst-case nature outlined in the FOCUS report (2001) table 3.2.1-3.2-5. The criteria are described in chapter 4 in this report. Four run-off scenarios and six drainage scenarios were developed representing EU and European conditions. These scenarios were not meant to represent national scenarios for the registration of the pesticides, thus separate national risk assessment scenarios should be developed. Only a few member states such as the United Kingdom (ADAS, 2005), the Netherlands and Germany (Bach et al., 2017; Bach et al., 2016) did, however, develop own national scenarios and questioned the representativeness of the FOCUS Surface Water Scenarios at the national level. To cover diversity and representativity of local conditions, agro-environmental scenarios were developed to support pesticide risk assessment in Europe (Centofanti et al., 2008). These included both climatic scenarios (Blenkinsop et al., 2008) and detailed soil maps (JRC, 2013a; JRC, 2013b). The Northern groundwater scenarios and their representativity were assessed by Burns et al. (2015), but the Norwegian scenarios were not included.

To better represent pesticide fate in the risk assessment, the EU was divided into 3 zones: North, Central and South. Norway is a part of the Northern zone with Sweden, Denmark, Finland, Estonia, Latvia, Lithuania, and Iceland. A guidance document describes the collaboration within the Northern zone established in 2011 and is continuously developed (Northern Zone, 2020). This document describes the requirement for risk assessment of surface water and sediment exposure. Some Member States within the Northern zone also have developed specific national modelling scenarios e.g., Sweden at the locations Krusenberg, Näsbygard and Önnestad, Denmark at Karup and Langvad, and Norway at Syverud, Rustad, Bjørnebekk and Heia. The Norwegian scenarios include two drainage scenarios, Heia and Rustad, and two surface water scenarios, Syverud and Bjørnebekk (Bolli et al., 2013; Bolli et al., 2011). The Norwegian scenarios have never been used as a part of the national approval strategy.

Objective 1 (ToR1) was to identify and quantify size and distribution of agricultural areas in Norway corresponding to soil and climate conditions in the ten FOCUS surface water standard scenarios and the four Norwegian scenarios. Detailed information on soil and climate in the ten EU FOCUS scenarios and four Norwegian scenarios were collected and compared to agricultural land in Norway. Methods for quantification are described in chapters 2.5 - 2.8.

Objective 2 (ToR2) was to determine how worst-case the areas identified in objective 1 are in terms of surface water exposure-potential compared to agricultural land across Norway, and if they could be considered protective of additional areas, even if they were not directly representative. Please see section 3.2 and 3.5 in FOCUS (2001) for an example of a «worst case assessment».

This objective was assessed by applying the worst-case scenario criteria to Norwegian agricultural areas and further classifying these areas according to the document "FOCUS surface water scenarios in the EU evaluation process under 91/414/EES". Parameters used for worst-case characteristics were: 1. Average autumn and spring temperature, 2. Classes of average annual recharge (drainage) and rainfall (run-off), 3. Slope and 4. Drainage. The criteria are described in more detail in chapter 2.4.

Objective 3 (ToR 3) was to identify characteristics and spatial distribution of all agricultural land in Norway that is not represented by any of the ten FOCUS surface water scenarios or four Norwegian scenarios. This was assessed by extracting the areas identified in ToR 1 using the method described in chapter 2.5 - 2.8.

Objective 4 (ToR 4) was to assess the relative importance of surface run-off (both dissolved and particulate phases), drain-flow and spray drift as routes of aquatic exposure to pesticides in Norway based on pedoclimatic characteristics. The contribution from surface run-off, drain-flow and drift was calculated by using SWASH for the FOCUS scenarios with adaption to the Norwegian climate and WISPE for the Norwegian scenarios. The Norwegian scenarios were simulated using four selected pesticides based on data from the field studies, when the Norwegian scenarios were established (Bolli et al., 2011).

2 Methodology

2.1 Overview

The FOCUS scenarios

In the report of the FOCUS Surface Water Scenario group, a methodology for analysing the relevance of their run-off and drainage scenarios for the different regions in the EU (FOCUS, 2001) was presented. For such an analysis, several thematic maps are needed which describe soil properties, climate, land geometry and land cover. Six years after FOCUS

(2001), Hollis repeated the analysis of the FOCUS Surface Water Scenario and relevance for the different member states of the European Union, providing more detailed map information (Hollis, 2007). Klein presented a study where the representativeness of the FOCUS scenarios was evaluated for Germany using a similar methodology (Klein, 2011). However, this methodology has a general deficiency because peak PEC_{sw} caused by drainage or runoff are event-driven (e.g. caused by a runoff event or a macropore flow event), triggered mainly by a daily rainfall amount and thus not the annual rainfall and only to a lesser extent soil properties and even less by temperature and slope (eroded soil is the exception, it depends on slope). The situation could improve by extending the simulation period from a single to 20 years. This is planned for the next release of the software.

The Norwegian scenarios

The Norwegian scenarios are based on data from field experiments from four sites: Syverud and Bjørnebekk run-off, Rustad and Heia drainage. These field sites were selected because they represented some of the most frequently distributed soil types in the main area for cereal and vegetable crops in Norway. Syverud and Bjørnebekk already had on-site installed equipment for monitoring surface and drainage flux. The soil profile has been described down to one-meter depth and classified according to the WRB (World Reference Base for Soil Resources) units. As large areas in Norwegian agriculture are relatively steep, field experiment from such areas was important from a protectiveness aspect. This was especially important as the pesticide run-off from inclined areas was not included in the EU scenarios. Data from these experiments were used to calibrate and validate the models MACRO and PRZM in 2011 (Bolli, et al. 2011).

2.2 Main agricultural areas in Norway

The agricultural areas in Norway cover 3.5 % of the total land area (SSB, 2020). The largest and most continuous region for agricultural production is "Østlandet og Trøndelags lavlandsbygder" (figure 2-1). More than 70 % of that region is cereal and rape seed production. A region in the south of Norway is called "Sør-Norges dal- og fjellbygder" (figure 2-2). Husbandry is an important part of the agriculture in this region dominated by pasture and gras production along the hillsides. Cereal production cover 20 % of the agriculture area and conned to the flat parts of the river deposits in the bottom of the valley (Puschmann et al., 2004).

The westcoast (region 4, figure 2-3) of Norway is famous for the fruit and berry production, but totally these areas have limited extention (Puschmann et al., 2004). This area is dominated by small scale agriculture mainly used for husbandry. Region 3 contains important agricultural areas (figure 2-3), especially Jæren and Rogaland. In the northern part of Norway, the agriculture is dominated by husbandry and gras production. Some exceptions are potato production on flat areas along big rivers (Målselv). More detailed information on agricultural regions is given by Puschmann et al. (2004).

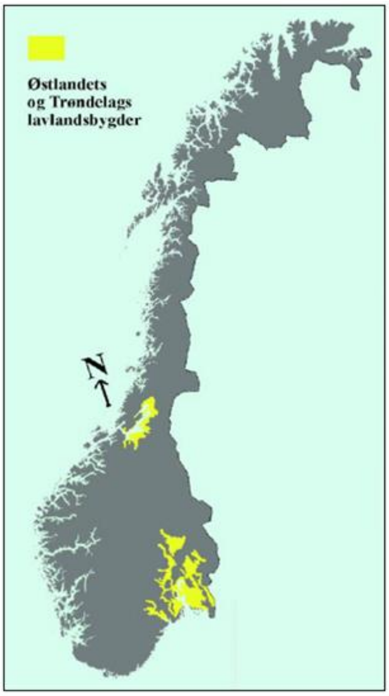

Figure 2-1. Trøndelag and South-Eastern part of Norway (Puschmann et al., 2004)

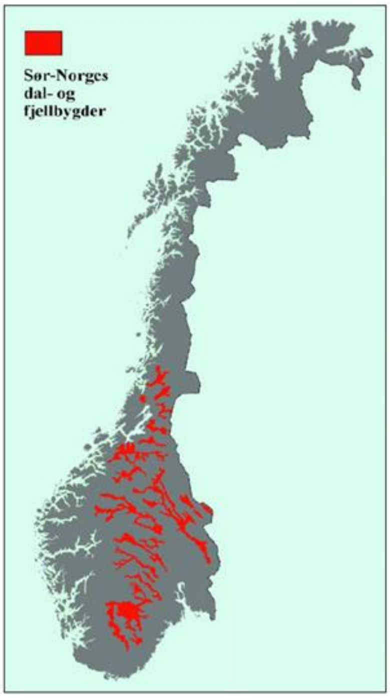

Figure 2-2. Valley and mountainous region of South of Norway (Puschmann et al., 2004)

Mapping of agricultural soil and soil properties started in 1980. In 2017, 52 % of agricultural land in Norway had been mapped (Lågbu et al., 2018) and described down to one-meter depth by origin, texture, organic matter, drainage properties, soil depth and development. NIBIO has implemented and adapted the international classification system World Reference Base of Soil Resources (WRB) as a national classification system. Until 2008 (Sperstad and Nyborg, 2008), 13 WRB groups and 270 soil units have been reported and mapped on agricultural lands in Norway. Each agricultural region in Norway is dominated by one specific soiltype for each region. Albeluvisol, Cambisol, Umbrisol, Stagnosol and Histosol in respectively Eastern Norway south (1), Eastern Norway north (2), Rogaland (3), Trøndelag (4) and North of Norway (6). Detailed distribution of the soil types is outlined in annex III. New updates for Norway include especially Umbrisols and Histosols rich in organic matter. Albeluvisols, Cambisols and Stagnosols are representing the main soil types in the agricultural area in Norway.

According to figure 2-1, the highest temperature (>4°C) is found from the south-east border to Sweden along the west-coast up to Lofoten in the north. The precipitation map (figure 2-3) shows average annual rainfall > 1600 mm along the west of the country. The annual precipitation decreases to the east (800-1000 mm) and Oppland, Hedmark (area 2), Troms and Finnmark in the north have less than 800 mm. In annex IV, precipitation and temperature data for the reference period 1961-1990, which was the last standard 30-year period, is compared to a later period 1991-2014. These data show that annual precipitation for the southern parts of Norway has increased, and for the last period, also an increase in temperature can be seen in all regions.

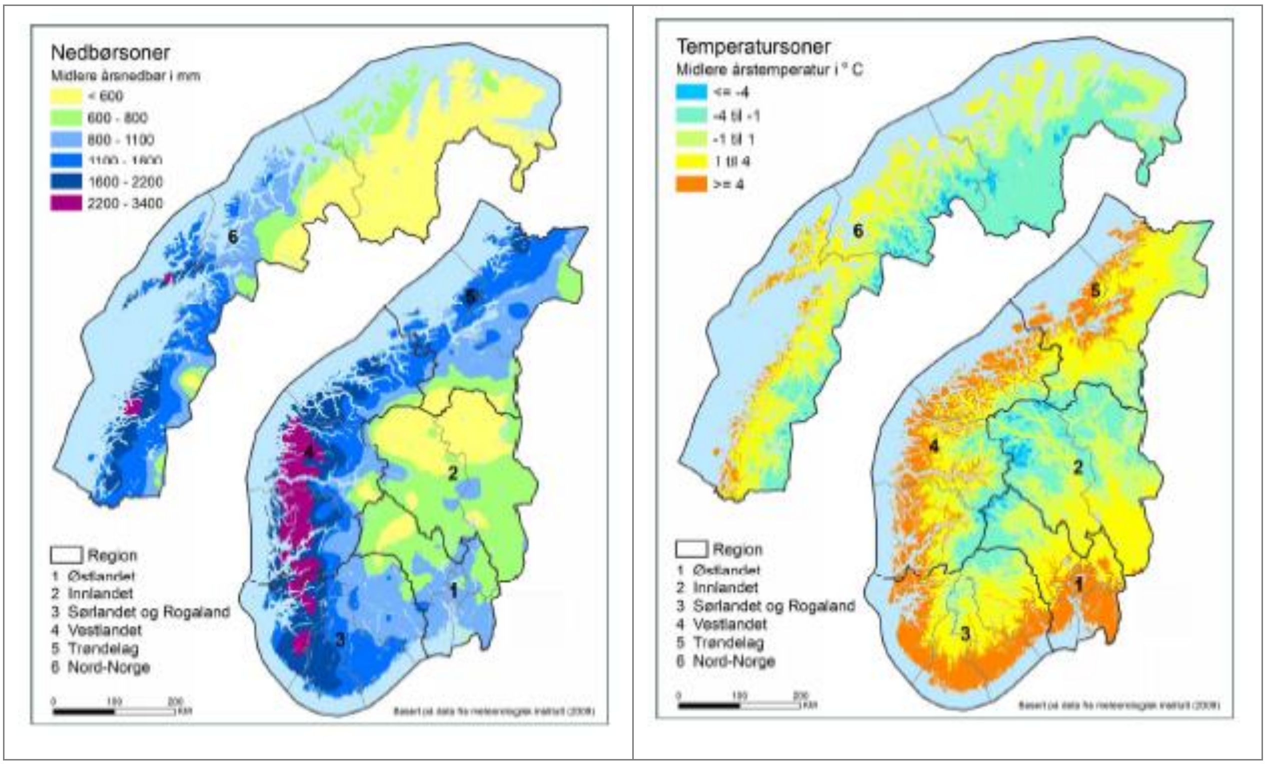

Figure 2-3. Important regions with characteristic of climate (Lågbu et al., 2018).

2.2.1 Characteristic of the Norwegian scenarios

This chapter describe the main characteristic of the field sites Syverud, Bjørnebekk, Rustad and Heia. The first three sites were in Ås, former Akershus county, and the last was Heia in Råde, former Østfold county. Former studies and data collections of pesticide runoff and drainage studies has earlier been used as background for calibration and validation of the two models MACRO and PRZM (Bolli et al., 2011), described in this report as the four Norwegian scenarios.

Syverud. A field experiment was conducted at Syverud and Bjørnebekk during two seasons: 2005 – 2006 and 2007 -2008. The experimental plots at Syverud were 27 m long and 7 m wide with a slope of 13 % (figure 2-4). Before the experiment at Syverud was established, the area was used for meadow and pasture for many years, which resulted in a good soil structure with high infiltration capacity and saturated hydraulic conductivity as well as very high aggregate stability. The drainage system was installed about 1960, and the runoff measurements started about 1980 and used to measure drainage and runoff of fertilizers. Surface and drainage water were collected from each of the field plots (2 plots). Because of the high infiltration capacity, even though the summer months brought much precipitation, there was little excess of water available for surface runoff. Late autumn and winter, there was, however, a significant contribution from surface runoff. The plot was sprayed with metalaxyl, propiconazole and potassium bromide. Drainage water and surface water was collected at the end of the sites through drainpipes entering a tilting bucket, recording and sampling the water leaving the sites.

The soil type of Syverud (figure 2-10) is classified as Epistagnic Albeluvisol (Endoeutric, Siltic) (WRB 2006) A lot of macropores appear through the profile and the profile was very dry despite of a lot of rain. The profile belongs to the main group of Albeluvisols, which are marine deposits with the largest extension in Vestfold (30 %), Østfold (35 %), Akershus (25 %), Telemark, Buskerud and Trøndelag (8.7 %). Albeluvisols are often a mosaic with Stagnosols, and in the later versions of WRB units (WRB 2013) these two groups are merged and called Stagnosols, which represent more than 60 % of the agricultural soil in Norway.

Figure 2-4. Syverud field 7. June 2007 (Photo: M. Almvik)

Bjørnebekk. The area at Bjørnebekk was artificially levelled before 1980, when the field experiment was established. The plot length is 21 m and plot width 8 m, and the slope is 13 % (figure 2-5). The soil structure is weak and the aggregate stability very low. Water proportional samples were collected from surface runoff at Bjørnebekk. The chemical application followed the same strategy as for Syverud. A large part (10 %) of the areas of the marine deposits is artificially levelled (Regosols) and have the origin of Albeluvisols. The soil profile of Bjørnebekk is a profile with mixed layers from Albeluvisols.

Figure 2-5. The Bjørnebekk field 12. May 2005 (Photo: M. Almvik)

Figure 2-6. Overview of Skuterud catchment, Holstadvannet in the upper end.

Rustad. The field experiments at Rustad and Heia was performed from 1999 - 2001. The Rustad field site was a field plot established as a small part of the Skuterud catchment area (figure 2-6), which is a part of the national monitoring program of pesticides and nutrients. The field plot and experimental design was a randomized split plot block with four replicates. The field dissipation studies were performed with isoproturon, metalaxyl and potassium bromide. Leaching of the chemicals were followed by five soil samplings at four depths for two years. The soil type of Rustad belong to the WRB group Albeluvisols which is dominating in this area (figure 2-7).

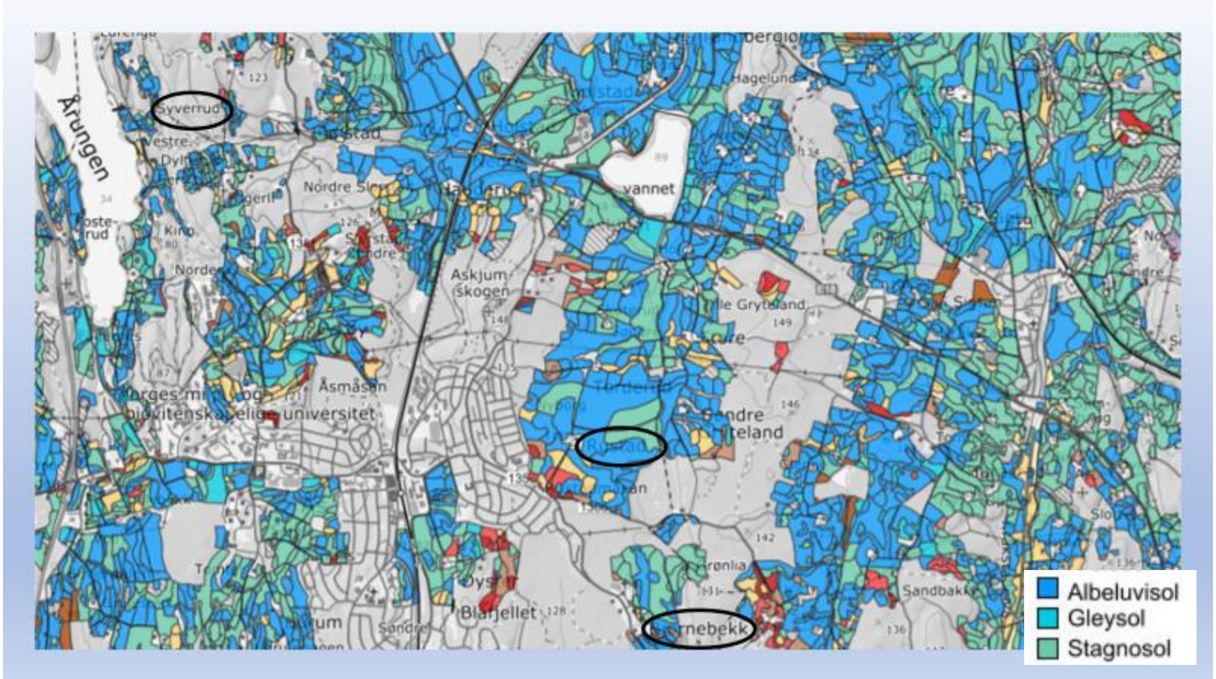

Figure 2-7. Overview of the experimental sites of the Norwegian scenarios Syverud, Bjørnebekk and Rustad in Ås. The dominating soil types are Albeluvisols and Stagnosols (blue and green) (map from kilden.nibio.no).

Heia. This experimental field was located at the catchment Heiabekken in Råde, which is also connected to the national monitoring program of pesticides and nutrients. Because of the early spring and suitable soil for agriculture, production of vegetables and potatoes are important and beside cereals the most frequently grown crops in the area. This region represents one of the most intensively cultivated areas in Norway and the use of pesticides and nutrients are important.

The experimental plot was 80 m X 24 m, containing 8 subplots of 24 m X 10 m. The area was flat, less than 1 % slope (figure 2-9). Pesticide application and field sampling followed the same procedure as for Rustad. The soil is generated from marine deposits and belong to the WRB group Mollic Stagnosol (siltic, figure 2-8). In Råde, 54 % of the soil belong to the Stagnosol group (Nyborg et al., 2008). This soil type is periodically saturated of stagnating waterface. Stagnosols cover 22.4 % of the total agricultural area of Norway (annex III) and is an important part of the agriculture land in South-Eastern Norway (27%) and Trøndelag (28 %).

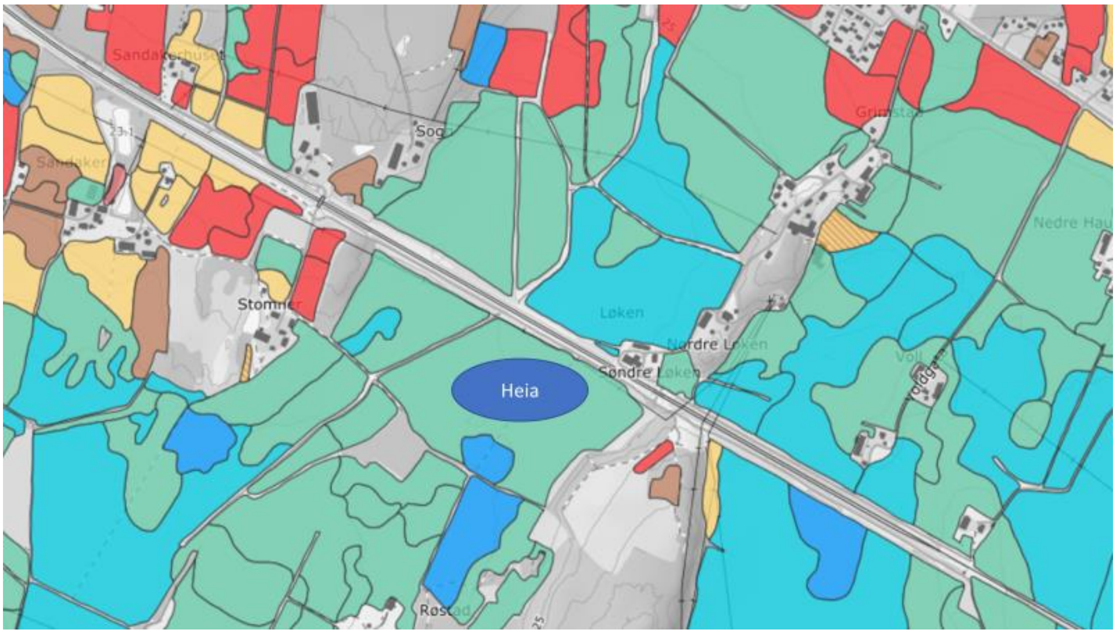

Figure 2-8. Map of WRB units in the region where field data from the "Heia" scenario were collected. The green areas are Mollic Stagnosols (map from kilden.nibio.no)

Figure 2-9. The field site Heia (Photo: O.M. Eklo).

A detailed description of the soil profile of the four sites are given in annex IV, figure 2-10 and figure 2-11. The topsoil properties are summarized in table 2-1. The grain size distribution for the Norwegian scenarios are summaries in the soil triangle and compared to some of the FOCUS scenarios in figure 2-15.

Table 2-1. Topsoil primary properties of soils of the four Norwegian scenarios

Source	Field site	Organic carbon %	Organic matter %	Texture class	Clay %	Silt %	Sand %	pH	Bulk density g cm^{-3}
Norwegian SW Scenarios	Syverud	3.1	5.34	Loam/silt loam	27	47	26	5.5	1.22
	Bjørnebekk	1.5	2.586	Silty clay loam	26	64	9	6.0	1.52
Norwegian GW scenarios	Rustad	1.9	3.28	Silty clay loam	27	60	13	6.6	1.3
	Heia	2.2	3.79	Sandy loam	5	30	65	6.4	1.4

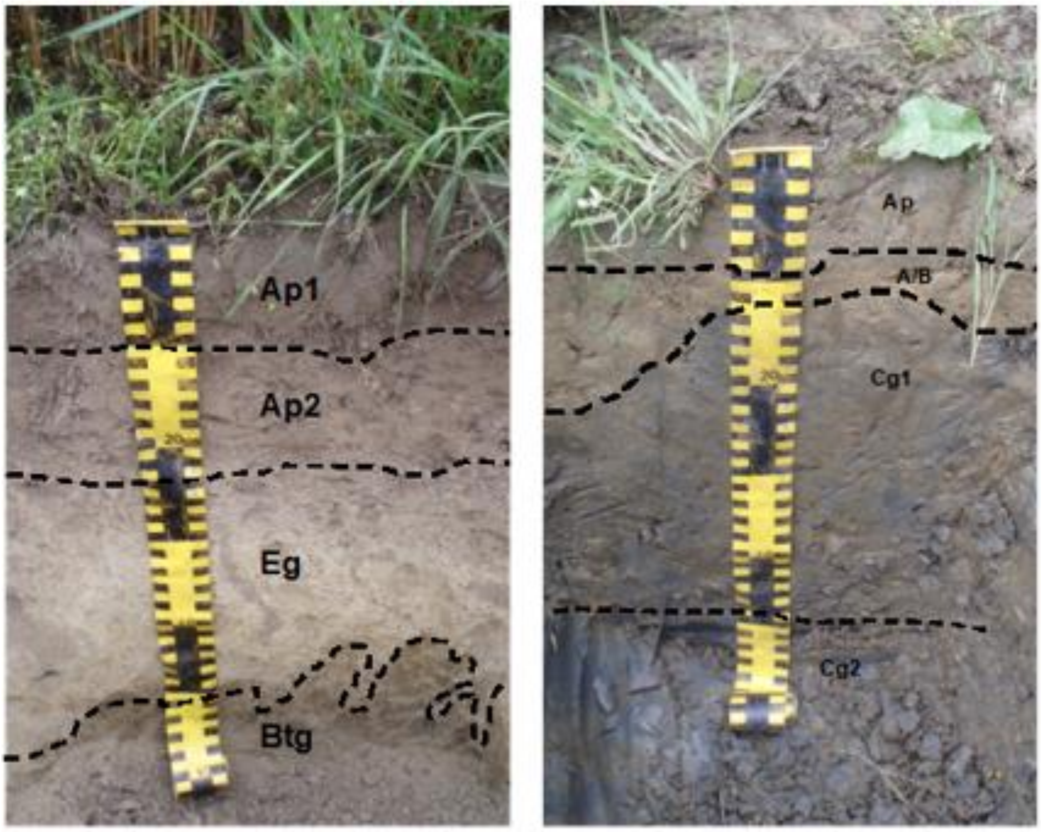

Figure 2-10. Soil profile from Syverud (left) and Bjørnebekk (right). A = arable layer, E = mineral horizon with loss of silicates and iron, B = mineral horizon with accumulation of silicates, iron, aluminium and humus, C= Underground horizon (Photo: E. Solbakken).

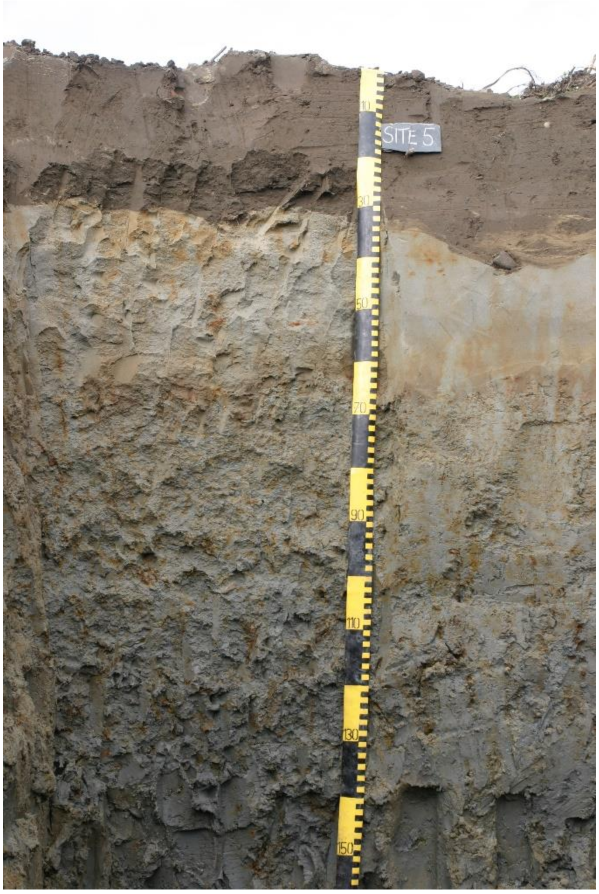

Figure 2-11. Soil profile from "Heia", Mollic Stagnosol (siltic). Photo :S. Svendgård-Stokke.

Table 2-2. Characteristic of climate and topography of the sites Bjørnebekk, Syverud, Rustad and Heia, for 2005-2007.

Site	Annual Temp (°C)	Rainfall (mm)	Drainage (mm)	Run-off (mm)	Slope (%)
Syverud	5.3 (normal)	798-1066	499-569	33-115	13
Bjørnebekk	5.3 (normal)	798-1066	n.a.	290-440	13
Rustad	5.3 (normal)	785 (normal)	n.a.	n.a.	<2
Heia	5.6 (normal)	829 (normal)	n.a.	n.a.	<2

The Norwegian scenario sites are all located within the same region (1-Østlandet, figure 2-3). The main agricultural area in region 1, close to Oslofjorden, have the same precipitation (800-1100 mm) as large parts of the area close to Trondheimsfjorden, representing the main agricultural area in region 5. Region 2, Innlandet, is dryer and area 3 is more wet. The average annual rainfall for the last 30 years has increased 100 mm/year in the southern regions, especially during the winter season (annex V).

Norway is a member of the Northern zone participating in the authorisation of plant protection products in EU (figure 2-12). The two drainage scenario sites Lanna (D1) and Skousbo (D4, figure 2-14) of the FOCUS scenarios, belong to this region. There are no run-off scenarios in this region.

Figure 2-12. Members of the Northern zone participating in the authorisation of plant protection products. Source: (Northern Zone, 2020).

2.3 Soil and climate classes in the EU FOCUS scenarios (FOCUS 2001)

This chapter gives an overview of the different climate and soil classes used to characterize the different EU scenarios. These categories have also been used to assess the realistic worst case for the Norwegian conditions and scenarios in chapter 4. These classes include temperature, precipitation, soil, and topography.

According to the EU FOCUS (2001) temperature classes, the spring period is from March to May, and autumn from October to February (table 2-3). Despite these seasons do not fit the Norwegian conditions well (December to February is winter season in Norway), these categories have been included in the analysis.

Table 2-3. Temperature classes in the EU-FOCUS scenarios

Average Autumn & Spring temperature	
Range °C	Assessment
<6.6	Extreme worst-case
6.6 – 10	Worst case
10 – 12.5	Intermediate case
>12.5	Best case

Data for recharge for the Norwegian situation has not been obtained, but average annual rainfall has been used for classification of the influence of precipitation on the risk assessment run-off and drainage. Especially the south- and west-coast of Norway belong to the category extreme worst case of the EU-FOCUS scenarios (table 2-4 and figure 2-3).

Table 2-4. Rainfall and run-off classes in the EU-FOCUS scenarios

Average Annual Recharge (drainage)		**Average Annual Rainfall (Run-off)**	
Range mm	Assessment	Range mm	Assessment
>300	Extreme worst case	>1000	Extreme worst case
200 – 300	Worst case	800 – 1000	Worst case
100 – 200	Intermediate case	600 – 800	Intermediate case
<100	Best case	< 600	Best case

In the EU scenarios only one of the run-off scenarios belong to the slope category "extreme worst case" (table 2-9), which is a terraced scenario (R2). To cover risk assessment of run-off from steep areas, which is common in Norway, two sites with slopes more than 10 % slope was selected to represent Norwegian conditions.

Table 2-5. Slope classes and run-off in the EU-FOCUS scenarios

Slope (Run-off)	
Range %	Assessment
>10	Extreme worst case
4 – 10	Worst case
2 – 4	Intermediate case
<2	Best case

The soil characteristics used to classify worst cases for drainage and run-off are given in table 2-6 and table 2-7.

Table 2-6. Soil characteristics and relative worst-case for drainage in the EU FOCUS-scenarios

Soil Characteristics	**Assessment**
Coarsely structured 'cracking clay' soils with extreme by-pass flow on impermeable substrates	Extreme worst case
Clays and heavy loams with by-pass flow over shallow groundwater	Worst case
Sands with low organic matter content over shallow groundwater	Worst case
Light loams with low organic matter content and some by-pass flow on slowly permeable substrates	Intermediate case

Table 2-7. Soil characteristics and relative worst-case run-off in the EU-FOCUS scenarios

Soil Characteristics	Assessment
Soil hydrologic group D3 (heavy clay soils)	Extreme worst case
Soil hydrologic group C 4 (silty or medium loamy soils with low organic matter content).	Worst case
Soil hydrologic group B 4 (light loamy soils with small clay and moderate organic matter content)	Intermediate case

2.3.1 Characteristics of the FOCUS scenarios

The FOCUS scenarios and primary soil properties are described in table 2-8. More details are given in chapter 4.3.1 in the FOCUS report (FOCUS, 2001). Lanna and Skousbo belong to the Northern zone. Brimstone, Vredepel, Weierbach and La Jailliere belong to the Central zone, and Thiva, Porto, Bologna and Roujan belong to the southern zone (figure 2-13, figure 2-14).

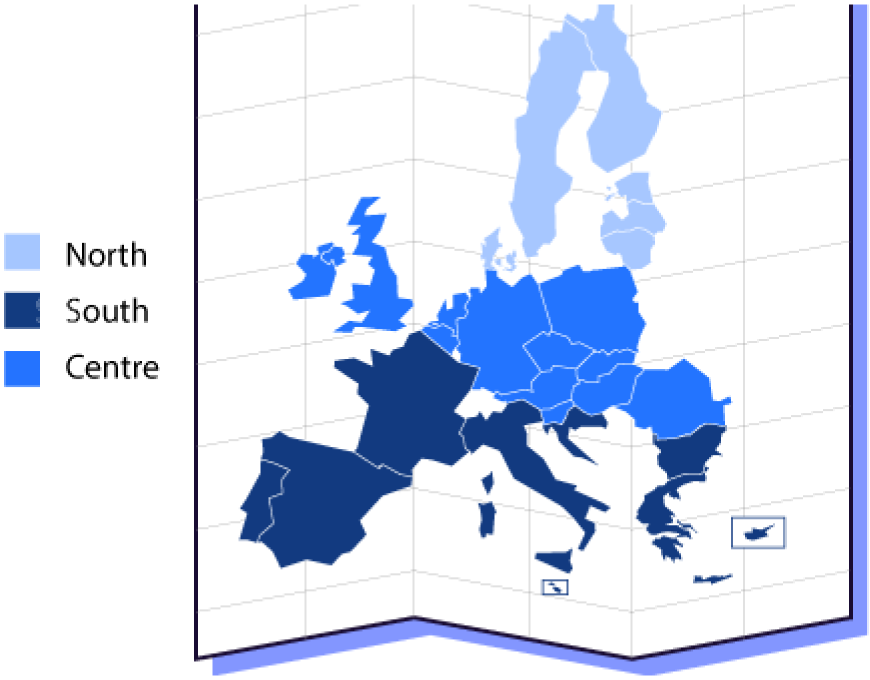

Figure 2-13. For pesticide authorisation, the EU is split into three zones. Source:(EU pesticides explained, 2021).

[3] Descriptions of soil hydrologic groups are according to the PRZM manual Carsel R.F., Imhoff J.C., Hummel P.R., J.M. C., Donigian Jr A.S. (1995) PRZM-3. A Model for Predicting Pesticide and Nitrogen Fate in the Crop Root and Unsaturated Soil Zones. Users Manual for Release 3.0. National Exposure Research Laboratory, U.S. Environmental Protection Agency, Athens, GA, USA. ibid.

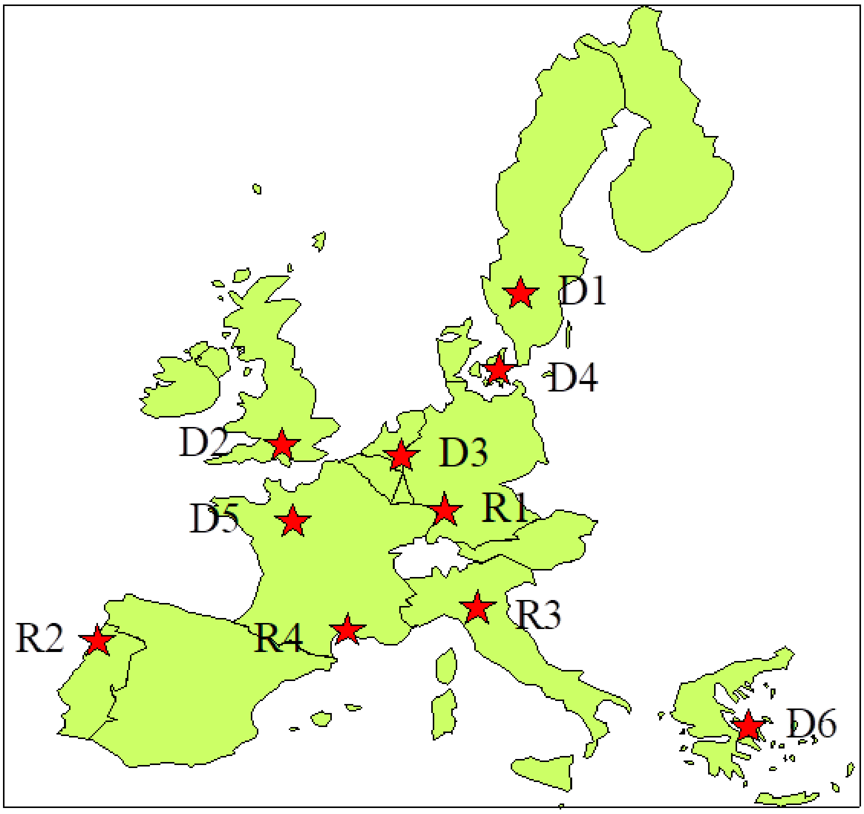

Figure 2-14. The ten EU scenarios for surface water PEC calculations (D=drainage, R= runoff) (FOCUS, 2001).

Table 2-8. Topsoil properties of the EU-scenarios for drainage (D) and surface run-off (R).

Source	Representative field site	Organic carbon %	Texture class	Clay [1] %	Silt [1] %	Sand [1] %	pH	Bulk density g cm^{-3}
Focus SW Scenario								
D1	**Lanna**	2.0	Silty clay	47	46	7	7.2	1.35
D2	**Brimstone**	3.3	Clay	54	39	7	7.0	1.20
D3	**Vredepeel**	2.3	Sand	3	6	91	5.3	1.35
D4	**Skousbo**	1.4	Loam	12	37	51	6.9	1.48
D5	**La Jailliere**	2.1	Loam	19	39	42	6.5	1.55
D6	**Váyia, Thiva**	1.2	Clay loam	30	34	36	7.5	1.43
R1	**Weiherbach**	1.2	Silt loam	13	82	5	7.3	1.35
R2	**Valadares, Porto**	4.0	Sandy loam	14	19	67	4.5	1.15
R3	**Ozzano, Bologna**	1.0	Clay loam	34	43	23	7.9	1.46
R4	**Roujan**	0.6	Sandy clay loam	25	22	53	8.4	1.52

Grain size distribution of the topsoil from D1, D2 and D6 have high content of clay which makes bypass flow a dominant process in these scenarios. D3 is extremely sandy soil, while R1 is extremely silty and R3 and 4 are characterized as medium loamy and high risk of runoff (table 2-8).

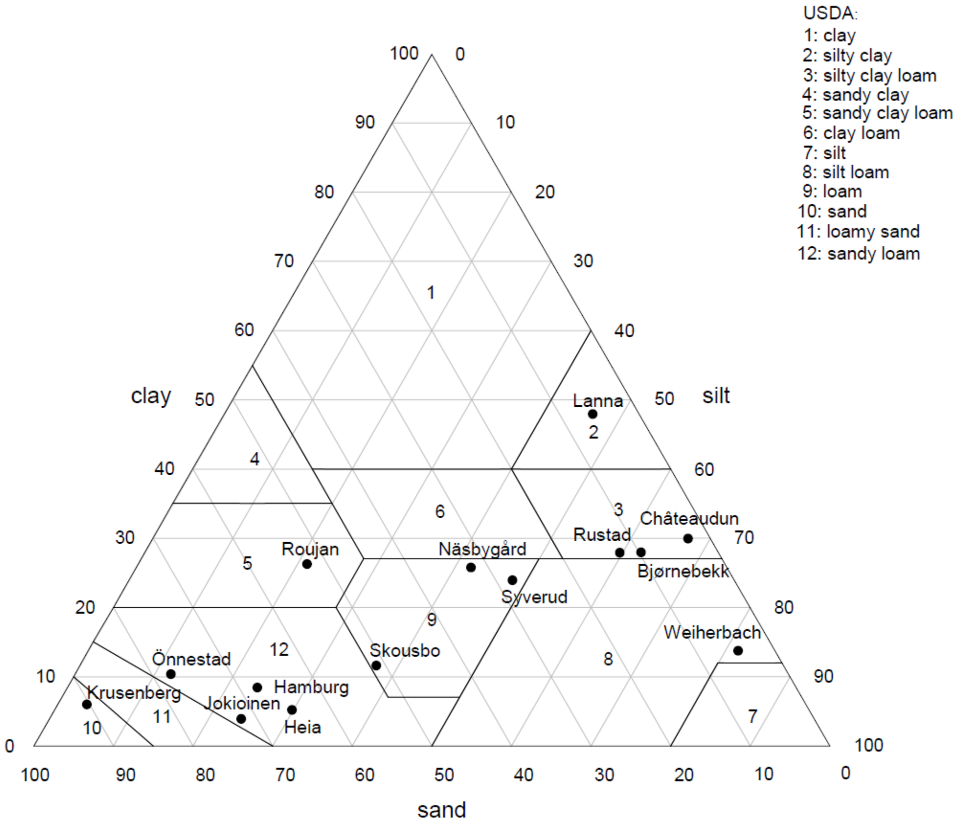

Figure 2-15. Grain size distribution of selected topsoil of the four Norwegian scenarios compared to some of the FOCUS scenarios

All scenarios have a low organic carbon content except Porto (R2), which is influenced by the wet Atlantic climate > 1000 mm (table 2-9). All the other scenarios have 600-800 mm annual precipitation, except Bologna (R3).

Table 2-9. Inherent Agro-environmental characteristics of the drainage and surface water scenarios.

Scenario	Mean spring & autumn temp (ºC)	Mean annual rainfall (mm)	Mean annual recharge (mm)	Slope (%)	Soil
D1	<6.6	600 – 800	100 – 200	0 – 0.5	Clay with shallow groundwater
D2	6.6 – 10	600 – 800	200 – 300	0.5 – 2	Clay over impermeable substrate
D3	6.6 – 10	600 – 800	200 – 300	0 – 0.5	Sand with shallow groundwater
D4	6.6 – 10	600 – 800	100 – 200	0.5 – 2	Light loam over slowly permeable substrate
D5	10 – 12.5	600 – 800	100 – 200	2 – 4	Medium loam with shallow groundwater
D6	>12.5	600 – 800	200 – 300	0 – 0.5	Heavy loam with shallow groundwater
R1	6.6 – 10	600 – 800	100 – 200	2 – 4	Light silt with small organic matter
R2	10 – 12.5	>1000	>300	10 – 15	Organic-rich light loam
R3	10 – 12.5	800 – 1000	>300	4 – 10	Heavy loam with small organic matter
R4	>12.5	600 – 800	100 – 200	4 – 10	Medium loam with small organic matter

2.4 Thematic input maps considered for the analysis

2.4.1 Land cover

To estimate the relevance of the FOCUS SW scenarios in Norway, it was necessary to identify the agricultural areas.

This was done based on Corine land cover data (EU Commission, 2005). For this project the 2018-version of this map was used (EEA, 2018)). Based on this map, which was not available when the FOCUS Surface Water working group defined their scenarios, the representativeness of the FOCUS run-off scenarios for the agricultural area of Norway was analysed. The original map had a resolution of 100m * 100m. To make it compatible with the other maps used in this analysis it was resampled to a lower resolution of 1 km² always considering the dominant land cover for the new map. Afterwards, all countries except Norway were filtered out from this European map. The extent of the new map was the same as the land cover map (easting: 3800 km to 5150 km, northing: 3812 km to 5512 km, 1350 x 1700 pixel).

Due to climatic conditions, agriculture is not the dominant land use in Norway (table 2-10, figure 2-16).

Table 2-10. Area distribution of different land cover classes in Norway (EEA, 2018).

Colour	**Assignment**	**Distribution (km^2)**
black	technical areas (urban, industrial, road, etc.)	2367
orange	agricultural areas	6095
Red	Permanent crops	0
light green	pasture	197
brown	Land principally occupied by agriculture, with significant areas of natural vegetation and complex cultivation patterns	9042
dark green	forest	115147
purple	natural areas	49511
grey	rocks and sparsely vegetated areas	108467
light blue	inland marshes	17939
dark blue	water bodies	14583
sum	**Total map area**	**323348**

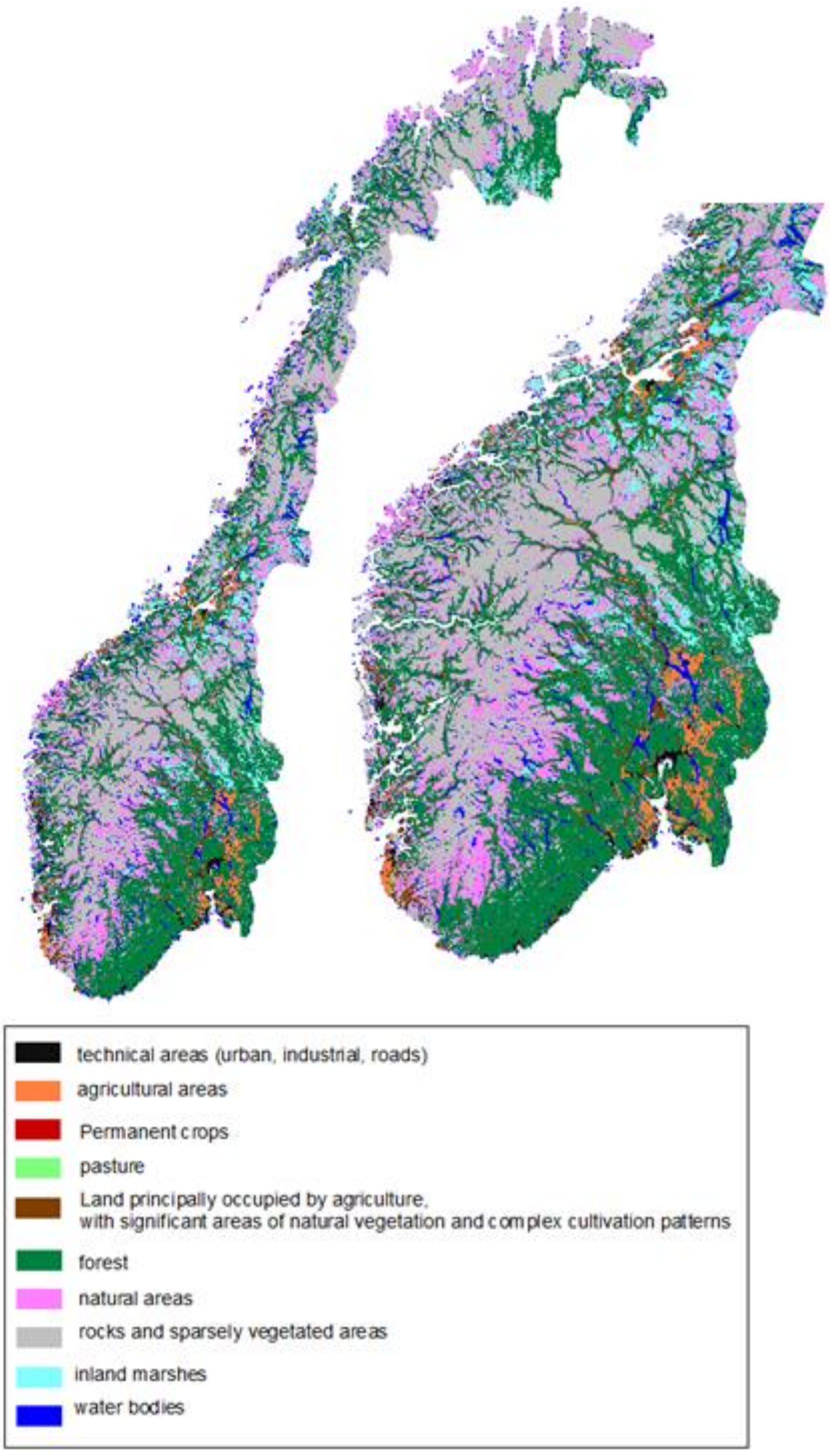

Figure 2-16. Land cover in Norway (Total map area: 323348 km²)

To ensure a conservative approach, all agricultural land cover classes shown in table 2-11 were considered for the evaluation, except pasture as it is not relevant for pesticide use.

Table 2-11. Area distribution of agriculturally relevant land cover classes in Norway (EEA, 2018)

Colour	**Assignment**	**Distribution (km²)**
yellow	Non-irrigated arable land	6095
red	Permanent crops	0
brown	Land principally occupied by agriculture, with significant areas of natural vegetation and complex cultivation patterns	9042
Sum	**Agricultural area considered in the analysis**	**15137**
green	*Pastures [not considered]*	*197*
grey	*Remaining areas*	*301919*
sum	**Total area of Norway**	**323348**

The distribution shown in figure 2-17 differs from the maps presented in figure 2-1 and figure 2-2. Background is the definition of the brown attribute in figure 2-17 (Land principally occupied by agriculture, with significant areas of natural vegetation and complex cultivation patterns). Due to the aggregating procedure (change of the resolution from 100x100 m² to 1000x1000 m² in the land-use map, the agricultural area was overrepresented at the cost of natural vegetation and complex cultivation patterns. The consequence is that the total agricultural area of 15137 km² considered in the map is too high compared to the real situation in Norway. The only alternative would have been to omit completely the brown area. However, the remaining yellow area of 6095 km² does surely not represent all Norwegian agricultural regions and worst-case conditions could have been missed. Therefore, it was decided to consider the yellow and the brown area (154137 km²) for the analysis.

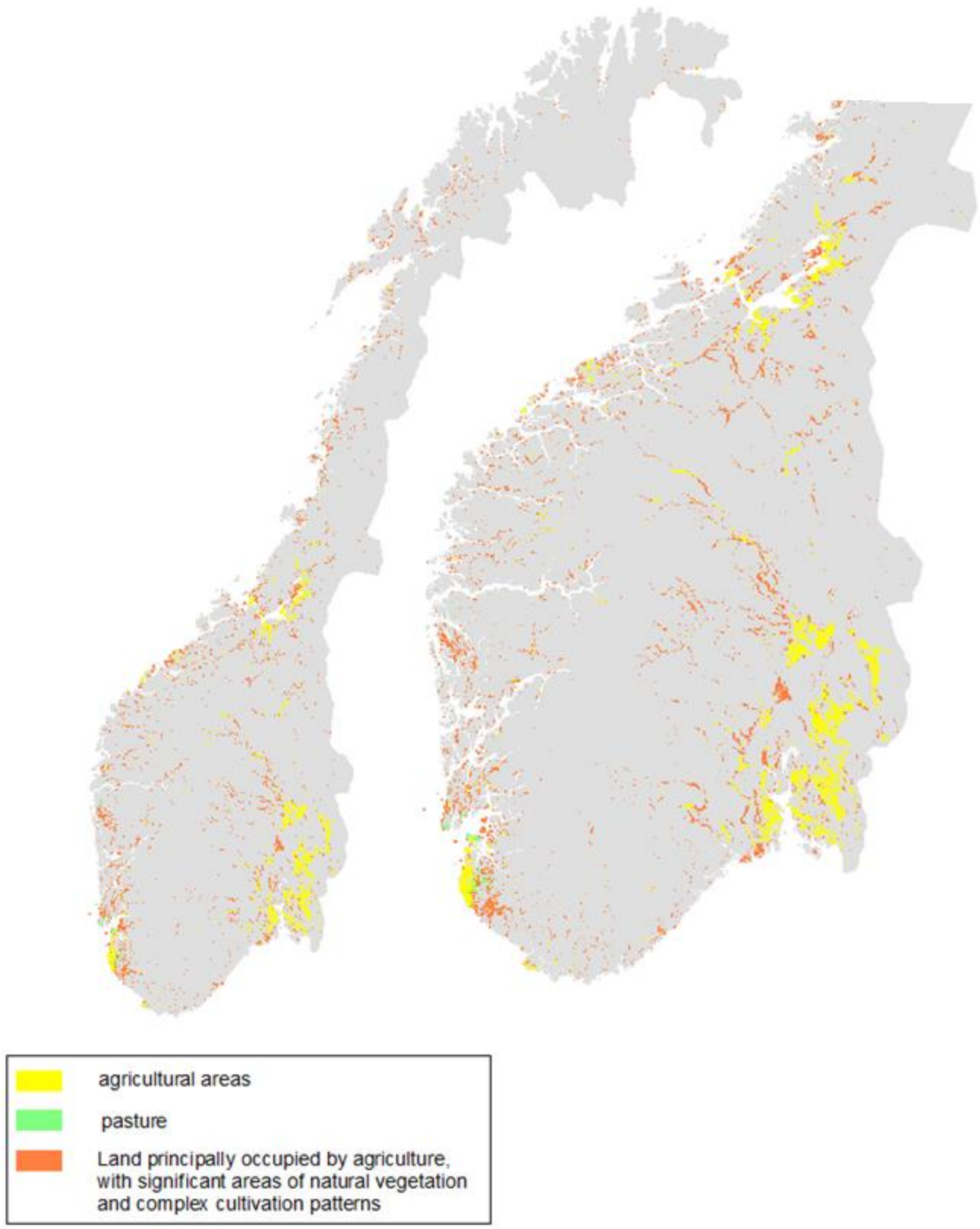

Figure 2-17. Arable land in Norway (sum: 15137 km²)

2.4.2 Soil texture

The information on soil texture was based on the European soil data base ESDB v2 (current version 2.0) and the raster library SGDBE (Soil Geographical Database of Europe, European soil Bureau 2006 (Jones et al., 2005)). The data base contains information on many parameters necessary to evaluate soil properties. For this analysis only the parameter "soil type" was considered. The same data base was also used by EFSA when developing new scenarios for pesticide persistence in soil (EFSA, 2017). The original map projection was *ETRS 1989 LAEA, Lambert Azimuthal Equal Area.* All countries except Norway were filtered out from this European map. The extent of the new map was the same as the land cover map (easting:3800 km to 5150 km, northing: 3812 km to 5512 km, 1350 x 1700 pixel). A bitmap of the transformed map is presented in figure 2-18.

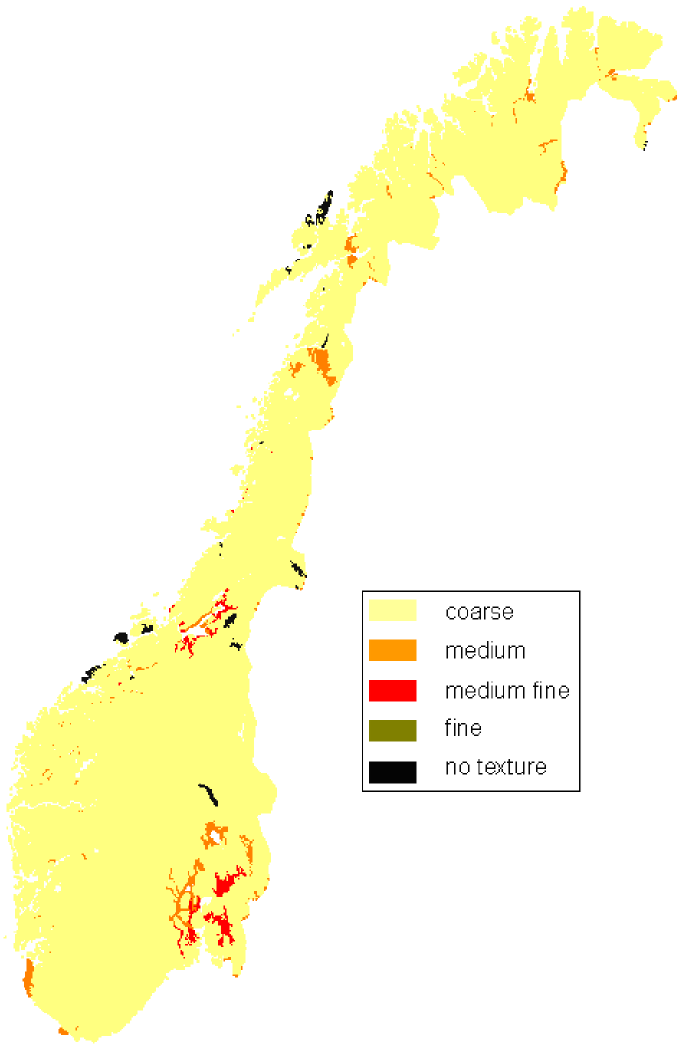

Figure 2-18. Soil types in Norway (European Soil Bureau, 2006)

As shown in Figure 2-18, soil texture was characterised by 5 different classes. Their definition and their distribution in Norway are presented in table 2-12. The soil texture classes 3 (R1, R3), 1 (R2) and 2 (R4) are relevant for run-off, according to FOCUS (2001). The total area of Norway in this map (314920 km²) is smaller than in the land cover map (323348 km²) because no information is given for the bigger urban areas.

Table 2-12**.** Area distribution of soil texture classes in Norway (ESDB v2) with relevance for run-off according to table 3.4-2 in FOCUS (2001)

Value	Assignment	Interpretation for run-off	Distribution (km²)
0	No information	not relevant	0
9	No texture (histosols, ...)	not relevant	1982
1	Coarse (clay < 18% and sand > 65 %)	not relevant	303582
2	Medium (18% < clay < 35% and sand > 15%, or clay < 18% and 15% < sand < 65%)	relevant	6024
3	Medium fine (clay < 35 % and sand < 15 %)	relevant	3332
4	Fine (35 % < clay < 60 %)	not relevant	0
5	Very fine (clay > 60 %)	not relevant	0
	Possible run-off locations		**9356**
	Total map area		**314920**

2.4.3 Organic matter

The information on organic matter in the topsoil was based on the European soil data base OCTOP. The same data base was also used by EFSA when developing new scenarios for pesticide persistence in soil (EFSA, 2017). The original map projection was *ETRS 1989 LAEA*, *Lambert Azimuthal Equal Area.* All countries except Norway were filtered out from this European map. The extent of the new map was the same as the land cover map (easting: 3800 km to 5150 km, northing: 3812 km to 5512 km, 1350 x 1700 pixel). The transformed map is presented in figure 2-19.

As shown in figure 2-19, the organic matter content in the topsoil was characterised by 6 different classes according to the classification of Jones et al., (2005). Their distribution in Norway is presented in table 2-13. Generally, all classes are relevant for run-off, according to FOCUS (2001). The total area of Norway in this map (299519 km²) is smaller than the land cover map (323348 km²) because no information is given for the bigger urban areas.

Table 2-13. Area distribution of soil organic matter content classes for topsoil in Norway (ESDB v2)

Value		Distribution (km²)
< 2 %		17339
2 % - 4 %		100326
4 % - 6 %		31633
6 % - 8 %		70953
8 % - 10 %		44980
> 10 %		34288
possible run-off locations (total map area)		299519

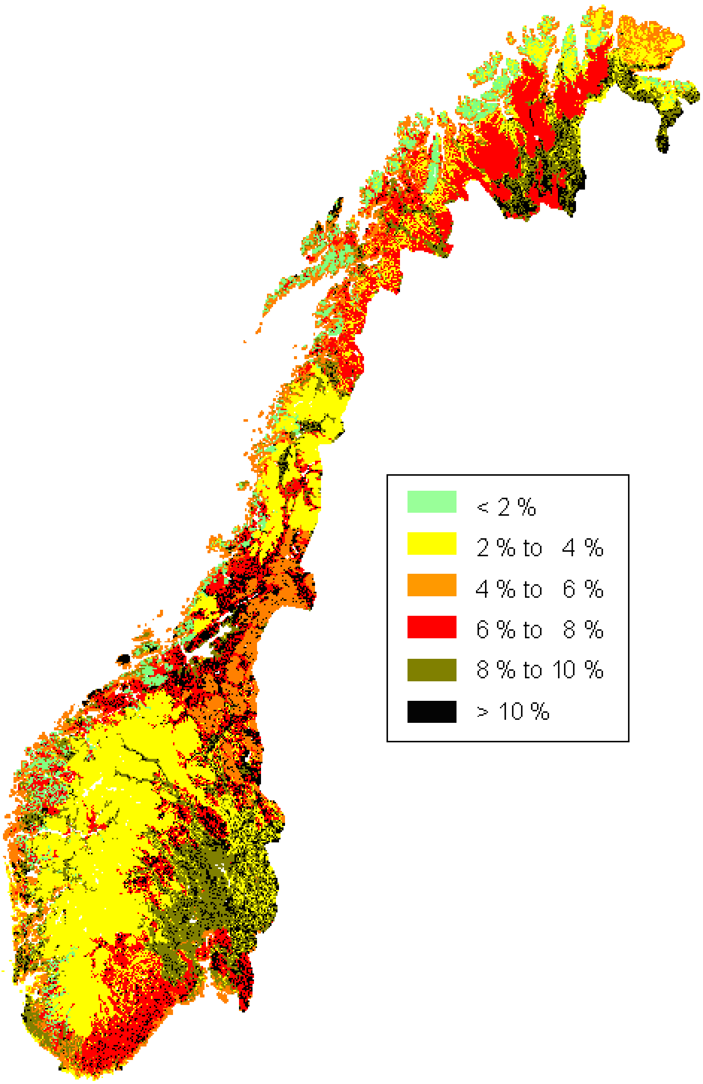

Figure 2-19. Organic matter content in the topsoil (Jones et al., 2005)

2.4.4 Annual precipitation

The information on precipitation was based on WorldClim data. The interpolation was done based on (Hijmans et al., 2005). Observations from more than 60000 weather stations across the world and multiple satellite-derived data for the period of 1970-2000 were utilized to update the current estimates of monthly precipitation. The map projection was *ETRS 1989 LAEA*, *Lambert Azimuthal Equal Area.* All countries except Norway were filtered out from this European map. The extent of the new map was the same as the land cover map (easting: 3800 km to 5150 km, northing: 3812 km to 5512 km, 1350 x 1700 pixel). The transformed map is presented in figure 2-20.

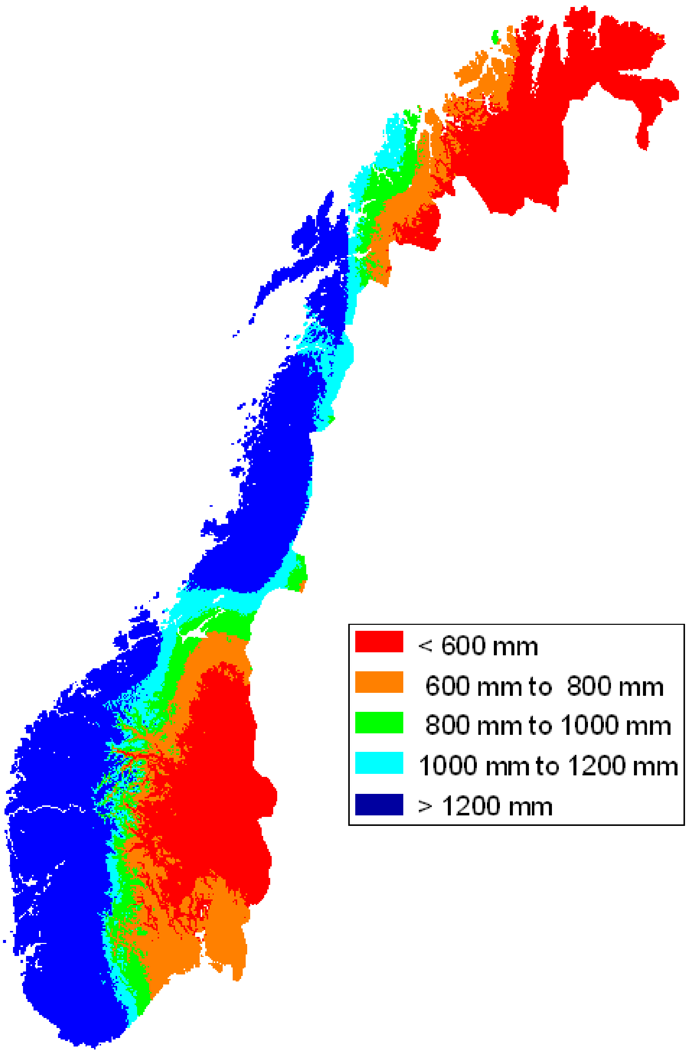

Figure 2-20. Annual precipitation in Norway

As shown in figure 2-20, the annual rainfall was expressed in 5 different classes. Their distribution in Norway is presented in table 2-14. Locations with annual precipitation of more than 600 mm are relevant for run-off, according to FOCUS (2001).

Table 2-14. Area distribution of annual precipitation classes in Norway

Value	FOCUS assessment	Interpretation for run-off	Distribution (km²)
<600 mm	Best case	not relevant	104145
600 mm to 800 mm	Intermediate case	relevant	49597
800 mm to 1000 mm	Worst case	relevant	24944
1000 mm to 1200 mm	Extreme worst case	relevant	27785
>1200 mm		relevant	116890
Possible run-off locations (sum >600 mm)			219216
Total map area			323361

2.4.5 Mean temperatures in spring and autumn

The information on temperature was based on WorldClim data. The interpolation was done based on Hijmans et al. (2005). Observations from more than 60000 weather stations across the world and multiple satellite-derived data for the period of 1970-2000 were utilized to update the current estimates of monthly temperature. The map projection was ETRS 1989 LAEA, Lambert Azimuthal Equal Area. All countries except Norway were filtered out from this European map. The extent of the new map was the same as the land cover map (easting: 3800 km to 5150 km, northing: 3812 km to 5512 km, 1350 x 1700 pixel).

As shown in table 2-15, the annual mean temperature is expressed in 4 different classes according to the FOCUS classification. Their area distribution in Norway is presented in figure 2-21. Generally, all locations, independent on their annual mean temperature, are relevant for run-off or drainage, according to FOCUS (2001).

Table 2-15. Area distribution of mean temperature classes in spring and autumn in Norway (FOCUS classes)

Value	FOCUS assessment	Distribution (km²)
<6.6 °C	Extreme worst case	314285
6.6 °C to 10.0 °C	Worst case	9076
10.0 °C to 12.5 °C	Intermediate case	0
>12.5 °C	Best case	0
Possible run-off locations		323361
Total map area		323361

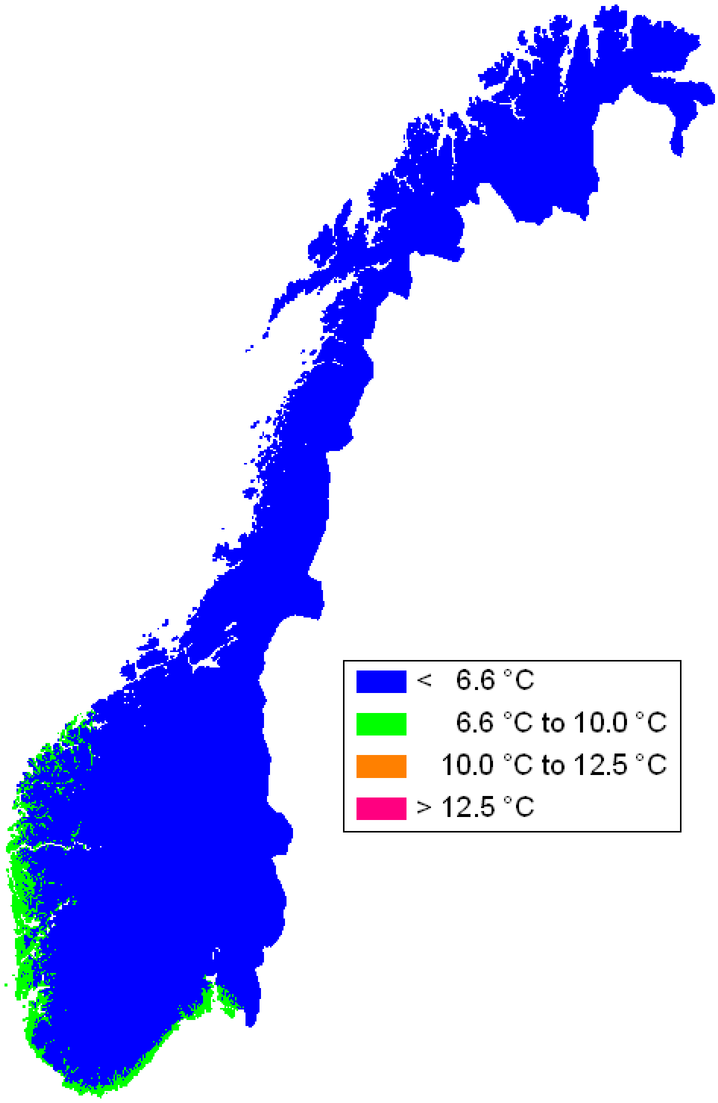

Figure 2-21. Average spring-autumn-temperatures in Norway (FOCUS classes)

As is seen from table 2-15 and figure 2-21, more or less the whole area of Norway falls into the first FOCUS category (Temperature < 6.6 °C). An alternative classification (not based on FOCUS) was developed within this project. It should better address the cold climate in Norway (figure 2-22).

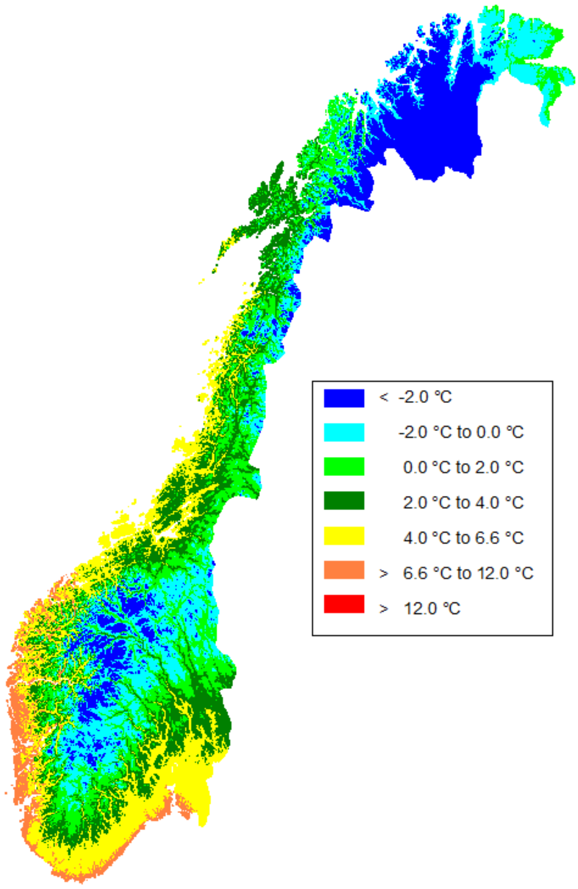

Figure 2-22. Average spring-autumn-temperatures in Norway

Table 2-16 demonstrates that the area distribution for the alternative classes is more equal.

Table 2-16. Area distribution of mean temperature classes in spring and autumn in Norway (alternative classes)

Value	Distribution (km²)
<-2.0 °C	61322
-2.0 °C to 0.0 °C	69287
0.0 °C to 2.0 °C	65578
2.0 °C to 4.0 °C	63043
4.0 °C to 6.6 °C	55055
>6.6 °C to 12.0 °C	9076
>12.0 °C	0
Possible run-off locations	323361
Total map area	323361

2.4.6 Slope

For the parameter slope, a map was used that was developed by the Julius Kühn Institut as part of the SYNOPS-WEB application. This web application is being adapted for assessment of environmental risk from pesticide use under realistic field conditions in Norway (JKI, 2013). The original dataset had a resolution of 10 x 10 m and was resampled to a raster of 1 km² to match the resolution of the other maps in this evaluation. The extent of the new map was the same as the land cover map (easting: 3800 km to 5150 km, northing: 3812 km to 5512 km, 1350 x 1700 pixel). The transformed map is presented in figure 2-23.

As shown in figure 2-23, the average slope was characterised by 6 different classes. According to the FOCUS classification, areas with slope above 2% were relevant for run-off. The area distribution of mean slope classes in Norway is presented in table 2-17, showing that 98% of the Norwegian agricultural area fulfils the FOCUS criterion (above 2% slope). According to the FOCUS classification, areas with slope below 4% are relevant for drainage which is 10 % of the agricultural area (table 2-17).

Table 2-17: Area distribution of mean slope classes in Norway

Value	FOCUS assessment	Distribution (km²)
0 to 0.5%		10
0.5 to 2%	Best case	1362
2% to 4%	Intermediate case	6968
4% to 10%	Worst case	32759
10% to 15%	Extreme worst case	19787
15% to 100%		17273
Relevant for run-off		69819
Relevant for drainage		8340
Total number of pixels with slope attribute		78159

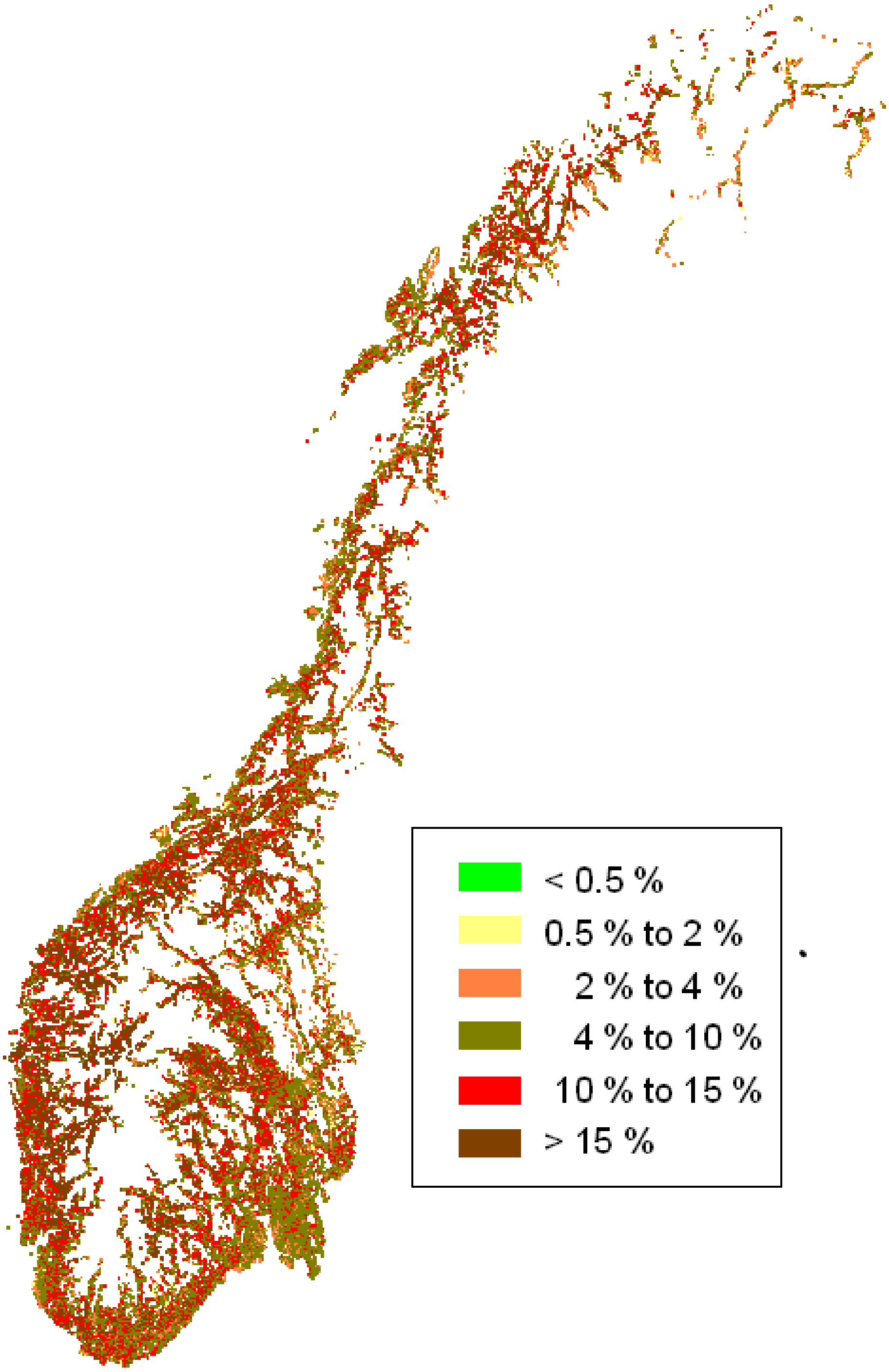

Figure 2-23: Mean slope in Norwegian agricultural regions (Synopsweb, 2021).

2.5 Strategy for FOCUS run-off scenarios

According to the SW FOCUS report (FOCUS, 2001*)* each of the 4 run-off scenarios represents a defined vulnerable situation with respect to possible surface water contamination by pesticides. The concrete characterisation of the scenarios, the FOCUS SW group explained in their report on table 3.2-6 *(*FOCUS, 2001), page 37). The most relevant information is summarised in table 2-18.

Table 2-18: Selection properties of the FOCUS run-off-scenarios (FOCUS, 2001).

Scenario	**Mean spring and** autumn temperatures (°C)	**Mean annual precipitation (mm)**	**Mean annual recharge (mm)**	**Slope (%)**	**Soil**
R1	6.6 – 10	600 – 800	100 – 200	2 – 4	Light silt with low organic matter content°
R2	10 – 12.5	>1000	>300	10 – 15	Organic-rich light loam^
R3	10 – 12.5	800 – 1000	>300	4 – 10	Heavy loam with low organic matter content°
R4	>12.5	600 – 800	100 – 200	4 – 10	Medium loam with low organic matter content*

° soil texture class 3 (medium fine) used in the analysis for R1 and R3
^ soil texture class 1 (coarse) used in the analysis for R2 as the soil in the scenario is actual sandy
* soil texture class 2 (medium) used in the analysis for R4

In this study a similar procedure was followed to analyse the relevance of the FOCUS EU run-off scenarios for the agricultural area of Norway, considering thematic maps with information on topsoil texture, annual rainfall, annual temperature, and land cover. As the models does not consider slope for calculating the amount of runoff water, slope was not considered further here. To perform an analysis similar to the original FOCUS evaluation, also other soil parameters (e.g., parent material) were not taken into consideration.

Different tables in FOCUS (2001) shows that this report is not very strict regarding the methodology described in its chapter 3 since the soil that was picked for R2 is rather sandy (>70 %). Therefore, the soil texture class 1 (coarse) was used for R2 in this analysis.

Table 2-19: Key properties of the FOCUS surface water scenarios (FOCUS, 2001).

Scenario	**Corresponding STU attributes**			**Annual rainfall^**		
location	**Soil type**	**Texture class+**	**Parent material**	**Date of first application**		
				March to May	**June to September**	**October to February**
R1*	All	3	All	829.4 mm (1984)	962.5 mm (1978)	962.5 mm (1978)
R2**	All	1	All	2127 (1977)	1425 (1989)	2400 (1977)
R3°	All	3	All	724 mm (1980)	875.5 mm (1975)	724 mm (1980)
R4°°	All	2	All	991.7 mm (1984)	694.9 mm (1985)	1021.7 mm (1979)

+ **1**: Coarse. >65% sand and ≤18%clay. **2**: Medium. 15 to 65% sand and ≤18%clay, OR >18 to 35% clay and ≥15% sand. **3**: Medium fine. <15% sand and ≤35% clay. **4**. Fine 35% to 50% clay

* all R1-locations with rainfall < 800 mm were considered as being dryer than FOCUS R1

** All R2 locations with annual rainfall <1000 mm were considered as being dryer than FOCUS R2

°° All R4 locations with annual rainfall < 700 mm were considered as being dryer than FOCUS R4

^ Based on the selected weather year for each application season for creation of PRZM to TOXSWA (P2T) files and the corresponding rainfall over 12 months

Comparing different tables in the FOCUS report further shows that it is also not very strict on climate data categorization. Therefore, another adjustment was done regarding the grouping of scenarios based on precipitation data. The actual annual rainfall in the selected weather years (table 2-19) used when performing FOCUS simulation (see also FOCUS 2001, table 4.1.2-3), shows that the actual weather conditions selected by FOCUS for R1 is not lower than for R3, as opposed to what is indicated in table 2-19. Therefore, the following classification was performed to compensate for these inconsistencies in the FOCUS document:

- All locations with rainfall >800 mm were considered representative for R1
- All R2 locations with annual rainfall >1000 mm were considered as being representative for FOCUS R2 (extreme worst-case selection since the actual minimum rainfall at R2 is, at least 1400 mm)
- All locations with rainfall ≤800 mm were considered representative for R3
- All locations with annual rainfall >700 mm were considered representative for R4

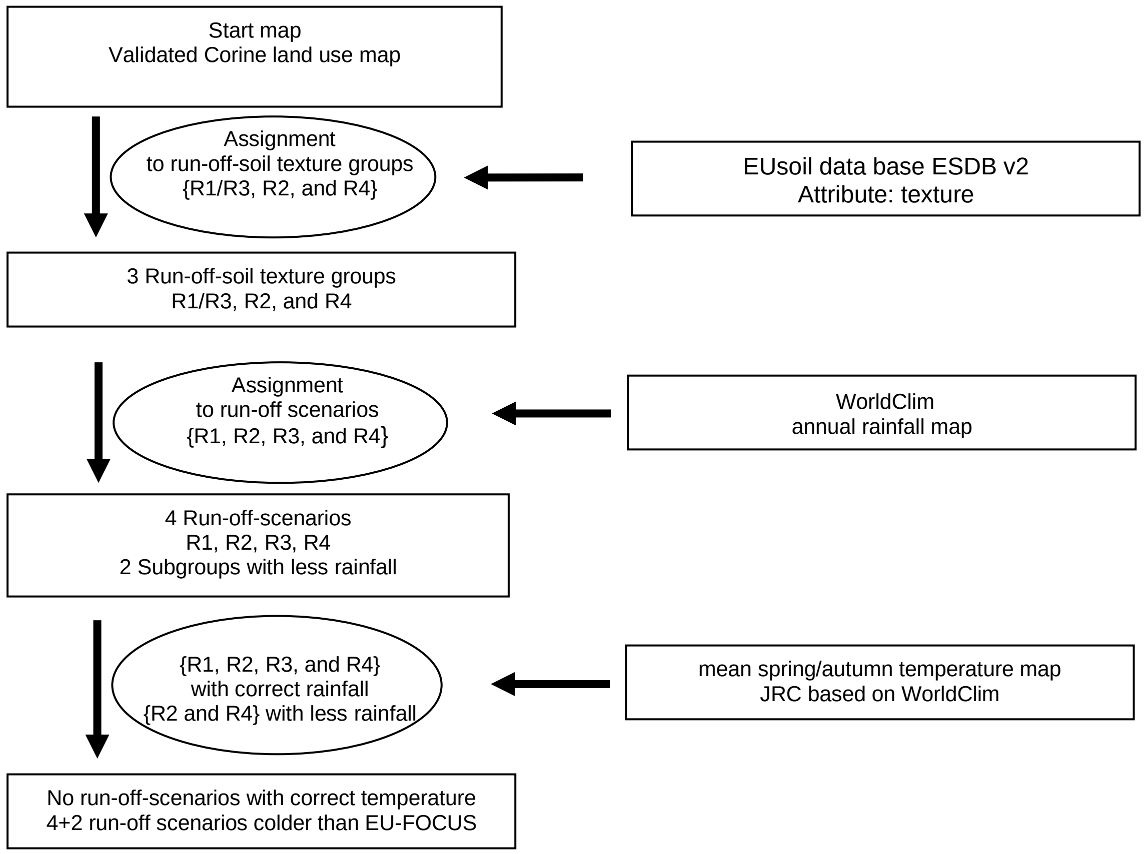

Figure 2-24. Flow chart describing the representativeness analysis of the FOCUS surface run-off scenarios in this study

The flowchart in figure 2-24 shows how the respective maps were combined.

The initial procedure of the analysis was to consider the two key properties texture and rainfall in the same way as FOCUS developed in 2001. Based on the map for soil texture (figure 2-18) and overlay of annual rainfall (figure 2-20), the agricultural area will contain four main groups; three run-off groups (R1/R3, R2, R4) and a group of locations which is considered as not vulnerable to run-off according to FOCUS because they have no soil texture (i.e., histosols).

It is not possible to distinguish between the scenarios R1 and R3 because they belong to the same texture class. Therefore, they are called "run-off groups" rather than "run-off scenarios". After overlay with annual rainfall R1 (locations with annual rainfall >800 mm) and R3 (locations with annual rainfall <800 mm), the analyses would split up and finally result in four different run-off scenarios. In contrast, the representative locations for runoff scenarios R2 and R4 were already completely defined based on soil texture only. However, rainfall was used to further classify respective locations (either "rainfall according to FOCUS" or "rainfall lower than FOCUS").

The next steps were to consider climate information on temperature to further classify into subgroups for run-off scenarios (Jones et al., 2005).

Organic matter and slope were not further considered as criteria. Organic matter was not considered because pesticides are anyhow transported during the run-off event, either via the water phase (soils with low organic matter contents) or via the suspended soil particles (soils with high organic matter content). According to the respective map presented previously (figure 2-23), slope is a dominant factor in nearly all agricultural fields in Norway. Therefore, also the slope was not considered further to discriminate among scenarios.

The exact analysis procedure was based on the methodology FOCUS developed in 2001. In the final step, the temperature map (figure 2-21) was used to complete the given climate properties of the run-off scenarios. Areas which do not fit with respect to the temperature are considered as variations to the main scenarios.

2.6 Strategy for FOCUS drainage scenarios

According to the SW FOCUS report (FOCUS, 2001) each of the 6 drainage scenarios represents a defined vulnerable situation with respect to possible surface water contamination by pesticides. The concrete characterisation of the scenarios, the FOCUS SW group explained in their report on table 3.2-6 (FOCUS, 2001), page 37). The most relevant information for the drainage scenarios is summarised in table 2-20.

In this study a similar procedure was followed to analyse the relevance of the FOCUS EU drainage scenarios for the agricultural area of Norway, considering thematic maps with information. To perform an analysis similar to the original FOCUS evaluation, also other soil parameters (e.g., parent material) were not taken into consideration.

Table 2-20. Key properties of the FOCUS drainage scenarios (FOCUS, 2001).

Scenario location	General soil properties	corresponding soil texture class*	Temperature (°C)	slope (%)	Annual rainfall (mm)	organic matter in topsoil (%)
D1	Clay soil with groundwater at shallow depth	4	6.1	0-0.5	600-800	3.4
D2	Clay soil over a soft impermeable clay substrate	4	9.7	0.5-2	600-800	5.7
D3	Sandy soil with groundwater at shallow depth	1	9.9	0-0.5	600-800	4.0
D4	Medium loam with a slowly permeable substrate.	2	8.2	0.5-2	600-800	2.4
D5	Medium loam with a perched seasonal water table at shallow depth	2	11.8	2-4	600-800	3.6
D6	Heavy loam soil with groundwater at shallow depth	2	16.7	0-0.5	600-800	2.1

*Texture class: **1**: Coarse. >65% sand and ≤18%clay.
2: Medium. 15 to 65% sand and ≤18%clay, or >18 to 35% clay and ≥15% sand.
3: Medium fine. <15% sand and ≤35% clay.
4. Fine 35% to 50% clay

The first step of the analysis was to consider the key properties soil type and temperature to define the drainage scenarios. The latter contrasts with run-off scenarios. The background for this decision is all drainage scenarios belong to the same rainfall category (600 – 800 mm) and no discrimination would be possible for EU FOCUS drainages with the same soil texture class. Furthermore, temperature might be more important when simulating drainage concentrations than concentrations caused by run-off events, because it normally takes more time after application for reaching surface water via drainage than via run-off. Based on the two parameters soil texture and temperature, three EU drainage scenarios suitable for Norway were found (D1, D3, and D4).

The next part of the flowchart was used to find further variations of the three basic scenarios considering additional FOCUS scenario definitions based on the following parameters: rainfall, slope, and organic matter. This second part resulted in the determination of in total 24 variations of the EU FOCUS drainage scenarios. The flowchart in figure 2-25 shows how overlay of the respective maps were combined. The base for the discrimination of variation is given in the previous table 2-20, that shows key properties of the FOCUS drainage scenarios (FOCUS, 2001), and the interpretation in terms of attributes defined in the European soil data base.

As mentioned above, rainfall, slope, and organic matter were not dominant parameters when defining the FOCUS drainage scenarios. They were used only to differentiate between variations of the drainage scenarios (e.g., locations with the exact same or smaller/higher organic matter content than the original scenario).

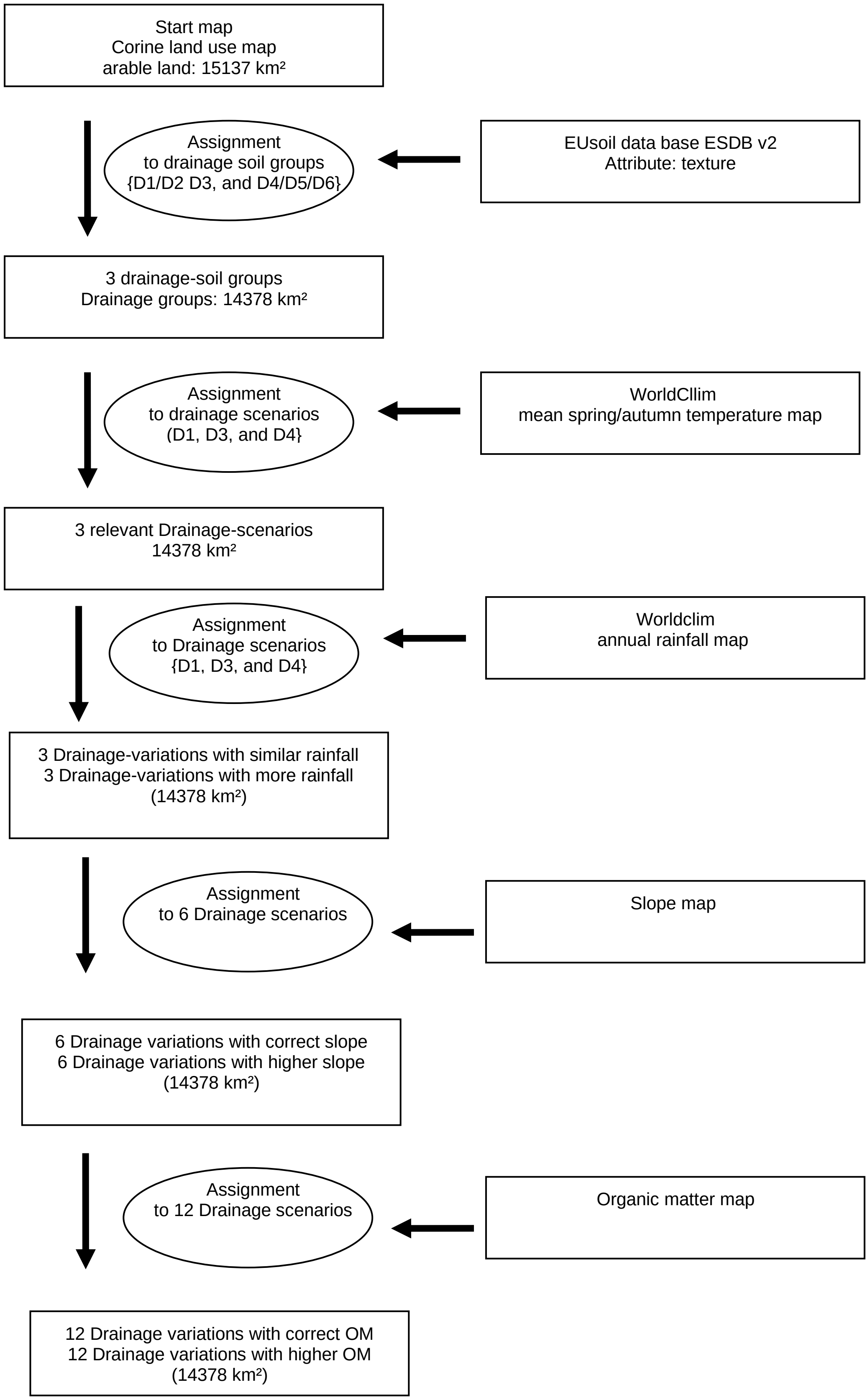

Figure 2-25. Considering soil properties when analysing the representativeness of the drainage scenarios

2.7 Strategy of the Norwegian run-off scenarios

To analyse the representativeness of the Norwegian run-off scenarios, the same type of methodology and relevant information was used for the Norwegian scenarios as for the FOCUS scenarios. The key properties of the Norwegian surface run-off scenarios are presented in table 2-21.

Table 2-21. Main properties of the Norwegian surface run-off scenarios

No	Field site	Texture Class	Organic carbon %	Precipitation (mm)	Temperature (°C)	Slope (%)
NR1	Syverud	2	3.1	798-1066	5.3	10-15
NR2	Bjørnebekk	3	1.5	798-1066	5.3	10-15

Texture class: **1**: Coarse. >65% sand and ≤18%clay.
2: Medium. 15 to 65% sand and ≤18%clay, or >18 to 35% clay and ≥15% sand.
3: Medium fine. <15% sand and ≤35% clay.
4. Fine 35% to 50% clay

A flow chart of the surface run-off of the Norwegian scenario analysis is shown in figure 2-26. The initial phase of the analysis was to consider the distribution of the soil texture classes and rainfall. As shown in table 2-21, there was no Norwegian run-off scenario with soil texture class 1 (coarse). However, soil texture class 1 is the dominant soil texture in the Norwegian agricultural area. Therefore, the scenario Syverud (texture class 2) was considered as a surrogate for agricultural areas with soil texture class 1. This can be considered a worst-case selection.

The next phase was to consider climate information on temperature. The temperature map was used to zoom to Norwegian fields, which were basically similar as the scenarios NR1 or NR2.

As explained previously discussing the FOCUS run-off scenarios, the organic matter content was not considered in this analysis, because pesticides are anyhow transported during the run-off event, either via the water phase (soils with low organic matter contents) or via the suspended soil particles (soils with high organic matter content).

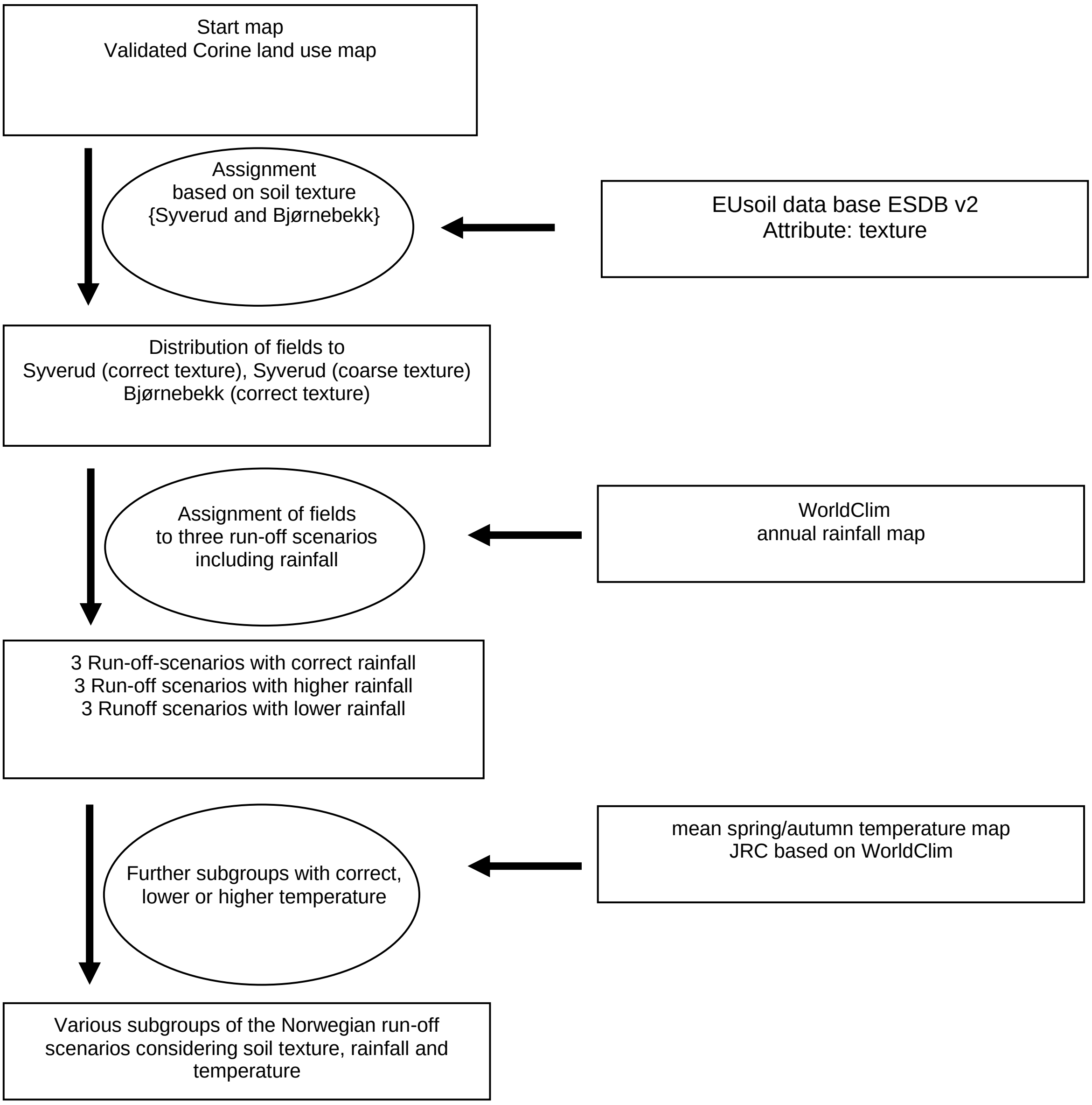

Figure 2-26. Flow chart describing the representativeness analysis of the Norwegian surface run-off scenarios in this study

2.8 Strategy of the Norwegian drainage scenarios

To analyse the representativeness of the Norwegian drainage scenarios, the same type of methodology and relevant information has been used as for the EU FOCUS drainage scenarios. The key properties of the Norwegian drainage scenarios are presented in table 2-22.

Table 2-22. Key properties of the Norwegian drainage scenarios

No		Field site	Texture class	Clay %	Silt %	Sand %	Org. carbon %	Org. matter %	Precipitation (mm)	Temperature (°C)	Slope (%)
ND 1		Rustad	3	27	60	13	1.9	3.28	785	5.3	< 2
ND 2		Heia	1	5	30	65	2.2	3.79	829	5.6	< 2

Texture class: **1**: Coarse. >65% sand and ≤18%clay.
2: Medium. 15 to 65% sand and ≤18%clay, or >18 to 35% clay and ≥15% sand.
3: Medium fine. <15% sand and ≤35% clay.
4. Fine 35% to 50% clay

According to table 2-22, Rustad is representative for all locations having medium fine soil texture (class 3) whereas Heia can be considered for all locations with coarse soil texture (class 1). In principle, Heia could be also assigned to class 2 (medium) since its sand content is at the edge of the two classes. However, it was assigned to class 1 since the clay content is also very low (5%). To find suitable scenarios also for this major part of the agricultural area, Rustad (texture class 3) was considered as a surrogate for soil texture class 2. This can be considered a worst-case selection.

That means that the first step of the analysis was to consider only the key property soil texture for the definition of the spatial distribution of the two Norwegian drainage scenarios. The latter contrasts with the EU drainage scenarios where soil texture and temperature were considered as key parameters. All other spatial parameters (e.g., rainfall, slope, organic matter) were therefore used to define further variations of Rustad and Heia, which are either more or less protective than the original scenario.

The second part of the analysis resulted in the determination of in total 16 variations of the EU FOCUS drainage scenarios using rainfall, slope, and organic matter as discriminating factors. The flowchart (

figure 2-27) shows how the respective maps were combined. The base for the discrimination of variation is given in the previous table 2-22, that shows key properties of the Norwegian drainage scenarios (see also chapter 2.2). As mentioned above, rainfall, slope, and organic matter were also not dominant parameters when defining the EU FOCUS drainage scenarios only to differentiate between variations of the drainage scenarios (e.g., locations with the exact same or smaller/higher organic matter content than the original scenario). The same strategy was followed here. It was not expected that the Norwegian scenarios show extensive temperature difference compared to the agricultural area. Nevertheless, in the final step temperature differences of Rustad and Heia compared to the climate of the whole Norwegian agricultural area were calculated.

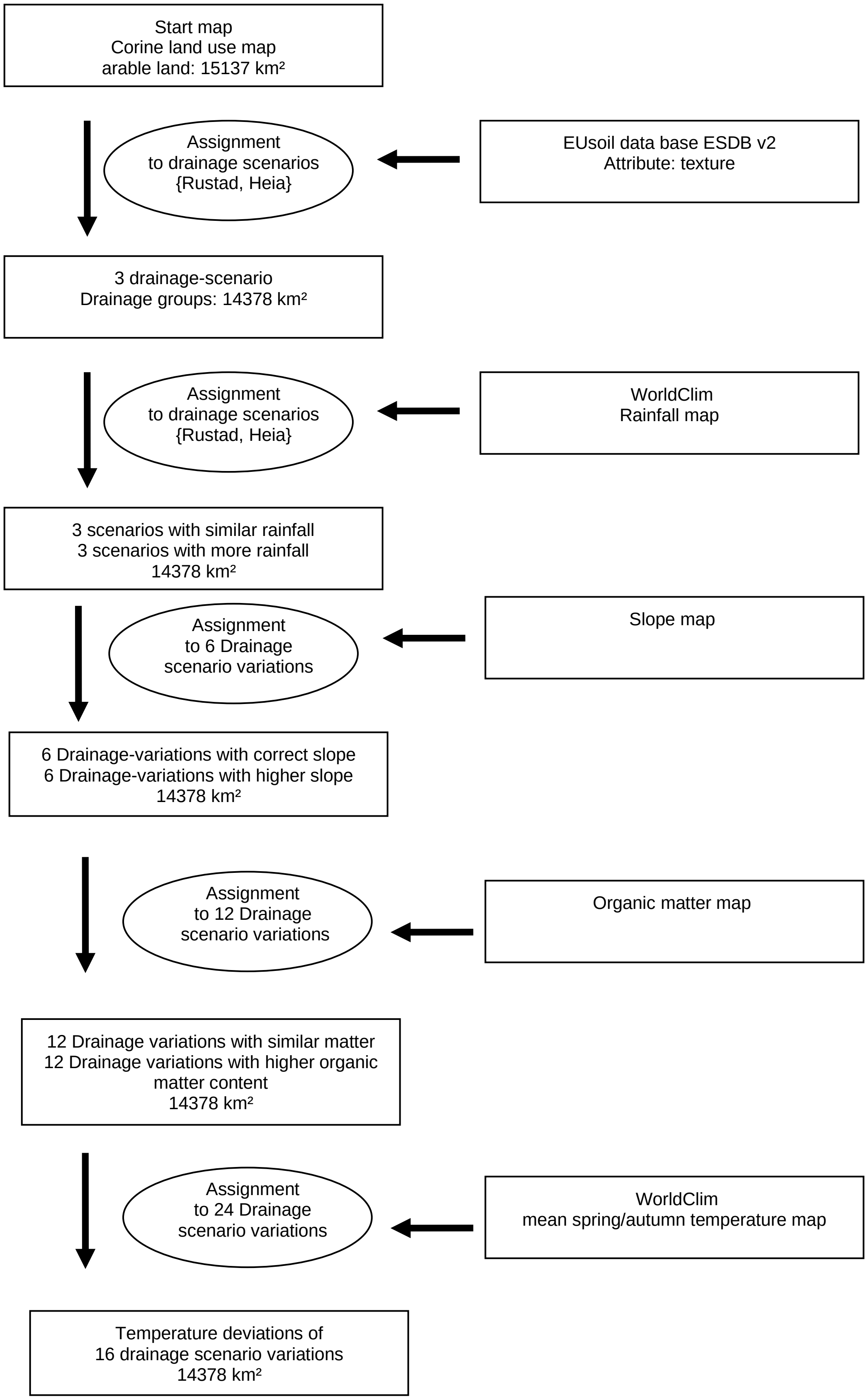

Figure 2-27. Considering soil properties when analysing the representativeness of the Norwegian drainage scenarios

2.9 Assessing importance of surface run-off, drain flow and spray drift

For the FOCUS scenarios, three calculators were used to calculate the PEC values in surface water and sediment. The MACRO model was used to calculate drainage inputs to surface water bodies for selected drainage scenarios (D1, D2, D3, D4, D5 and D6). The Pesticide Root Zone Model (PRZM) was used to calculate run-off and erosion loadings for the run-off scenarios R1, R2, R3 and R4 into surface water bodies. TOXSWA was used to calculate the dilution in stream, ditch, and pond. This test was conducted with a series of hypothetical parameters to evaluate the impact of environmental fate properties (table 2-23).

Table 2-23. Properties of the test substances (FOCUS, 2001).

	Example Compound:								
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Molar mass (g/mol)	300 for all compounds								
Vapour pressure (Pa @ 20°C)	1.0×10^{-7} for all compounds								
Water solubility (mg/L @ 20°C)	1.0 for all compounds								
Log Kow	0.2	2.1	4.1	0.2	2.1	4.1	0.2	2.1	4.1
Application rate (kg/ha)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Soil half-life (days)	3	3	3	30	30	30	300	300	300
Koc (cm^3. g^{-1})	10	100	1000	10	100	1000	10	100	1000
Freundlich 1/n	1								
Surface water half-life (days)	1	1	1	10	10	10	100	100	100
Sediment half-life (days)	3	3	3	30	30	30	300	300	300
Total system half-life (days)	1	1	2	10	12	22	102	126	219

Based on these simulations, importance, and contribution to surface run-off, drain flow and drift of the different substances with different properties could be assessed. Also, the effect of temperature correction considering the difference between original FOCUS scenarios and the predominant Norwegian temperatures was investigated.

To assess the importance of surface and drainflow for the Norwegian scenarios, results from two years of field experiments was used. Information on the field experiments are described in chapter 2.2.1 and in earlier reports (Bolli et al., 2013; Eklo et al., 2009; Eklo et al., 2008). Waterborne Environmental Inc. has included the Norwegian surface- and groundwater scenarios from Bjørnebekk and Syverud into WISPE **(W**orld **I**ntegrated **S**ystem for **P**esticide **E**xposure) (Cheplick et al., 2012), which makes it possible to do pesticide exposure assessments.

Three calculators were used to calculate the PEC values in surface water and sediment. The MACRO model was used to calculate drainage inputs to surface water bodies from the drainage scenarios Rustad and Heia. The Pesticide Root Zone Model (PRZM) was used to calculate run-off and erosion loadings for the run-off scenarios Syverud and Bjørnebekk into surface water bodies. In WISPE the PRZM model is connected to EXAM (The Exposure Analysis Modeling System) (Cheplick et al., 2012). EXAMS use the output files from PRZM as input to calculate pesticide exposure in water and in sediment at the downstream end of a ditch, stream or pond neighboring a treated field. EXAMS is the U.S. equivalent to TOXSWA with similar capabilities. The pesticides used for validation of the models were isoproturon, metalaxyl, and propiconazole. Pesticide simulations with EU endpoints and climate files (table 2-24) were compared with site specific properties for sorption, degradation, and climate files (table 2-25, table 2-26).

Table 2-24. Properties of the substances used on the field experiments for the Norwegian scenarios (PPDB, 2021) used as EU endpoints in the simulations chapter 6.

	Compounds used in the field experiment:		
	Metalaxyl	**Isoproturon**	**Propiconazol**
Molar mass (g/mol)	279	206	342
Vapour pressure (Pa @ 20°C)	0.75	5.5×10^{-3}	0.056
Water solubility (mg/L @ 20°C)	8400	70.2	150
Log Kow	1.75	2.5	3.72
Application rate (kg/ha)	0.225		0.25
Soil half-life (days)	7.1	12	71.8
Koc ($cm^3 . g^{-1}$)	162	122	1086
Freundlich 1/n	0.98	0.8	0.86
Surface water half-life (days)	56	40	6
Sediment half-life (days)	56	149	561

Table 2-25. Half-lives (days) of isoproturon and metalaxyl in soil from Heia and Rustad (Bolli et al., 2011).

Pesticide	**Rustad**		**Heia**	
	Topsoil (0-20 cm)	Subsoil (20-40 cm)	Topsoil (0-20 cm)	Subsoil (20-40 cm)
Isoproturon	13	13	13	14
Metalaxyl	21	34	46	68

Table 2-26. **A**) Half-lives (days) and **B**) sorption (Kf) of the pesticides in the topsoil and subsoil from Syverud, Bjørnebekk, Heia and Rustad (Bolli et al., 2011).

A)

Soil	Depth	Metalaxyl ($t_{1/2}$)	Propiconazole ($t_{1/2}$)
Syverud	0-20 cm	38	281
	20-40 cm	32	389
Bjørnebekk	0-20 cm	107	144
	20-40 cm	546	172

B)

Pesticide-Kf	Rustad	Heia	Syverud	Bjørnebekk
Metalaxyl	1.8	0.9		
Isoproturon	2.9	2.2		
Propiconazol			25.7	20.9

2.10 Literature search and selection

2.10.1 Search strategy

A systematic literature search was performed in collaboration with a research librarian from the National Institute of Public Health, Oslo, Norway (see Appendix I for details). The titles and abstracts of all search results were scanned for relevance to the terms of reference. Full texts for those of potential relevance, 88 in total, were assessed to determine their relevance to this report. Additionally, the reference lists in the selected articles may form the basis for identifying additional articles or reports within the topics listed in the terms of reference, overlooked by the searches.

2.10.2 Inclusion criteria

Relevant research articles, reviews as well as guidelines published within the last 20 years relating to the terms of reference were included.

2.10.3 Exclusion criteria

Articles were excluded if they did not relate to the terms of reference. Articles that are not in English, German or a Scandinavian language (Swedish, Danish, and Norwegian) were also excluded.

3 Agricultural areas in Norway represented by the ten FOCUS surface water standard scenarios and the four national scenarios

3.1 Representativeness of FOCUS run-off scenarios

3.1.1 Considering key properties for the characterisation of the scenarios

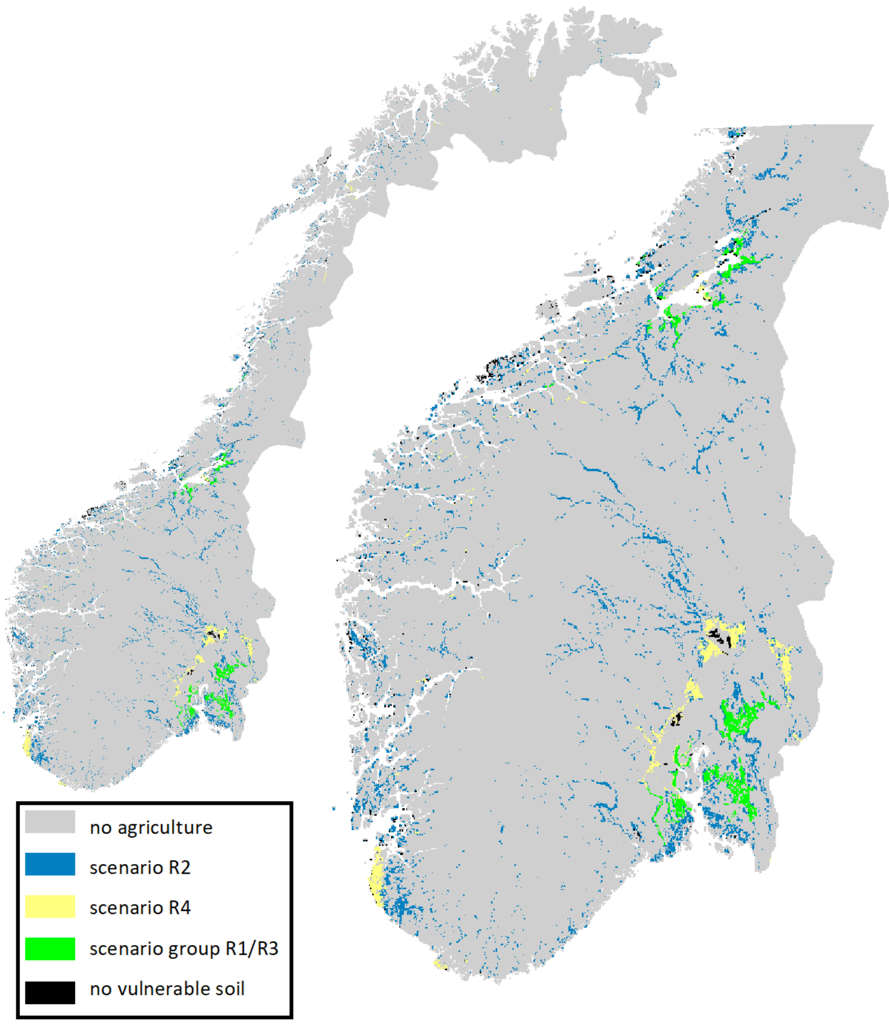

Figure 3-1: Assignment of agricultural areas to FOCUS run-off groups based on 3 FOCUS soil texture classes

Figure 3-1 shows the distribution of the FOCUS run-off scenarios using soil texture as categorical/nominal variable. The green area with R1 and R3, belong to the same soil texture category (medium fine, class 3; figure 3-1). They do not split up based on soil texture alone. The green areas coincide visually with parts of the areas below the marine limit both in South Eastern Norway and Trøndelag. The sharp line separating the blue and green area on both sides of Oslofjorden (Østfold and Vestfold) represent the terminal moraine (raet). The blue area outside this moraine to the sea, the dominating soil texture is coarse (class 1), while inside this border albeluvisols medium fine soil and marine deposits (class 3) are dominating (Nyborg et al., 2008; Solbakken et al., 2006). Detailed results are presented in table 3-1.

Table 3-1: Distribution of the FOCUS Run-off Scenarios in Norway when considering soil texture

Assignment	**Area (km^2)**	**Percentage related to the agricultural area**
R2 (coarse, class 1)	10241	67.7
R4 (medium, class 2)	2014	13.3
sum R1/R3 (medium fine, class 3)	2123	14.0
sum R2, R4, R1/R3	14378	95.0
remaining agricultural area*	759	5.0
total agricultural area	**15137**	**100.0**
no agriculture	308211	
total map area	**323348**	

*Organic soils (e.g., histosols)

Most of the agricultural area in Norway is characterised by sandy soils. Consequently, most of the area is comparable to R2 (67.7%). Large areas with coarse soil (class 1), cover the agricultural land along the rivers in valleys in the South of Norway (figure 2-1). The main area of this area is dominated by pasture (75 %), grassland and natural vegetation with limited use of pesticides. The agricultural land might be overestimated.

The other scenarios are less representative and cover less area: R4: 13.3% and R1/R3: 14%. Overall, the FOCUS scenarios represent all the agricultural area in Norway sufficiently when soil texture is the sole criterion for evaluation. 5% of the agricultural area cannot be assigned to one of the FOCUS scenarios, because the soils do not have a texture (e.g., histosols).

As shown in figure 3-2, including annual rainfall as a second key property further differentiates the R1/R3 group.

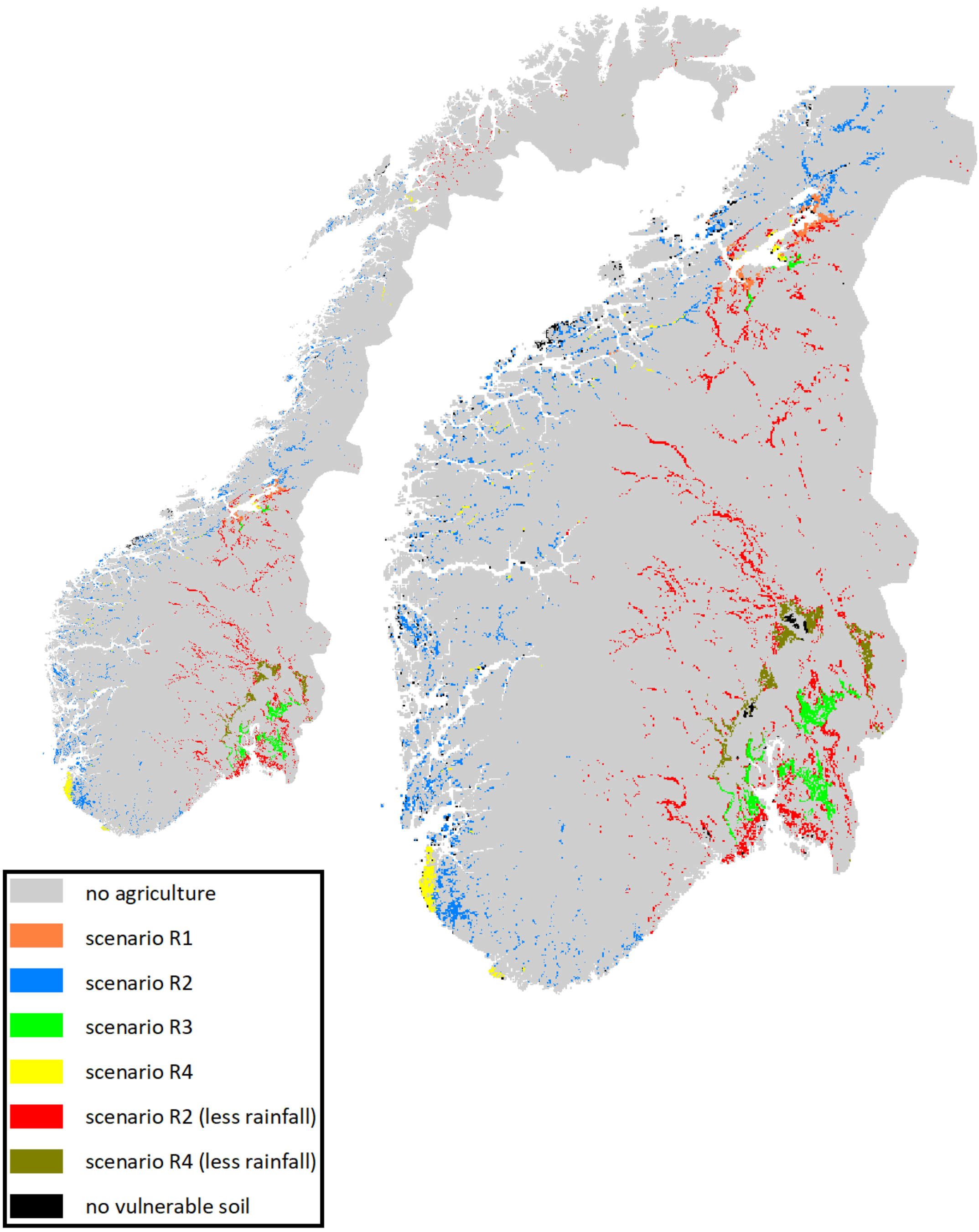

Figure 3-2. Assignment of agricultural areas to FOCUS run-off scenarios based on 3 FOCUS soil texture classes and FOCUS rainfall categories

Detailed results on the representativeness of the EU FOCUS run-off scenarios are shown in table 3-2.

Table 3-2. Area representation of the Run-off Scenarios in Norway when considering the key properties precipitation and soil properties

Assignment	Area (km²)	Percentage related to the agricultural area
R1 (> 800 mm rainfall)	479	3.2
R2 (> 1000 mm rainfall)	4724	31.2
R3 (< 800 mm rainfall)	1644	10.9
R4 (> 700 mm rainfall)	700	4.6
R2 (but < 1000 mm rainfall)	5517	36.4
R4 (but < 700 mm rainfall)	1314	8.7
sum R-scenarios	14378	95.0
remaining agricultural area*	759	5.0
total agricultural area	**15137**	**100**
no agriculture	308211	
total map area	**323348**	

According to table 3-2, 95% the Norwegian agricultural area can be attributed to one of the run-off scenarios (14378 km²). When applying the strict FOCUS definition of soil texture and annual precipitation, all FOCUS scenarios can be located somewhere in Norway. However, some locations with the same soil texture as FOCUS R2 and FOCUS R4 are represented by dryer conditions than the EU-FOCUS scenarios. However, these locations should be as well protected by the original EU-FOCUS scenario since less rainfall than in the EU-FOCUS scenario should result in fewer run-off entries. 5% of the agricultural area cannot be assigned to one of the FOCUS scenarios, because the soils do not have a texture (e.g., histosols).

3.1.2 Considering temperature as supplementary data for the characterisation of the scenarios

Based only on the key properties, it was already possible to discern among all FOCUS scenarios. Therefore, the parameter temperature was only used as a supplement to define variations of the scenarios.

All representative locations were characterised by lower spring and autumn temperatures than the original FOCUS definitions (table 3-3, figure 3-3). In other words, no locations were within the temperature range of the FOCUS definitions.

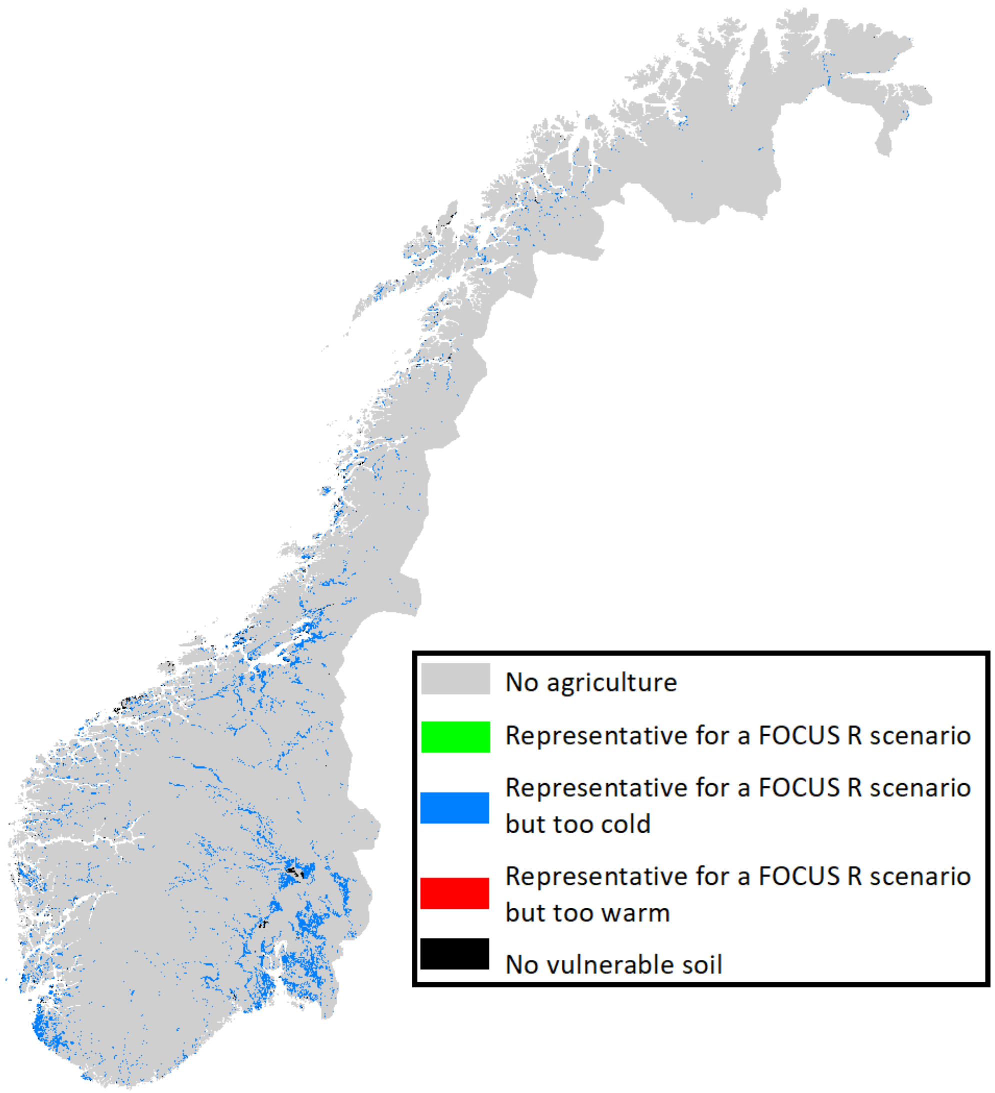

Figure 3-3. Assignment of agricultural areas to FOCUS run-off scenarios with regard to spring and autumn temperatures

Table 3-3. Area representation of the FOCUS-Run-off Scenarios in Norway when considering soil properties and climate

Assignment	Area (km²)	Percentage related to the agricultural area
R1	0	0
R2	0	0
R3	0	0
R4	0	0
R2, but too dry	0	0
R4, but too dry	0	0
R1, but too cold	479	3.2
R2, but too cold	4724	31.2
R3, but too cold	1644	10.9
R4, but too cold	700	4.6
R2, but too dry and too cold	5517	36.4
R4, but too dry and too cold	1314	8.7
R1, but too warm	0	0
R2, but too warm	0	0
R3, but too warm	0	0
R4, but too warm	0	0
R2, but too dry and too warm	0	0
R4, but too dry and too warm	0	0
agricultural area vulnerable to run-off*	14378	95.0
remaining agricultural area*	759	5.0
total agricultural area	**15137**	**100.0**
no agriculture	308211	
total map area	**323348**	

* estimated by excluding non-vulnerable soils (with no texture)

Including spring and autumn temperatures did not further discriminate the results. This clearly shows that the FOCUS run-off scenarios were originally designed for southern or central European conditions, not representative for Norway.

Though the Norwegian temperature conditions are very different from the FOCUS run-off conditions, this parameter was not dominating run-off events as did soil type and precipitation. However, to estimate the effect, the temperature deviation between FOCUS and Norwegian agricultural conditions was analysed (figure 3-4, table 3-4).

Higher temperature deviations were observed for agricultural fields in the North (about 8 °C) than in the South (minimum 2 °C).

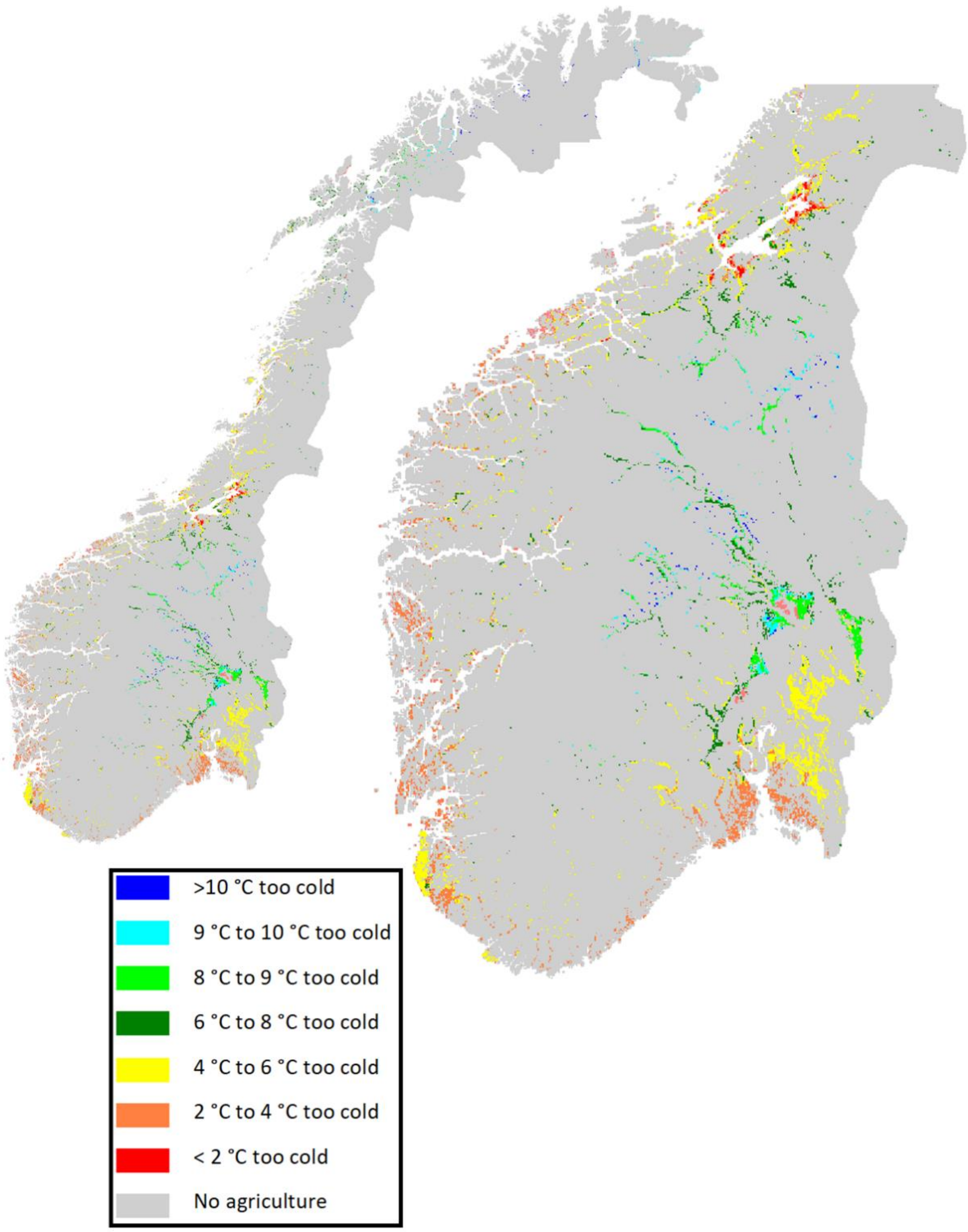

Figure 3-4. Difference of the average spring-autumn-temperatures in Norwegian agricultural conditions compared to the FOCUS run-off scenarios

Table 3-4. Deviation of the average spring-autumn temperatures in Norwegian agricultural conditions compared to the FOCUS run-off scenarios

Scenario	R1 km²	R2 km²	R3 km²	R4 km²	R-scenarios km²
>10 °C too cold	0	287	0	106	393
9 °C to 10 °C too cold	0	582	0	288	870
8 °C to 9 °C too cold	0	764	0	**704**	1468
6 °C to 8 °C too cold	0	1976	13	504	2493
4 °C to 6 °C too cold	0	**3919**	**1317**	412	**5648**
2 °C to 4 °C too cold	**262**	2713	314	0	3289
<2 °C too cold	217	0	0	0	217
all R-scenarios	479	10241	1644	2014	14378

This is further illustrated by the results presented in table 3-4, which also highlights differences between the scenarios. The smallest deviations were found among locations representative of R1 (deviation about 2 °C). This was not surprising, as the weather station of R1 is in Germany (Weiherbach), the most northern FOCUS R-scenario. The other southern R-scenarios were about 5 °C (R2, R3), or 8 °C (R4) warmer than the respective Norwegian agricultural fields.

3.1.3 Overview of the obtained results

Table 3-5 summarises the main results obtained in this analysis. The table was based on the following assumptions:

1. In this evaluation, it is assumed that key parameters for run-off are rainfall and soil type.
2. It is further considered that different temperature conditions in Norway and the EU would not directly influence the run-off event itself (*i.e.,* run-off amount and erosion).
3. 5.0% of the agricultural area have no run-off potential because the respective soils have no texture (e.g., histosols).
4. Consequently, the remaining 95.0% of the agricultural area may have a run-off potential.
5. The annual temperatures in Norway are between 2 °C to 8 °C lower than the respective FOCUS scenario. This deviation is dependent on the FOCUS scenario.
6. Though it is assumed that temperature does not affect the quality of the run-off event temperature may nevertheless influence pesticide behaviour. In order to use the FOCUS scenarios for Norwegian conditions, a temperature correction is therefore essential either by changing the respective pesticide information (DegT50, easy solution) or by changing the original FOCUS climate files (complicated solution).
7. If temperature correction has been performed and all remaining FOCUS definitions are met it can be assumed that the FOCUS scenario represents the respective location ("equivalent to FOCUS").

The following conclusions can be drawn:

There are no locations in Norway, which completely fulfil the FOCUS run-off definitions. The main reason being the low temperature conditions. However, FOCUS surface water simulations could be temperature corrected either by changing the respective pesticide standard temperature information (usually 20 °C) or by changing the original FOCUS climate files. After having adapted the FOCUS scenarios to Norwegian conditions, many locations in Norway fulfil at least part of the FOCUS run-off definitions. As summarised in the table 3-5 below, R2 is most representative for Norway (67.7%, 10241 km²). This is due to the sandy soils in Norway, which is covered by the R2-scenario. Two variations of this scenario are given in the table dependent on whether the original rainfall pattern is matched or not. All other FOCUS R-scenarios are less representative for Norwegian conditions: R1 (479 km², 3.2%), R3 (1644 km², 10.9%) and R4 (2014 km², 13.3%). 53.1% of the agricultural area were found to be in line with one of the FOCUS scenarios assumed temperature correction have been made. Further 45.1% of the agricultural field can be assigned to R2 or R4 but the fields are characterised by less rainfall than the EU FOCUS scenarios. Therefore, the EU-FOCUS scenarios can be considered especially protective for these Norwegian agricultural fields. After a temperature correction there are no agricultural fields for which the EU FOCUS scenarios should be less protective than the original FOCUS locations.

Table 3-5. Representativeness of the FOCUS-surface water scenarios in Norwegian agricultural area after excluding non-vulnerable soils

Scenario	Rainfall	Temperature*	Distribution (km^2)	Percentage related to the total agricultural area f	Rating (after temperature correction)
R1	**analogue**	**analogue**	**479**	**3.2**	equivalent to EU-FOCUS
R2	analogue	analogue	4724	31.2	equivalent to EU-FOCUS
R2	lower than FOCUS	analogue	5517	36.4	EU-FOCUS is more protective
R2	**sum**		**10241**	**67.6**	
R3	**analogue**	**analogue**	**1644**	**10.9**	equivalent to EU-FOCUS
R4	analogue	analogue	700	4.6	equivalent to EU-FOCUS
R4	lower than FOCUS	analogue	1314	8.7	EU-FOCUS is more protective
R4	**sum**		**2014**	**13.3**	
R1 to R4	sum		14378	100	
remaining agricultural area			759	5.0	no run-off potential
total agricultural area			**15137**	**5.0**	

* after temperature correction

3.2 Representativeness of FOCUS drainage scenarios

3.2.1 Considering key properties for the characterisation of the scenarios

Table 3-6 shows the distribution of the FOCUS drainage scenarios using texture as categorical/nominal variable. According to the FOCUS definition, the soil texture for D1 and D2 should be 4 (fine, 35 % < clay < 60 %). However, in this analysis, soil texture class 3 (medium fine, clay < 35 % and sand < 15 %) is used as a surrogate for class 4 (Fine), as fine texture does not occur in Norwegian agricultural fields. As it is expected that "fine" soils are more vulnerable to drain flow than "medium fine" soils, this procedure can be considered a worst-case approach, i.e., FOCUS scenarios are more worst-case than the corresponding Norwegian areas with medium fine textured soils. Only 2 % of the agricultural soil in Norway is considered to contain more than 40 % clay (Lågbu et al., 2018) and 1 % of the soil at Østlandet.

As D1/D2 ("medium fine") and D4/D5/D6 (medium) belong to the same soil texture categories, the FOCUS drainage scenarios do not separate completely based on soil texture alone. Detailed results are presented in table 3-6.

Table 3-6. Area representation of the FOCUS-Drainage Scenarios in Norway when considering soil texture

Assignment	Area (km²)	Percentage related to the agricultural area	Percentage related to the agricultural area vulnerable for drainage
sum D1/D2 (medium fine)	2123	14.0	14.8
D3 (coarse)	10241	67.7	71.2
sum D4/D5/D6 (medium)	2014	13.3	14.0
sum D1/D2, D3, D4/D5/D6	14378	95.0	100
remaining agricultural area	759	5.0	
total agricultural area	**15137**	**100.0**	
no agriculture	308211		
total map area	**323348**		

When only considering soil texture, 95% of the agricultural area in Norway can be attributed to at least one of the drainage scenarios (14378 km², table 3-6). Most relevant is D3 (soil texture class 1, coarse) corresponding to about two third of the area (10241 km²) followed by D1/D2 (14%, 2123 km² and D4/D5/D6 (2014 km², 13.3%). The distribution is presented in figure 3-5.

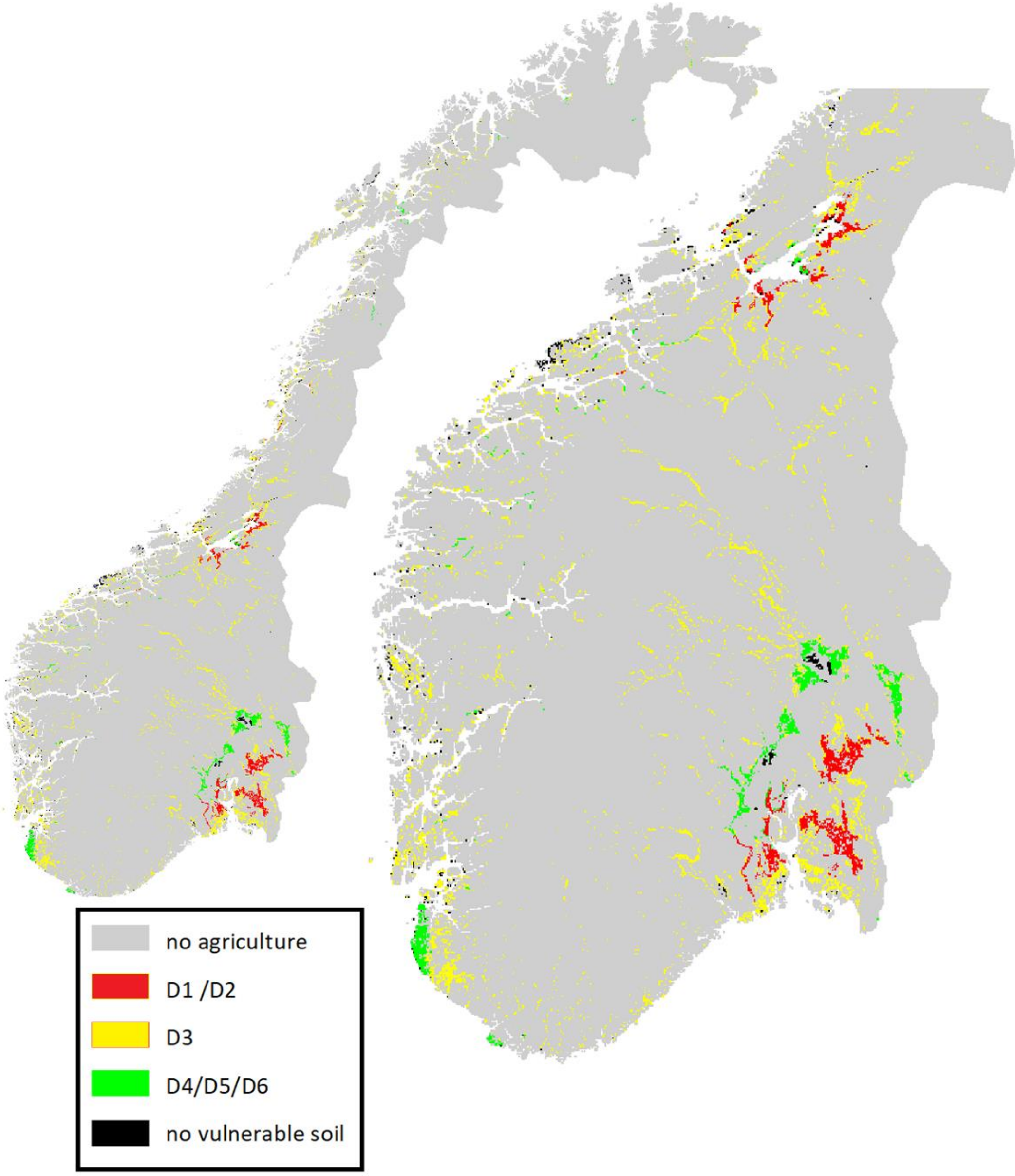

Figure 3-5. Assignment of agricultural areas to FOCUS drainage groups based only on soil texture

As indicated in figure 3-5, it cannot be decided whether a field belongs to D1 or D2 and D4, D5 or D6 based on soil texture alone. This is because the FOCUS soil texture definitions for these groups are identical; soil texture class 4 was defined for D1 and D2 and class 2 was defined for D4, D5 and D6, respectively. However, based on mean spring and autumn air temperature the most suitable FOCUS drainage scenario can be found if more than one scenario belongs to the same soil texture class. The result is presented in table 3-7.

Table 3-7: Deviation of the average spring-autumn-temperatures in Norwegian agricultural conditions compared to the FOCUS drainage scenarios

Scenario	**D1/D2 group (medium fine)**		**D3 (coarse)**	**D4/D5/D6 group (medium)**		
Scenario	D1 km²	D2 km²	D3 km²	D4 km²	D5 km²	D6 km²
> 10 °C too cold	0	0	249	12	69	**1629**
5 °C to 10 °C too cold	0	679	**5293**	261	**1582**	385
2.5 °C to 5 °C too cold	8	**1444**	**4649**	**1172**	363	0
1 °C to 2.5 °C too cold	**1109**	0	50	523	0	0
maximum 1 °C difference	**1006**	0	0	46	0	0
1 °C to 2.5 °C too warm	0	0	0	0	0	0
2.5 °C to 5 °C too warm	0	0	0	0	0	0
5 °C to 10 °C too warm	0	0	0	0	0	0
> 10 °C too warm	0	0	0	0	0	0

The table 3-7 clearly shows that especially the FOCUS scenarios D5 and D6 are significantly warmer than the agricultural fields in Norway. D1, D2, D3 and D4 fit better, but no agricultural field in Norway is warmer than the respective FOCUS drainage scenario. In order to pick the best scenario for a given soil texture class, the following selection was made in this analysis:

Soil texture class “medium fine”: D1 (original location Lanna, Sweden)
Soil texture class “coarse”: D3 (original location Vredepeel, The Netherlands)
Soil texture class “medium”: D4 (original location Skousbo, Denmark)

The result of the selection with regard to remaining temperature differences is presented in table 3-7. Most of the fields are 2.5 to 5 °C colder than the respective scenario.

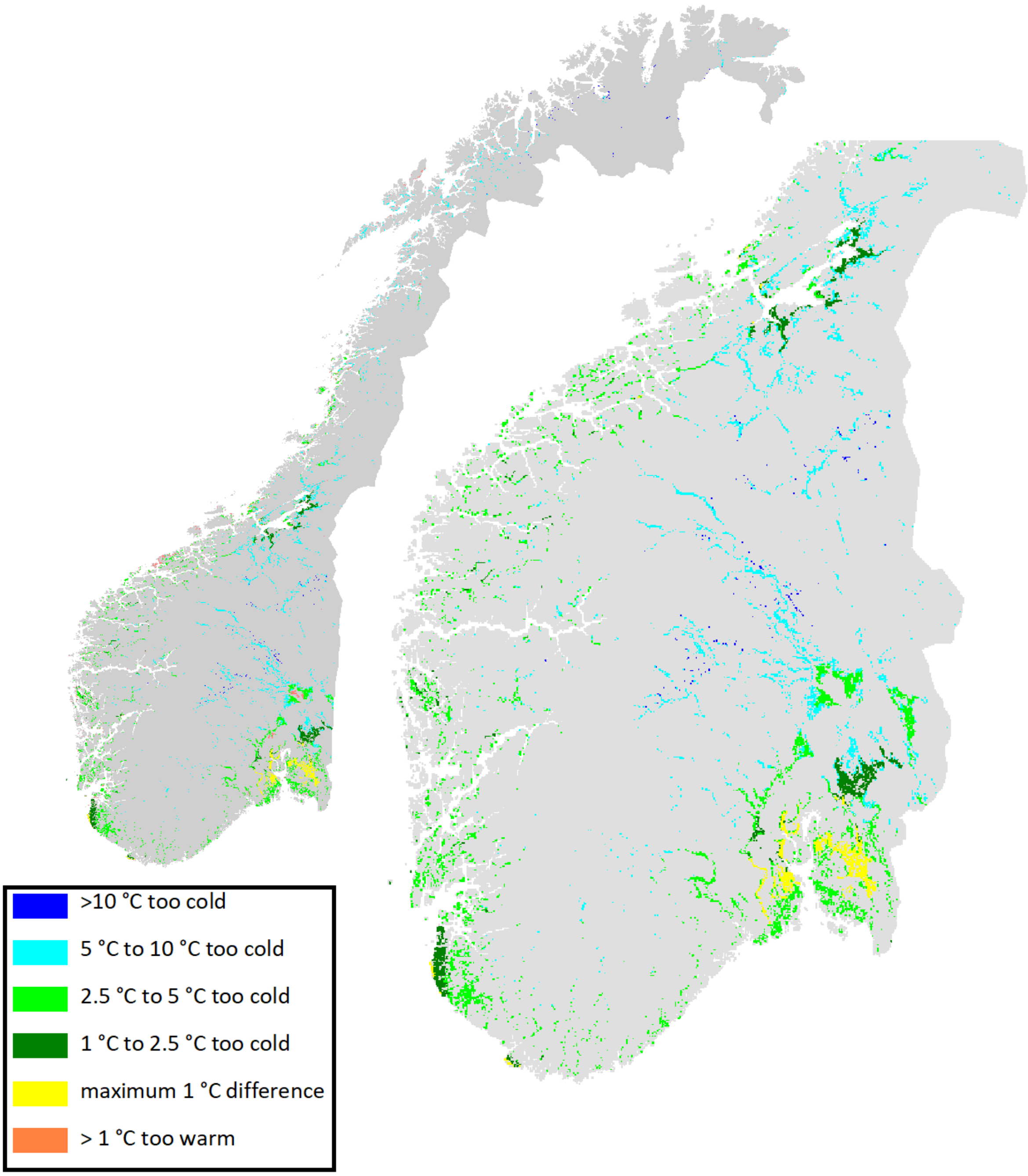

Figure 3-6. Difference of the average spring-autumn-temperatures in Norwegian agricultural conditions compared to the FOCUS drainage scenarios

3.2.2 Considering supplementary data for the characterisation of the scenarios

Based only on the key properties soil texture and temperature, it is already possible to find a FOCUS drainage scenario for nearly all agricultural fields (95%). The remaining 5% of the agricultural area have no soil texture. In this chapter, further variations of the FOCUS scenarios are analysed with regard to rainfall, slope and organic matter. Figure 3-7 shows the distribution when rainfall is added as an additional filter.

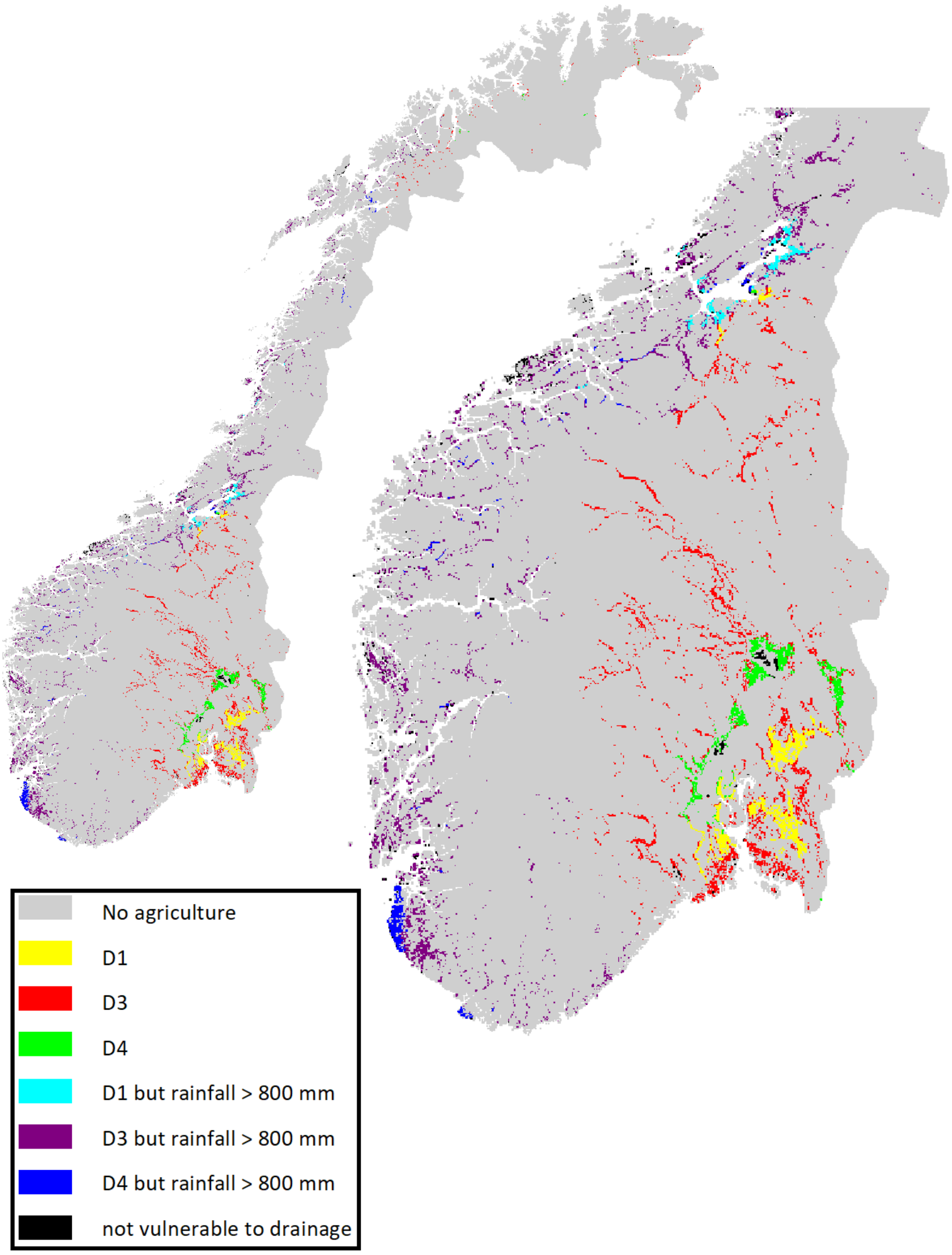

Figure 3-7. Assignment of agricultural areas to FOCUS drainage scenario variations considering soil texture, temperature and rainfall

Table 3-8 shows the percentages of the six variations with similar or more rainfall. According to this table, about 50% of the agricultural area has similar annual rainfall as the EU FOCUS drainage scenarios (i.e., < 800 mm) and about 45% more rainfall compared to FOCUS (i.e., > 800 mm). For locations with higher rainfall than the original FOCUS scenario, the level of protection may be lower than with respective scenarios with similar rainfall. 5% of the area are not relevant for drainage (fields with no soil texture). When comparing the situation for specific scenarios the situation is similar: 31.8% of the fields similar as D3 have similar rainfall, and 35.9% of the fields have more rainfall than the FOCUS scenario D3.

Table 3-8. Area representation of the FOCUS-Drainage Scenarios in Norway when considering soil texture, temperature, and rainfall

Assignment	**Area (km²)**	**Percentage related to the agricultural area**
D1	1644	10.9
D3	4812	31.8
D4	1327	8.8
D1 (but too wet)	479	3.2
D3 (but too wet)	5429	35.9
D4 (but too wet)	687	4.5
sum D-scenarios with similar rainfall	7783	51.4
sum D-scenarios with higher rainfall	6595	43.6
sum D-scenarios	14378	95.0
remaining agricultural area*	759	5.0
total agricultural area	**15137**	**100**
no agriculture	308211	
total map area	**323348**	

In the next step, the filter "slope" is used to discriminate further between variations. Dependent on the slope of the EU FOCUS drainage scenario, the Norwegian fields are classified as having "comparable slope" or "higher slope".

Due to this additional filtering, the 6 EU drainage scenarios described so far in table 3-9 discriminate further and result in 12 variations of the EU FOCUS drainage scenarios. They are presented in table 3-9.

Table 3-9. Area representation of the FOCUS-Drainage Scenarios in Norway when considering soil texture, temperature, rainfall and slope

Assignment	Area (km^2)	Percentage related to the agricultural area
D1 (comparable rainfall and slope)	0	0.0
D3 (comparable rainfall and slope)	0	0.0
D4 (comparable rainfall and slope)	0	0.0
D1 (too wet, but comparable slope)	0	0.0
D3 (too wet, but comparable slope)	5429	35.9
D4 (too wet, but comparable slope)	0	0.0
D1 (comparable rainfall, but with higher slope)°	1644	10.9
D3 (comparable rainfall, but with higher slope)°	4812	31.8
D4 (comparable rainfall, but with higher slope)^	1327	8.8
D1 (too wet and with higher slope)°	479	3.2
D3 (too wet and with higher slope)°	0	0.0
D4 (too wet and with higher slope)^	687	4.5
sum D-scenarios with comparable slope	5429	35.9
sum D-scenarios with higher slope	8949	59.1
sum D-scenarios	14378	95.0
remaining agricultural area*	759	5.0
total agricultural area	**15137**	**100**
no agriculture	308211	
total map area	**323348**	

° More than 0.5% slope, ^more than 2% slope

Obviously, not all variations occur in Norwegian agricultural areas. Especially the variations with comparable slope (i.e., low slope) are not very representative for Norway because the country is overall very hilly. The map showing the distribution of the variations is presented in figure 3-8. It confirms that comparable slope conditions as in the EU FOCUS drainage scenarios can be found only for D3. However, all these locations have more rainfall than the FOCUS definition describes. All locations with the same soil texture as D1 and D4 have higher slope than the original FOCUS scenario definition (i.e., <0.5% for D1 and < 2.0% for D4).

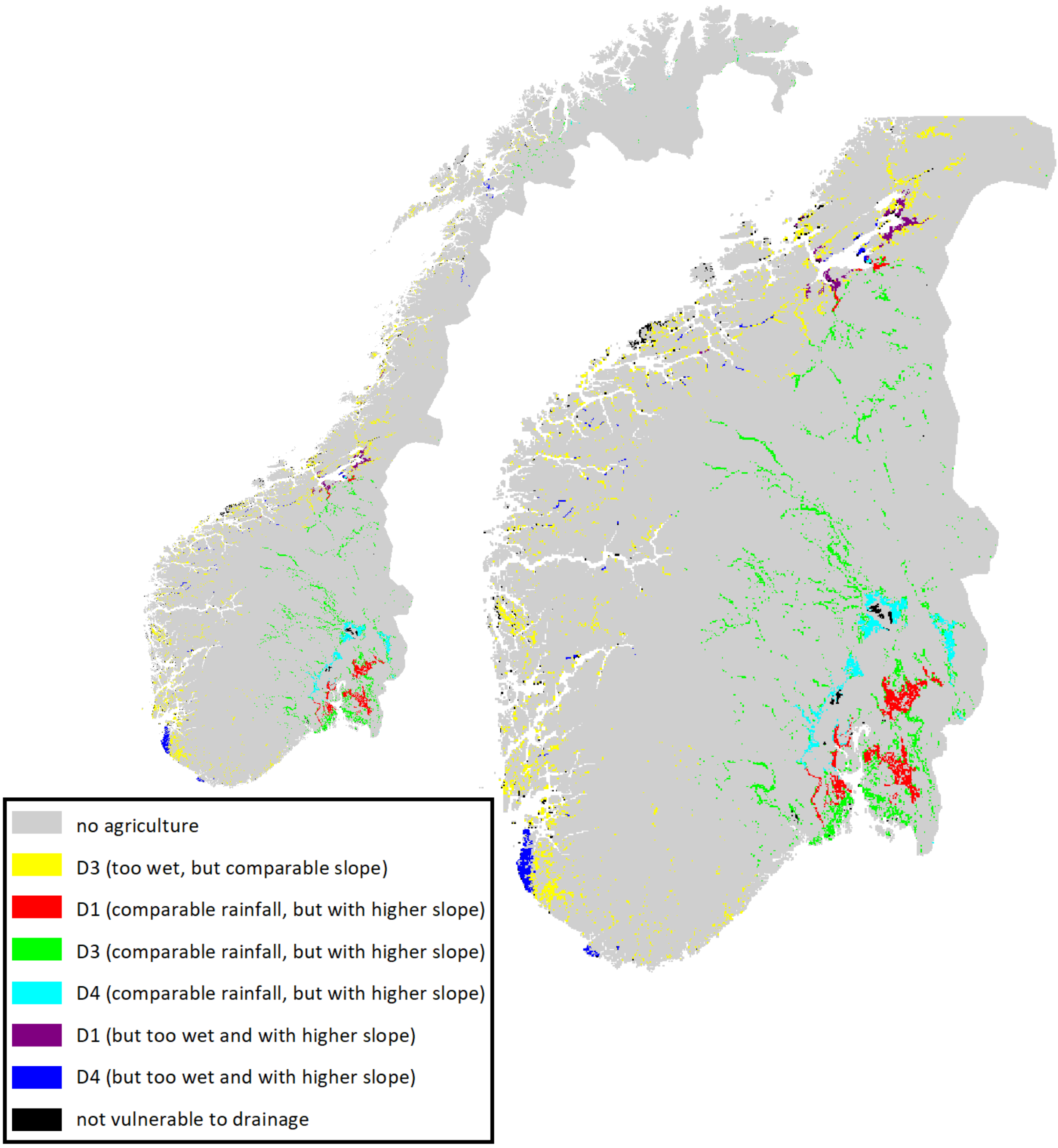

Figure 3-8. Assignment of agricultural areas to FOCUS drainage scenario variations considering soil texture, temperature, rainfall, and slope

In the final step, the filter "organic matter in the topsoil" is used to discriminate further between the scenario variations so far obtained. As previously mentioned, organic matter was considered only as a supplementary parameter. The influence of organic matter on pesticide concentrations in drainage systems is limited, especially when macro-pore flow is a dominant process. However, this is different for scenario D3; this scenario may be sensitive to organic matter content in soil. The background for this assumption, is the sandy soil texture of D3. Consequently, preferential flow is not considered at this location and organic matter becomes a very sensitive parameter in all agricultural fields representative for D3. The higher organic matter content in Norway (compared to the original FOCUS scenario) is therefore of relevance. The original FOCUS scenario D3 with its low organic carbon content should be consequently considered significantly more protective for Norwegian conditions.

Table 3-10. Area representation of the FOCUS-Drainage Scenarios in Norway when considering soil texture, temperature, rainfall, slope and organic matter

Assignment	Area (km²)	Percentage related to the agricultural area
D3 (too wet, but comparable slope and org. matter)	1217	8.0
D1 (comparable rainfall and org. matter, but with higher slope)°	198	1.3
D3 (comparable rainfall and org. matter, but with higher slope)#	817	5.4
D4 (comparable rainfall and org. matter, but with higher slope)^	117	0.8
D1 (comparable org. matter, but too wet and with higher slope)°	69	0.5
D4 (comparable org. matter, but too wet and with higher slope)^	57	0.4
D3 (too wet and higher org. matter, but comparable slope) #	4212	27.8
D1 (comparable rainfall, but with higher slope and higher org. matter)°	1446	9.6
D3 (comparable rainfall, but with higher slope and higher org. matter) #	3995	26.4
D4 (comparable rainfall, but with higher slope and higher org. matter)^	1210	8.0
D1 (but too wet and with higher slope and higher org. matter)°	410	2.7
D4 (but too wet and with higher slope and higher org. matter)^	630	4.2
sum D-scenarios with comparable org. matter	6687	44.2
sum D-scenarios with higher org. matter	7691	50.8
sum D-scenarios	14378	95.0
remaining agricultural area*	759	5.0
total agricultural area	**15137**	**100**
no agriculture	308211	
total map area	**323348**	

° More than 3.4% OM # more than 4.0% OM ^ more than 2.4% OM

Table 3-10 shows 12 different variations of the drainage scenarios. After filtering with three additional parameters, the maximum number of scenarios could have been 24. However, several combinations do not exist in Norway (e.g., D1 or D4 with comparable rainfall, organic matter and slope). The most relevant scenario is a variation of D3 with more rainfall and higher organic matter, but comparable slope (4212 km², 27.8%). However, also a second variation of the D3 scenario (comparable rainfall, but with higher slope and higher org. matter) is of similar importance (3995 km², 26.4%). There is a tendency that organic matter contents in Norway are higher than in the EU-FOCUS drainage scenarios as indicated by their relevance (comparable org. matter: 6687 km², 44.2%, higher org. matter: 7691 km², 50.8%).

Figure 3-9 shows the distribution of the FOCUS drainage scenarios when organic matter is used as a supplementary parameter for the analysis.

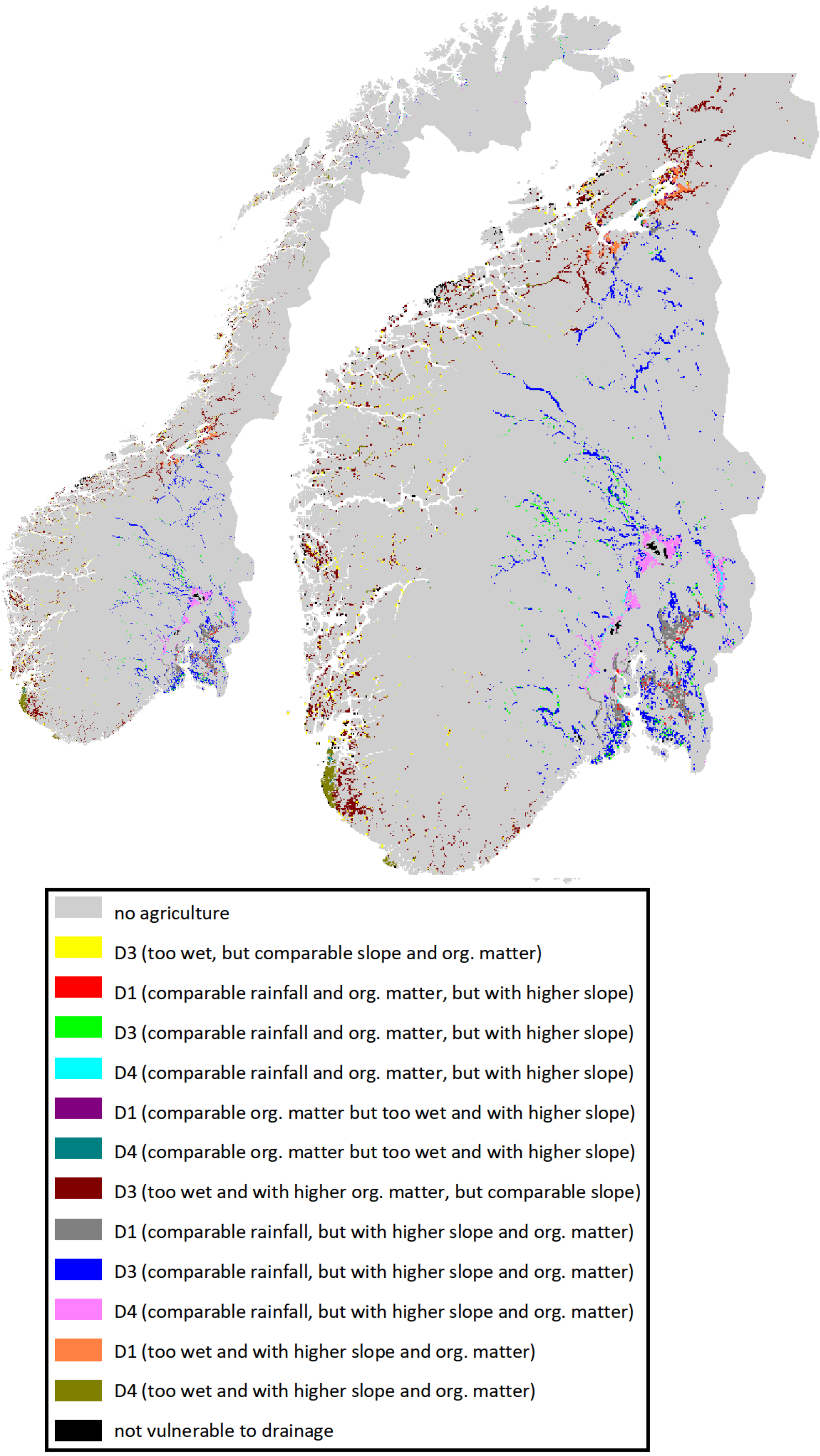

Figure 3-9. Assignment of agricultural areas to FOCUS drainage groups when considering soil texture, temperature, rainfall, slope and org. matter

3.2.3 Overview on the obtained representativeness

The following table 3-11 summarises the main results of the analysis:

1. In this evaluation, it is assumed that the key parameter for drainage is soil texture. Mean annual recharge is not considered because the spatial distribution of this parameter was not available
2. 5.0% of the agricultural area have no drainage potential because the respective soils have no texture (e.g. histosols).
3. Consequently, the remaining 95.0% of the agricultural area may have a drainage potential.
4. The parameter "spring and autumn temperature" is used to discriminate between scenarios with comparable soil texture (e.g., D1 and D2 or D3, D4 and D5)
5. Based on the temperature criterion, three EU-drainage scenarios are recommended to be used in Norwegian risk assessment: D1 (Lanna, Sweden), D3 (Vredepeel, The Netherlands) and D4 (Skousbo, Denmark).
6. The annual temperatures in Norway are in general between 0 °C to 8 °C lower than these three FOCUS scenarios, Lanna (D1) fits best with only minor differences.
7. In order to use the FOCUS scenarios for Norwegian conditions a temperature correction is recommended, either by changing the respective pesticide information (DegT50, easy solution) or by changing the original FOCUS climate files (complicated solution).This is especially important for D3 (original location NL) and D4 (Skousbo), whereas a correction for D1 (Lanna) is not necessary.
8. Further variations of the three EU-drainage scenarios are analysed based on the annual rainfall, slope and organic matter content. This analysis leads to 12 different variations with higher or lower level of protection compared to the original EU-drainage scenario.
9. If temperature correction has been performed and all remaining FOCUS definitions are met it can be assumed that the FOCUS scenario represents the respective location ("equivalent to FOCUS").
10. In this analysis, it is assumed that higher rainfall than in the FOCUS drainage scenarios will reduce the level of protection because it would increase the annual recharge followed by an increase in drainage water.
11. In this analysis, it is assumed that higher slope will increase the level of protection for drainage scenarios because part of the water could reach surface water via run-off instead of drainage system.
12. In this analysis, it is assumed that higher organic matter contents in the topsoil than in the EU drainage scenarios, will increase the level of protection for drainage scenarios. Higher organic matter content will increase sorption to the soil matrix and reduce pesticide concentrations in the drainage system. This is especially important for D3 because only (classical) chromatographic flow is considered for this scenario. In such a situation, organic matter in soil is a main driver for pesticide concentrations in the water of deeper soil layers.

The following conclusion can be drawn:

There are no agricultural areas in Norway where all scenario parameters (soil texture, temperature, rainfall, slope, organic matter) are comparable to the EU FOCUS drainage scenarios. The main reasons for these differences are steep slopes, high rainfall and low temperature conditions. However, at least FOCUS surface water simulation can be adjusted for temperature either by changing the standard temperature (usually 20 °C) of the respective pesticide information or by changing the original FOCUS climate files. After having adapted the FOCUS scenarios to Norwegian conditions, many locations in Norway fulfil at least part of the FOCUS drainage definitions. For these locations, the EU-FOCUS scenarios could represent either a higher or lower protection level.

Most important in Norway is the non-preferential flow scenario D3 because of its coarse soil type, which is rather common in Norway. D3 (original EU FOCUS location Vredepeel in the Netherlands) is representative for 59.6% of the agricultural fields. Three variations of this scenario were found in Norway due to higher rainfall, organic matter, or slope. Two of these variations represent a higher level of protection than the official FOCUS scenario because of higher slope or/and higher organic matter.

In total five different variation of D1 (original location Lanna in Sweden) represent 3340 km² (22.1%) of the Norwegian agricultural area. About 50% of these D1 variations can be considered as more protective (1644 km²). Either the other variations are less protective, or the level of protection is open. The underlying factor is that higher rainfall may lead to a reduced level of protection, but the same variation could lead to an increase of the level of protection because of higher slopes and higher organic matter.

The third drainage scenario (D4, original location Skousbo, Denmark) represents 13.3% of the agricultural area (2014 km²). The majority of the D4 variations (1327 km²) represents a higher level of protection for the same reason as explained above (higher slope or organic matter content).

In total all drainage variation considered as being more protective as FOCUS cover 51.5% of the agricultural area (7783 km²) and only 8% (1217 km²) can be clearly classified as less protective compared to FOCUS. For 35.6% (5378 km²) a clear assessment of the protection level is not clear for the above-mentioned reasons. The recommended strategy to guarantee a level of protection also for these locations is to scale the EU FOCUS rainfall data to match the higher precipitation amounts at these locations.

Table 3-11: Representativeness of the FOCUS-drainage scenarios in Norwegian agricultural area

Assignment	Area (km²)	Percentage related to the agricultural area	Rating (after temperature correction)
D3 (too wet, but comparable slope and org. matter)	1217	8.0	EU-FOCUS is less protective
D1 (comparable rainfall and org. matter, but with higher slope)°	198	1.3	EU-FOCUS is more protective
D1 (comparable org. matter, but too wet and with higher slope)°	69	0.5	Level of protection open^^
D1 (comparable rainfall, but with higher slope and higher org. matter)°	1446	9.6	EU-FOCUS is more protective
D1 (but too wet and with higher slope and higher org. matter)°	410	2.7	Level of protection open##
D1	**3340**	**22.1**	
D3 (comparable rainfall and org. matter, but with higher slope)#	817	5.4	EU-FOCUS is more protective
D3 (too wet and higher org. matter, but comparable slope) #	4212	27.8	Level of protection open°°
D3 (comparable rainfall, but with higher slope and higher org. matter) #	3995	26.4	EU-FOCUS is more protective
D3	**9024**	**59.6**	
D4 (comparable rainfall, but with higher slope and higher org. matter)^	1210	8.0	EU-FOCUS is more protective
D4 (comparable org. matter, but too wet and with higher slope)^	57	0.4	Level of protection open^^
D4 (but too wet and with higher slope and higher org. matter)^	630	4.2	Level of protection open##
D4 (comparable rainfall and org. matter, but with higher slope)^	117	0.8	EU-FOCUS is more protective
D4	**2014**	**13.3**	
sum D-variations which are more protective than EU-FOCUS	7783	51.5	
sum D-variations of which protective level is open	5378	35.6	
sum D-variations which are less protective than EU-FOCUS	1217	8.0	
sum D-scenarios	14378	95.0	
remaining agricultural area	759	5.0	no drainage potential
total agricultural area	15137	100	
no agriculture	308211		
total map area	323348		

° More than 3.4% OM # more than 4.0% OM ^ more than 2.4% OM ^^ more protective because of higher slope but less protective because of higher rainfall
°° more protective because of higher org. c matter content but less protective because of higher rainfall
more protective because of higher org. matter content and higher slope but less protective because of higher rainfall

3.3 Representativeness of the Norwegian surface run-off scenarios

3.3.1 Considering key properties for the characterisation of the scenarios

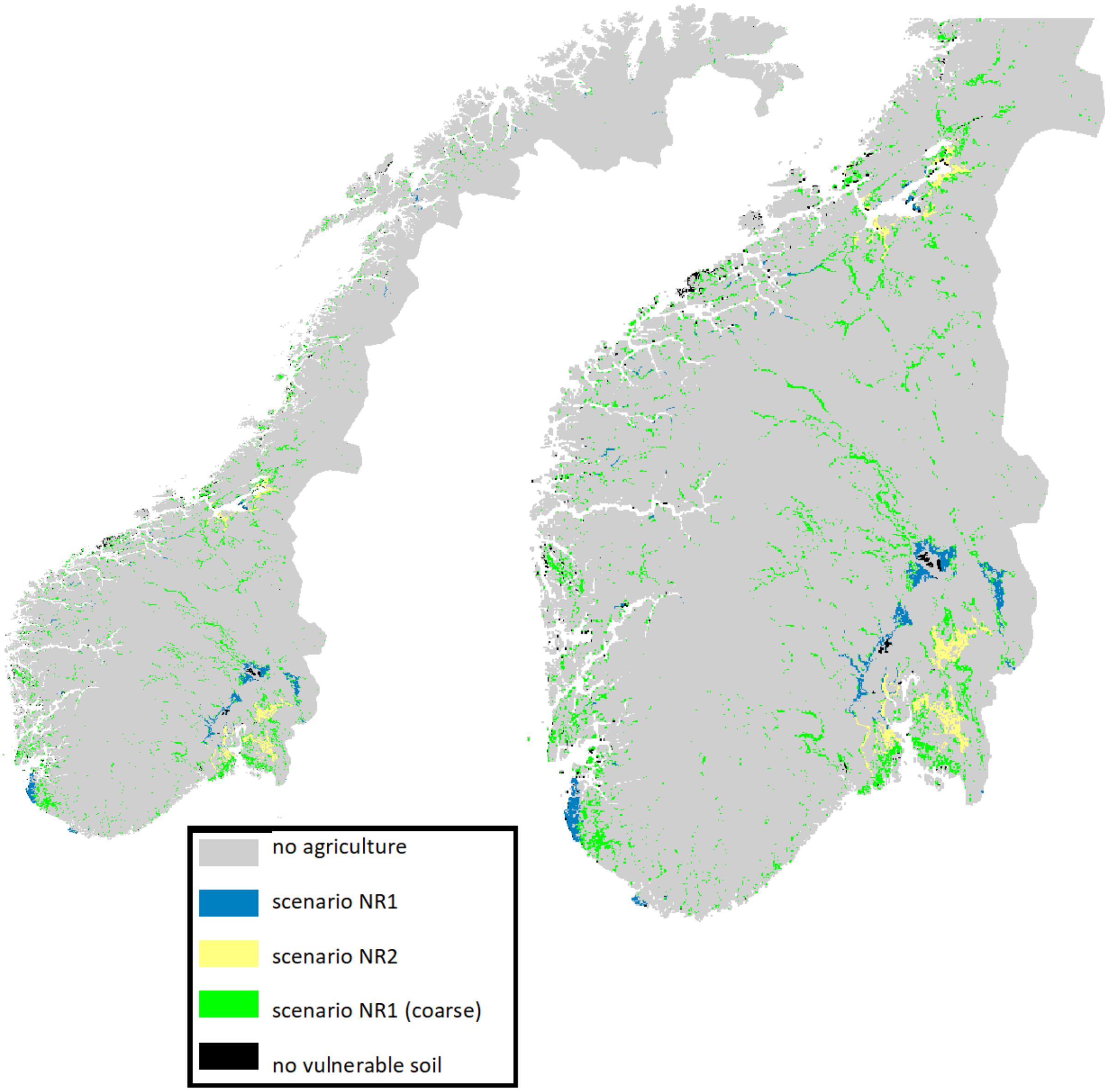

Figure 3-10. Assignment of agricultural areas to the Norwegian run-off scenarios based on 3 soil texture classes (NR1 = Syverud, NR2 = Bjørnebekk)

Figure 3-10 shows the distribution of the FOCUS run-off scenarios using soil texture as categorical/nominal variable. Two variations of NR1 (Syverud) are presented in the map with a total representativeness of 81% of the Norwegian agricultural area: NR1 with correct soil texture (medium, class 2) and NR1 with coarse soil texture as a surrogate. Sandy soils are most representative in Norway but unfortunately the two Norwegian scenarios are both not sandy. To have a representative scenario also for the sandy agricultural fields in Norway NR1 (Syverud) was picked as it is its sand content is higher than the sand content of NR2 (Bjørnebekk). As it can be expected that sandy soils are less vulnerable to run-off considering Syverud for sandy locations represents a worst-case selection. The other Norwegian scenario, Bjørnebekk (NR2) with medium fine soil texture, represents 14% of the Norwegian agricultural fields whereas 5% of the area cannot be assigned to one of the FOCUS scenarios because the soils does not have a texture (e.g., histosols). Further details are presented in table 3-12.

Table 3-12. Distribution of the Norwegian Run-off Scenarios in Norway when considering soil texture

Assignment	**Area (km^2)**	**Percentage related to the agricultural area**
NR1 (Syverud, medium, class 2)	2014	13.3
Bjørnebekk (NR2, medium fine, class 3)	2123	14.0
NR1 (Syverud, coarse, class 1)	10241	67.7
sum NR-scenarios	14378	95.0
remaining agricultural area*	759	5.0
total agricultural area	**15137**	**100.0**
no agriculture	308211	
total map area	**323348**	

* no texture (e.g., histosols)

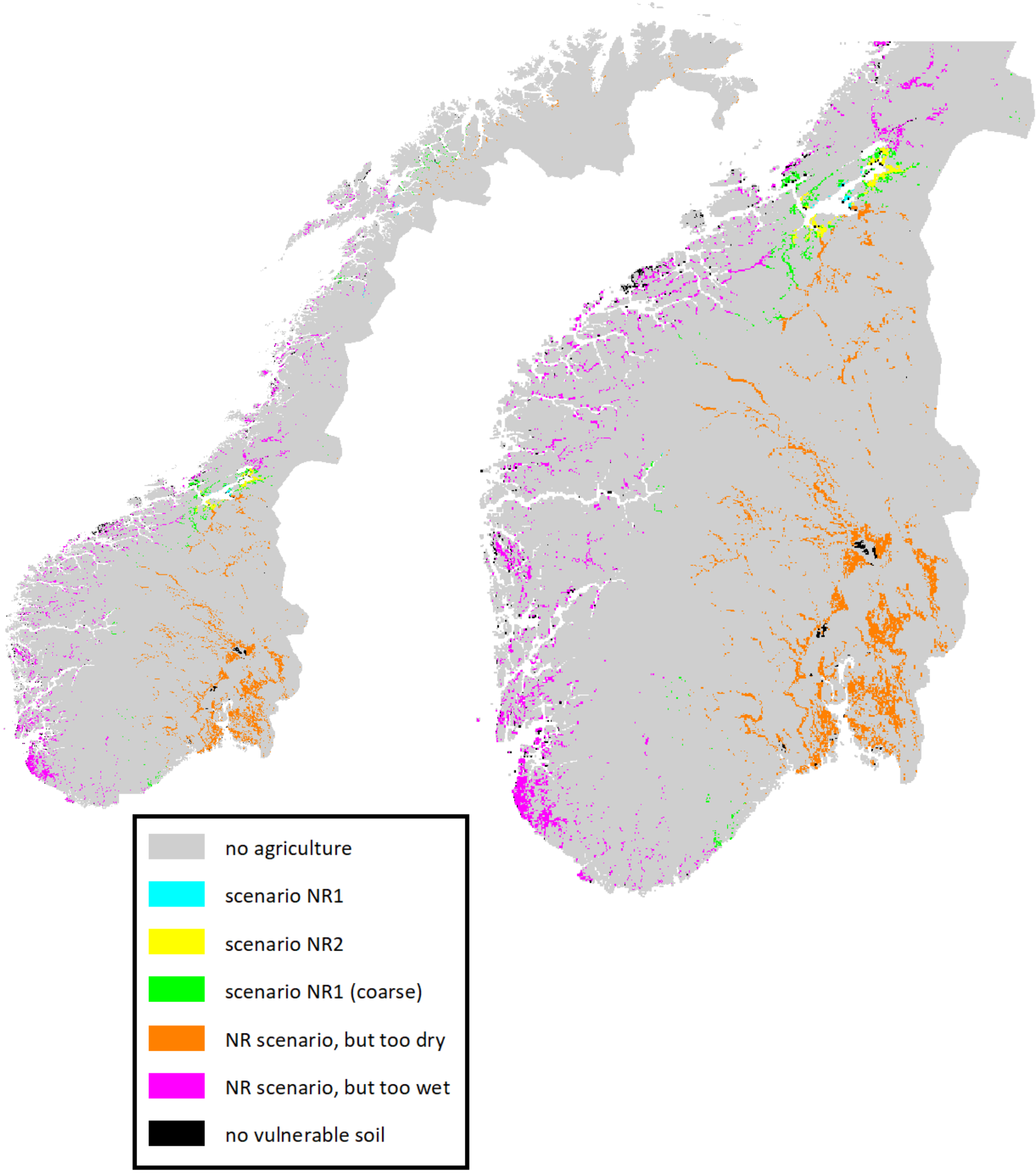

Figure 3-11. Assignment of agricultural areas to Norwegian run-off scenarios based on 3 soil texture classes and FOCUS rainfall categories (NR1 = Syverud, NR2 = Bjørnebekk)

Detailed results on the representativeness of the Norwegian scenarios for the whole agricultural area in Norway are shown in table 3-13.

Table 3-13. Area representation of the Norwegian Run-off Scenarios when considering the key properties precipitation and soil properties

Assignment °	**Area (km²)**	**Percentage related to the agricultural area**
NR1 (correct rainfall)	85	0.6
NR2 (correct rainfall)	430	2.8
NR1 (correct rainfall, but too sandy)	1102	7.3
NR1 (but too dry)	1327	8.8
NR2 (but too dry)	1644	10.9
NR1 (but too dry and too sandy)	4810	31.8
NR1 (but too wet)	602	4.0
NR2 (but too wet)	49	0.3
NR1 (but too wet and too sandy)	4329	28.6
NR-scenario with correct rainfall	1617	10.7
NR-scenario but too dry	7781	51.4
NR-scenario but too wet	4980	32.9
sum R-scenarios	14378	5.0
remaining agricultural area*	759	0.6
total agricultural area	**15137**	**100**
no agriculture	308211	
total map area	**323348**	

° NR1: Syverud NR2: Bjørnebekk * no texture (e.g., histosols)

Compared to the definition of the Norwegian run-off scenarios (rainfall of about 800 to 1100 mm) about 50% of the Norwegian fields were found to be dryer than the respective scenario, about 30% wetter, but only about 10 % in the correct rainfall range. This seems surprising since the Norwegian scenarios should match the situation in the Norwegian agricultural fields. However, that could be caused by differences of the European climate map (that was used for the analysis) and the actual Norwegian weather data. In general, are all locations, which are classified in the table as "dryer than the respective scenario" nevertheless protected by the scenario. However, the level of protection for the 32.9% locations with more rainfall than the respective scenario is questionable.

3.3.2 Considering temperature as supplementary data for the characterisation of the scenarios

Based only on the key properties, it was already possible to discern among all FOCUS scenarios. Therefore, the parameters temperature was only used as a supplement to define variations of the scenarios. The results are presented in figure 3-12.

About half (53.4%) of the representative locations were characterised by similar mean spring and autumn temperature (figure 3-12, table 3-14). About one third (28.6%) of the locations were found to be colder than the Norwegian scenarios (blue colours in the same map) and about 15% show warmer temperatures (red colours). The warmer locations are mainly located close to the sea, the colder areas more in parts of Innlandet, which have significant distance from the sea.

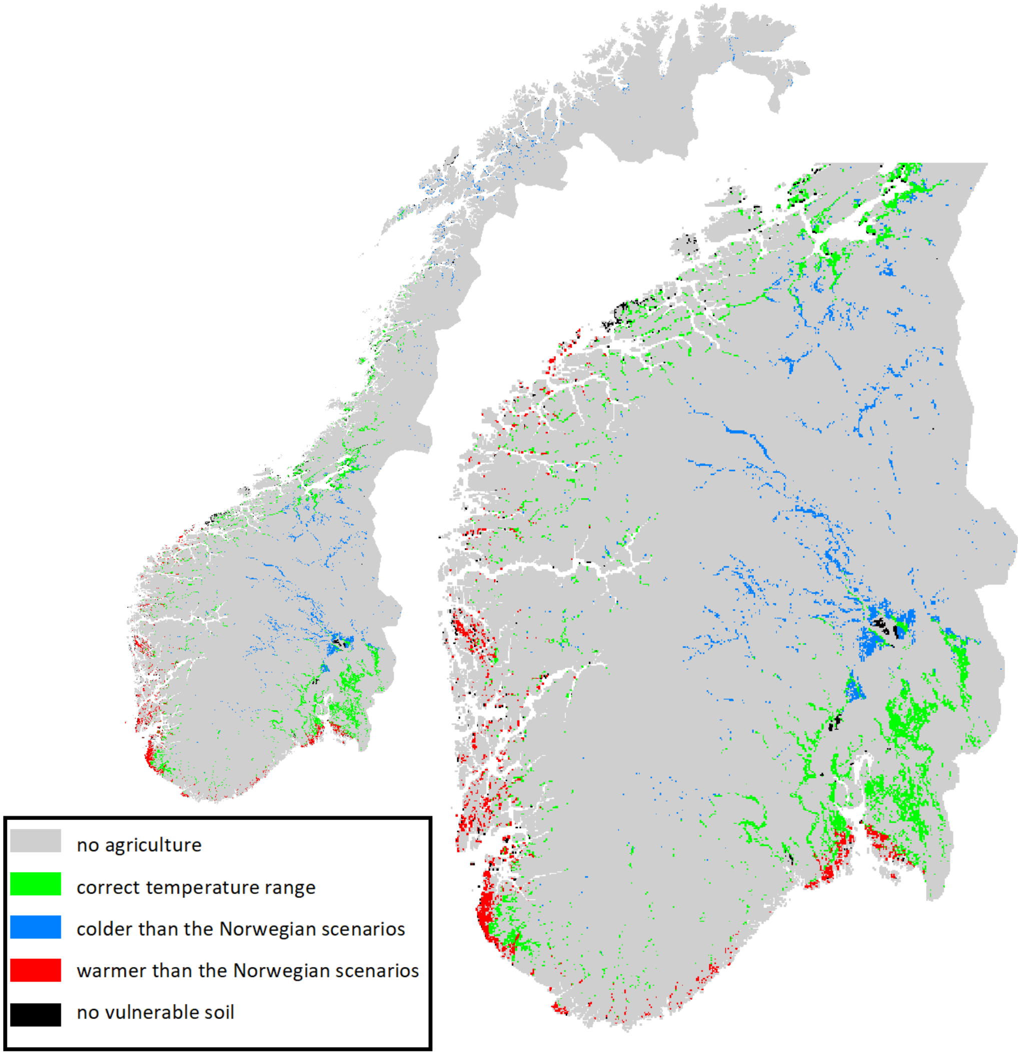

Figure 3-12. Assignment of agricultural areas to FOCUS run-off groups based on spring and autumn temperatures.

Table 3-14. Area representation of the Norwegian Run-off scenarios when considering soil properties and climate

Assignment	**Area (km²)**	**Percentage related to the agricultural area**
correct temperature range	8080.0	53.4
colder than the Norwegian scenarios	4331.0	28.6
warmer than the Norwegian scenarios	1967.0	13.0
sum Norwegian Runoff-scenarios	14378	95.0
remaining agricultural area*	759	5.0
total agricultural area	**15137**	**100.0**
no agriculture	308211	
total map area	**323348**	

* estimated by excluding non-vulnerable soils (with no texture)

Table 3-14 demonstrate that the Norwegian scenarios much better describe the climatic situation especially the temperature than the EU FOCUS scenarios. Most of the agricultural fields in Norway have similar climatic conditions as the two scenarios. However, Norway is a big country with a significant temperature shift from north to south. It is not surprising that there are also a lot of fields where the temperature is different compared to the two scenarios. A better impression about the size of the temperature deviation between the two run-off scenarios and actual Norwegian agricultural conditions is given in the following figure 3-13 and table 3-15.

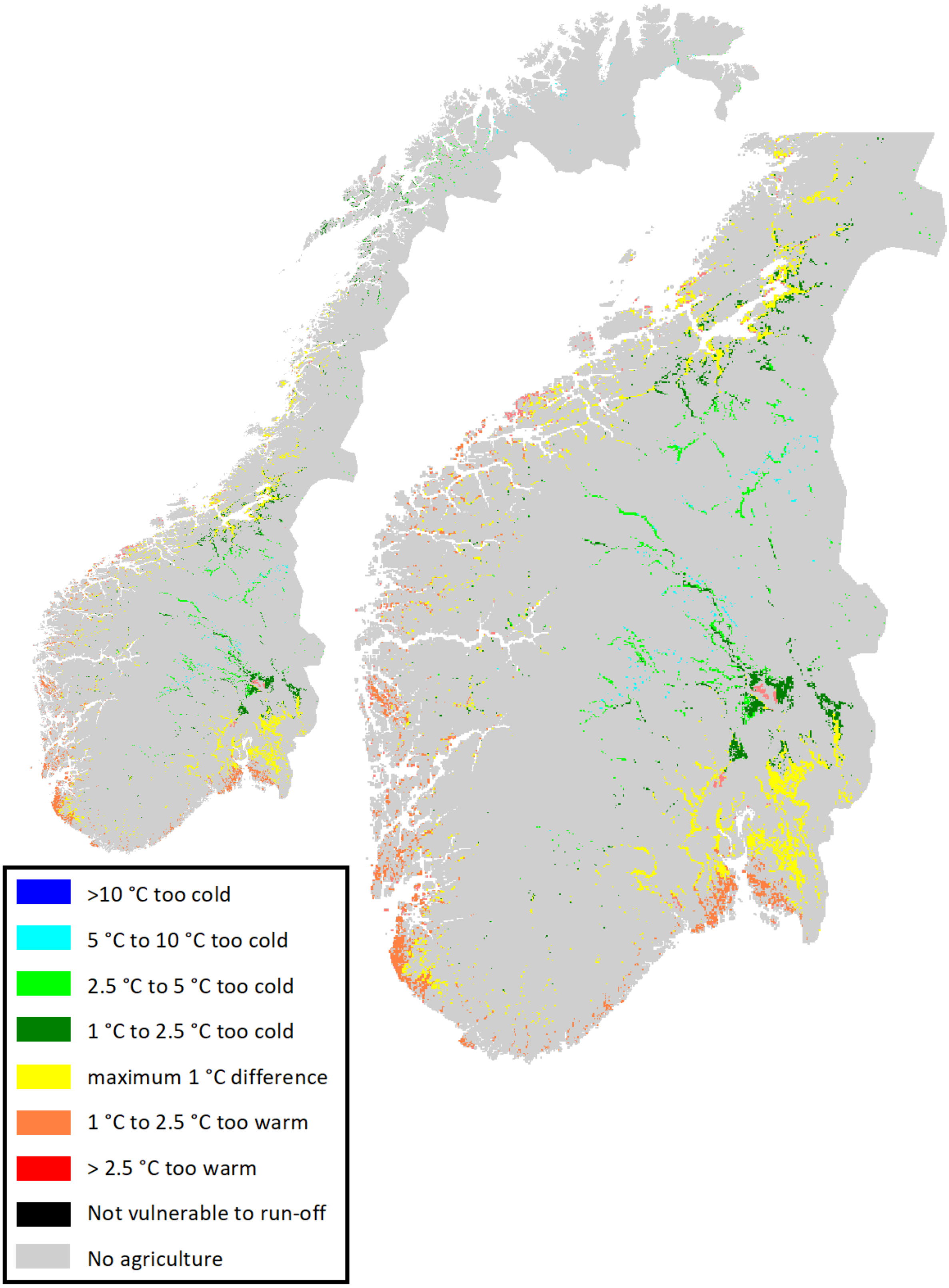

Figure 3-13. Difference of the average spring-autumn-temperatures in Norwegian agricultural conditions compared to the FOCUS run-off scenarios

Table 3-15. Deviation of the average spring-autumn temperatures in Norwegian agricultural conditions compared to the FOCUS run-off scenarios

Scenario	NR1 Syverud km²	NR2 Bjørnebekk km²	NR1* Syverud km²	NR-scenarios km²
>10 °C too cold	0	0	0	0
5 °C to 10 °C too cold	49	0	441	490
2.5 °C to 5 °C too cold	108	0	1793	1901
1 °C to 2.5 °C too cold	**817**	159	1954	2930
maximum 1 °C difference	603	**1832**	**3857**	**6292**
1 °C to 2.5 °C too warm	437	132	2196	2765
>2 °C too warm	0	0	0	0
all NR-scenarios	**2014**	**2123**	**10241**	**14378**

The table clearly demonstrates that the Norwegian scenarios well fit to the majority of agricultural fields in Norway with regard to temperature: 44% of fields show differences below 1 °C and 83% of the fields show differences below 2.5 °C compared to the scenario conditions. This is in principle valid for all Norwegian scenarios. Only to NR1 (Syverud, medium soil texture) there are slightly more fields attached with up to 2.5 °C colder temperatures than the original scenario (817 km²).

3.3.3 Overview of the obtained results

Table 3-16 summarises the main results obtained in this analysis. The table was based on the following assumptions:

1. In this evaluation, it is assumed that key parameters for run-off are rainfall and soil type.
2. It is further considered that different temperature conditions in scenario and the Norwegian agricultural fields would not directly influence the run-off event (*i.e.,* run-off amount and erosion).
3. 5% of the Norwegian agricultural area (759 km²) have no run-off potential because they have no soil texture (e.g., histosols).
4. Consequently, the remaining 95% of the agricultural area may have a run-off potential.
5. The Norwegian scenarios well fit to the majority of agricultural fields in Norway with regard to temperature: 44% of fields show differences below 1 °C and 83% of the fields exhibit differences below 2.5 °C compared to the scenario conditions.
6. An additional temperature correction for the Norwegian scenarios (as recommended for the European FOCUS Run-off scenarios) is not considered necessary since the differences are relatively small.
7. Most of the agricultural fields in Norway are characterised by sandy soils (soil texture class coarse). In these soils, limited runoff is expected compared to other soil texture

classes. Nevertheless, the scenario Syverud (NR1) was assigned to this class which can be considered a worst-case assumption.

The following conclusions can be drawn from the analysis:

In contrast to the European FOCUS scenarios, which did not fit completely to Norwegian conditions (mainly because of the scenario temperature) the Norwegian run-off scenarios much better fit to the agricultural area in Norway. 3.4 % of the agricultural area (515 km²) is having the same properties about rainfall and texture. Further 58.8% of the fields (8883 km²) can be considered less vulnerable than the original scenarios. Nevertheless, a certain scenario can always be assigned to this area. Using the Norwegian scenarios in these fields should guarantee a higher level of protection than the original scenarios. The scenarios do clearly not cover 4.3 % of the agricultural area (651 km²). The background is always the rainfall which is (according to the European rainfall map) higher in these areas than in the run-off scenarios. For 28.6% of the area the situation is open because the soils in these agriculture areas are less vulnerable whereas the rainfall is higher. In principle, this unfortunate situation could be solved by combining the soil with a station having more rainfall than the original scenario.

Table 3-16. Representativeness of the Norwegian-surface water scenarios in agricultural fields

Scenario°	Soil texture	Precipitation	Distribution (km²)	Percentage related to the agricultural area	Rating
NR1 (Syverud)	analogue	analogue	85	0.6	equivalent to NR-scenario
NR1	analogue	lower than the scenario	1327	8.8	NR-scenario is more protective
NR1	analogue	higher than the scenario	602	4	NR-scenario is less protective
NR1	**sum**		**2014**	**13.4**	
NR2 (Bjørnebekk)	analogue	analogue	430	2.8	equivalent to NR-scenario
NR2	analogue	lower than the scenario	1644	10.9	NR-scenario is more protective
NR2	analogue	higher than the scenario	49	0.3	NR-scenario is less protective
NR2			**2123**	**14**	
NR1*	too coarse	analogue	1102	7.3	NR-scenario is more protective
NR1*	too coarse	lower than the scenario	4810	31.8	NR-scenario is more protective
NR1*	too coarse	higher than the scenario	4329	28.6	Protectiveness open^
NR1*	**sum**		**10241**	**67.7**	
sum NR1, NR2, NR1*			14378	95.0	
not vulnerable to run-off			759	5.0	
total agricultural area			**15137**	**100**	

°NR1: Syverud, NR2: Bjørnebekk, ^soil more protective, rainfall less protective

3.4 Representativeness of the Norwegian drainage (groundwater) scenarios

3.4.1 Considering key properties for the characterisation of the scenarios

Figure 3-14 shows the distribution of the Norwegian drainage scenarios using texture as categorical/nominal variable. According to the description in table 2-22, the soil texture for Rustad (ND1) should be 3 ("medium fine", (clay < 35 % and sand < 15 %)) and Heia (ND2) should be 1 (coarse, >65%, < 18% clay). For the remaining agricultural areas with soil texture class 2 (medium) no Norwegian scenario was defined. However, Rustad was considered as a surrogate for these locations since a scenario with soil texture class 3 can be considered a worst-case situation for locations with soil texture class 2. All results of this assignment are presented in table 3-17.

Table 3-17. Area representation of the Norwegian-Drainage Scenarios when considering soil texture

No	Assignment	Area (km²)	Percentage related to the agricultural area
ND1	Rustad (medium fine)	2123	14.0
ND2	Heia(coarse)	10241	67.7
ND1	Rustad (but medium soil texture)^	2014	13.3
	agricultural area without drainage potential	759	5.0
	sum Norwegian drainage scenarios	14378	81.0
	total agricultural area	15137	100.0
	no agriculture	308211	
	total map area	323348	

^ using the ND1 (Rustad) scenario for this area can be considered a worst case

When only considering soil texture, 95% of the agricultural area in Norway can be attributed to one of the drainage scenarios (14378 km², table 3-17). Most relevant is Heia (ND2, soil texture class 1, coarse) corresponding to about two third of the area (10241 km²) followed by two Rustad-variations (ND1 with the correct medium fine soil texture, 2123 km², 14% and ND1 but with medium soil texture, 2014 km², 13.3%). Drainage is not relevant for 5.0% of the agricultural area in Norway according to the FOCUS definition because the soils at these locations have no soil texture (e.g., histosols). The spatial distribution is presented in figure 3-14.

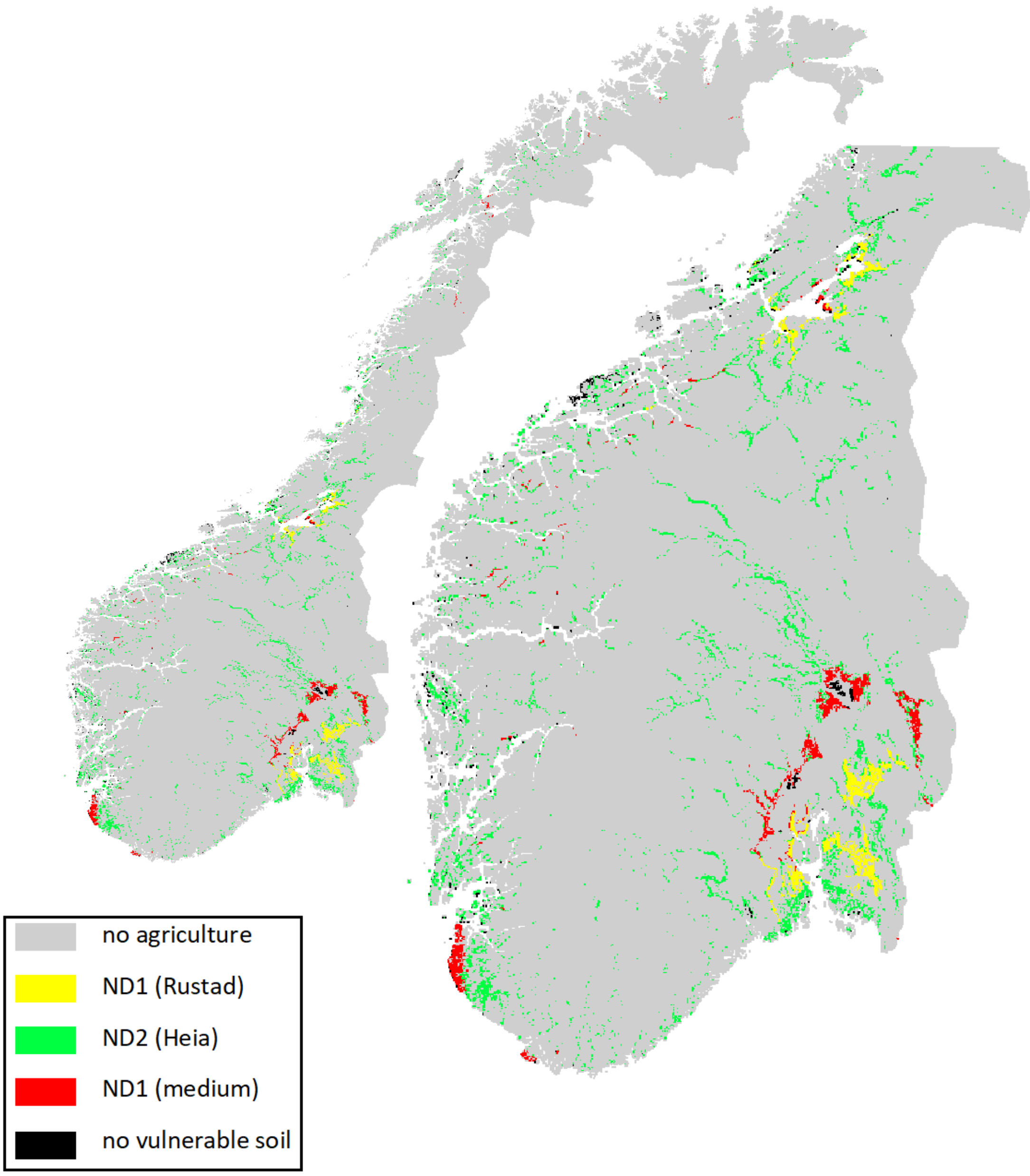

Figure 3-14. Assignment of agricultural areas to the Norwegian drainage scenarios based on soil texture

Based only on the key property soil texture a possible Norwegian drainage scenario could be found for 95% of the agricultural area. The remaining 5% have no drainage potential as they have no soil texture (e.g., histosols, 5%). In this chapter, further variations of the Norwegian scenarios are analysed with regard to rainfall, slope and organic matter. Figure 3-15 shows the distribution when rainfall is added as an additional filter.

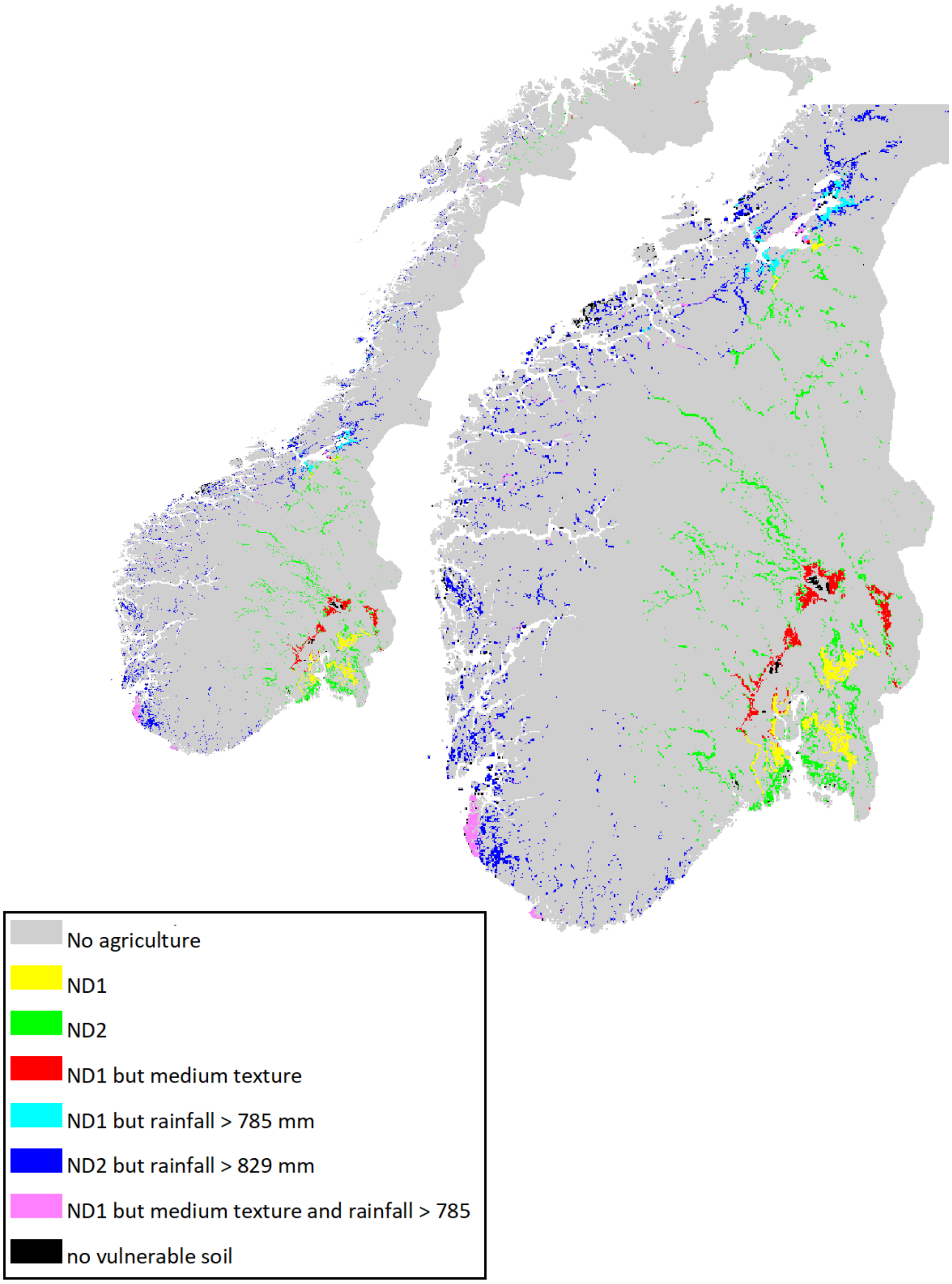

Figure 3-15: Assignment of agricultural areas to Norwegian drainage scenario variations considering soil texture and rainfall

Table 3-18 shows the percentages of the six variations with similar or more rainfall. According to this table, 52% (7867 km²) have similar annual rainfall as the Norwegian drainage scenarios and a similar fraction (43%, 6017 km²) more rainfall compared to the original scenario (i.e., > 785 mm for Rustad and >829 mm for Heia). For locations with higher rainfall than the original scenario, the level of protection may be lower than with respective scenarios with similar rainfall. 5% of the area is not affected to drainage entries (fields with no soil texture).

When comparing the situation for a specific scenario the situation is similar: 32.5% of the fields similar as ND2 (Heia) have also similar rainfall, whereas 35.2% of these fields have more rainfall than this scenario ND2.

Table 3-18. Area representation of the Norwegian-Drainage Scenarios, when considering soil texture, temperature, and rainfall

Assignment	Area (km²)	Percentage related to the agricultural area
ND1 (Rustad)	1629	10.8
ND2 (Heia)	4918	32.5
ND1 (Rustad, but medium texture)	1320	8.7
ND1 (Rustad, but too wet)	494	3.3
ND2 (Heia, but too wet)	5323	35.2
ND1 (Rustad, but medium texture and too wet)	694	4.6
sum ND-scenarios with similar rainfall	7867	52.0
sum ND-scenarios with higher rainfall	6511	43.0
sum D-scenarios	14378	81.0
remaining agricultural area with no drainage potential*	759	5.0
total agricultural area	**15137**	**100**
no agriculture	308211	
total map area	**323348**	

* no soil texture

In the next step, the filter "slope" is used to discriminate further between variations. Dependent on the slope of the original Norwegian drainage scenario (defined as <2.0%) the Norwegian fields are classified as having "comparable slope" or "higher slope".

However, this additional filtering does not lead to significant discrimination of scenario variations because – according to the slope map considered – there hardly any fields with slope below 2.0%. Consequently, table 3-19 presents similar results as the previous table 3-18.

Table 3-19. Area representation of the Norwegian-Drainage Scenarios when considering soil texture, temperature, rainfall, and slope

Assignment	Area (km²)	Percentage related to the agricultural area
ND1 (Rustad)	47	0.3
ND2 (Heia)	117	0.8
ND1 (Rustad, but medium texture)	64	0.4
ND1 (Rustad, but too wet)	12	0.1
ND2 (Heia, but too wet)	55	0.4
ND1 (Rustad, but medium texture and too wet)	26	0.2
ND1 (Rustad, but higher slope)	1582	10.5
ND2 (Heia, but higher slope)	4801	31.7
ND1 (Rustad, but medium texture and higher slope)	1256	8.3
ND1 (Rustad, but too wet and higher slope)	482	3.2
ND2 (Heia, but too wet and higher slope)	5268	34.8
ND1 (Rustad, but medium texture, too wet and higher slope)	668	4.4
sum ND-scenarios with comparable slope	321	2.1
sum ND-scenarios with higher slope	14057	92.9
sum ND-scenarios	14378	95.0
remaining agricultural area with no drainage potential*	759	5.0
total agricultural area	**15137**	**100**
no agriculture	308211	
total map area	**323348**	

° More than 2.0% slope

Consequently, the following map (figure 3-16) presents the same situation as the previous map (figure 3-15). Therefore, in the following steps the slope is not considered further as discriminating variable and it is assumed that the agricultural area in Norway is generally characterised by slope above 2.0%.

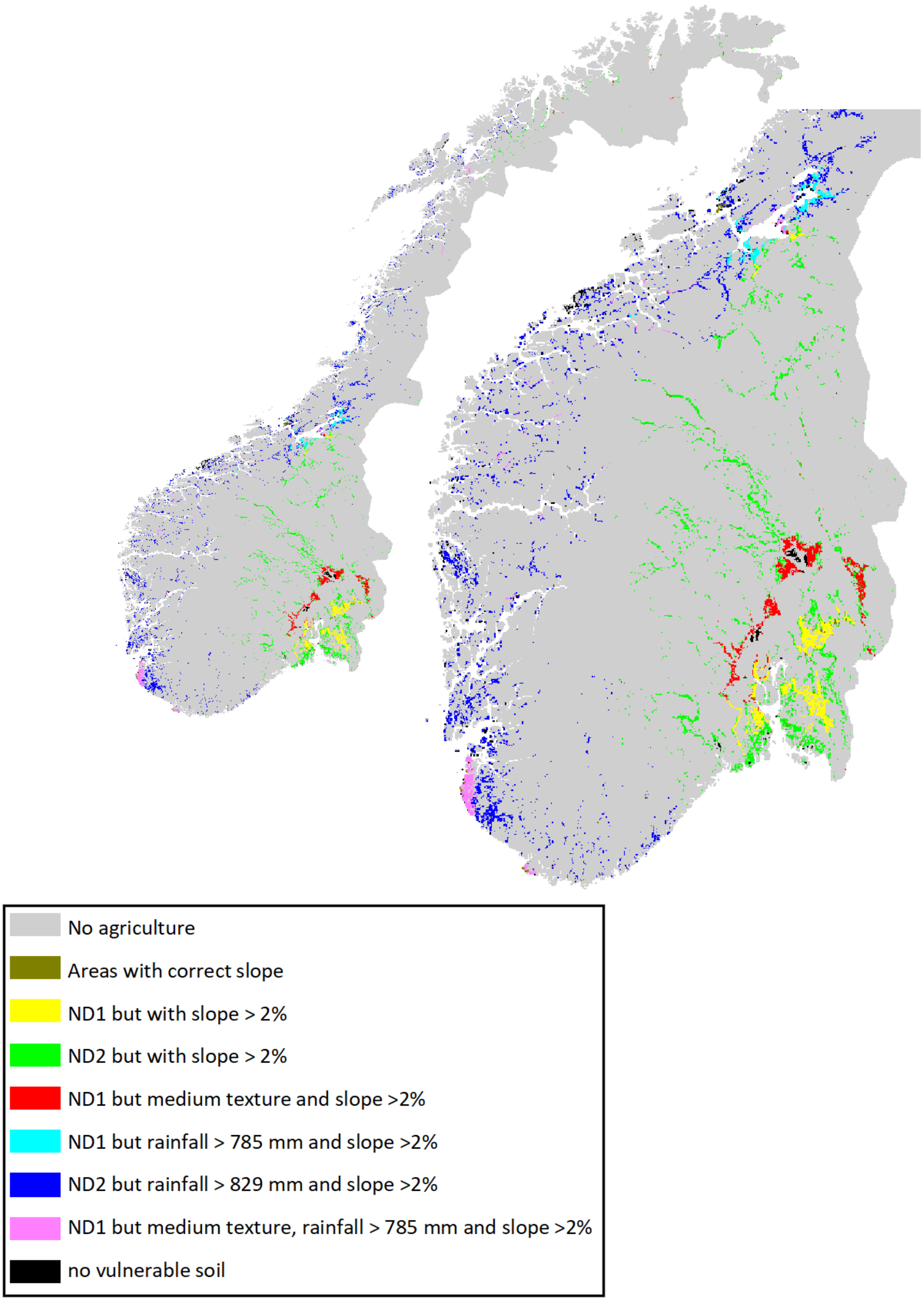

Figure 3-16. Assignment of agricultural areas to Norwegian drainage scenario variations considering soil texture, rainfall, and slope

In the next step, the filter "organic matter in the topsoil" is used to discriminate further between the scenario variations so far obtained. As previously, mentioned, organic matter is considered only as a supplementary parameter. The influence of organic matter on pesticide concentrations in drainage system is limited, especially when macro-pore flow is a dominant process. However, this is different for the scenario ND2 (Heia) and this scenario may be sensitive to organic matter content in soil. Background for this assumption is the sandy soil texture of ND2. Consequently, preferential flow is not that crucial at these locations and organic matter becomes a very sensitive parameter. As Heia (ND2) is most representative for Norwegian agricultural conditions, the higher organic matter content in Norway (compared to the field at Heia) should be of relevance. Regarding this ND2 scenario and the organic matter content, the Norwegian scenario with its lower organic carbon content should be considered significantly more protective for Norwegian conditions. Table 3-20 shows the result of the filtering.

Table 3-20. Area representation of the Norwegian-Drainage Scenarios when considering soil texture, rainfall, slope, and organic matter

Assignment*	Area (km^2)	Percentage related to the agricultural area
ND1 (Rustad, but higher slope)	198	1.3
ND2 (Heia, but higher slope)	806	5.3
ND1 (Rustad, but medium texture and higher slope)	117	0.8
ND1 (Rustad, but too wet and higher slope)	69	0.5
ND2 (Heia, but too wet and higher slope)	1070	7.1
ND1 (Rustad, but medium texture, too wet and higher slope)	57	0.4
ND1 (Rustad, but higher slope and org. matter)	1431	9.5
ND2 (Heia, but higher slope and org. matter)	4112	27.2
ND1 (Rustad, but medium texture, higher slope and higher org. matter)	1203	7.9
ND1 (Rustad, but too wet, higher org. matter and higher slope)	425	2.8
ND2 (Heia, but too wet, higher slope and higher org. matter)	4253	28.1
ND1 (Rustad, but medium texture, too wet, higher slope and org. matter)	637	4.2
sum ND-scenarios with comparable org. matter	2317	15.3
sum ND-scenarios with higher org. matter	12061	79.7
sum ND-scenarios	14378	95.0
remaining agricultural area with no drainage potential*	759	5.0
total agricultural area	**15137**	**100**
no agriculture	308211	
total map area	**323348**	

° More than 3.28% OM ^ more than 3.79% OM * all variations with higher org. matter

12 different variations of the drainage scenarios can be found when considering soil texture, rainfall, slope, and organic matter. After filtering with these additional parameters, the maximum number of scenarios could have been 32. However, already in the previous step all variations with slope <2.0% were not considered further as separate scenarios. In general, the agricultural fields in Norway are characterised by higher organic matter content than the

two scenarios Rustad and Heia (12061 km², 79.7%). In 15.3% of the fields the organic matter content remains below the scenario content. The two far most relevant scenario variations are Heia (ND2) with higher organic matter and higher slope (variation with similar rainfall: 4112 km², 27.2%, variation with higher rainfall 4253 km², 28.1%). Figure 3-17 shows the distribution of the dominant Norwegian drainage scenarios when soil texture, rainfall, slope, and organic matter are used as supplementary parameters for the analysis.

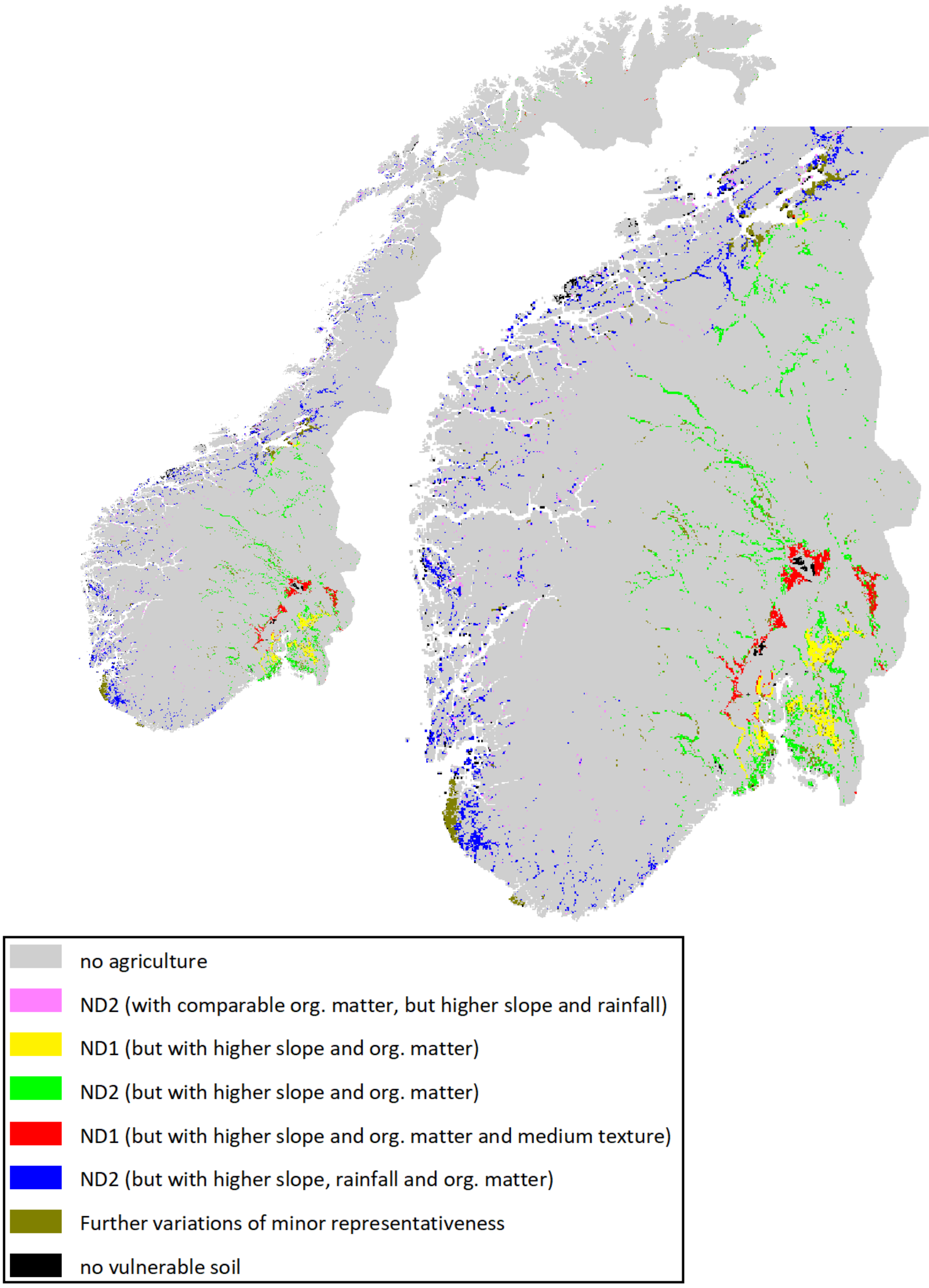

Figure 3-17. Assignment of agricultural areas to Norwegian drainage scenario variations based on soil texture, temperature, rainfall, slope, and org. matter

So far 12 variations of the 2 Norwegian drainage scenarios Rustad and Heia were defined by overlapping spatial data on rainfall, organic matter, and slope. In the final step, it is analysed in how far the temperature conditions from the actual field in Rustad or Heia are comparable to the whole agricultural are in Norway. Correct temperature range in this evaluation means mean spring and autumn temperatures in the range of 4 °C to 6.6 °C (actual mean temperature of the scenarios 5.3 °C). The results are presented in figure 3-18.

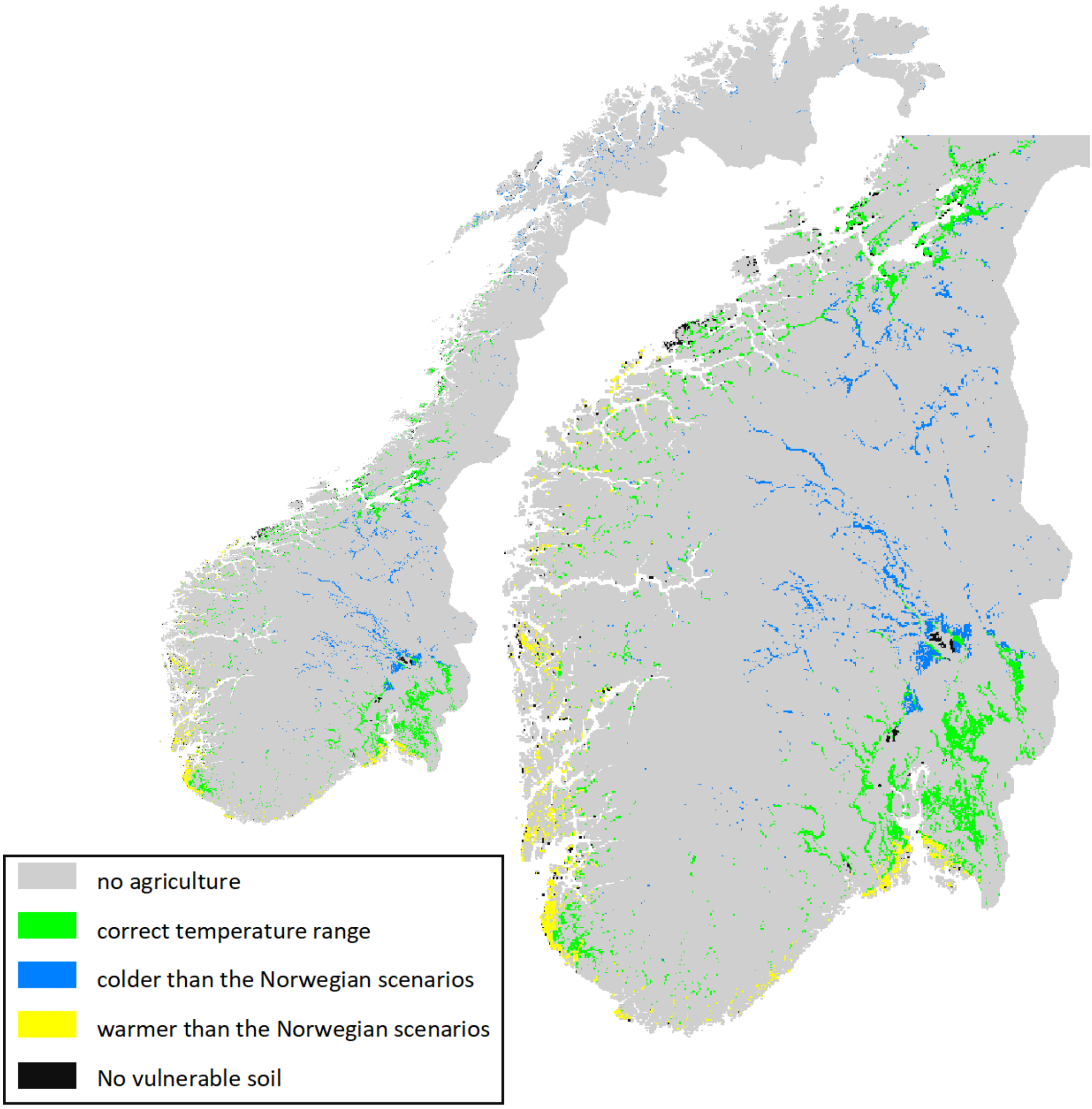

Figure 3-18. Assignment of agricultural areas to Norwegian drainage variations based on climate and soil properties

53.4% of the locations where a suitable Norwegian drainage scenario were found are characterised by similar mean spring autumn temperatures (see the green area in figure 3-18 and table 3-21. Furthermore, 28.6% and 13.0% of these locations were found to be colder (blue colour in the map) and warmer (yellow colour in the map), respectively. The warmer locations are mainly located close to the sea, the colder areas more in Innlandet with significant distance from the sea. These results are very similar to the results described in the previous chapter for the Norwegian run-off scenarios. However, this is not surprising since both type of scenarios show mean temperatures of 5.3 °C.

Table 3-21. Area representation of the Norwegian drainage scenarios when considering soil properties and climate

Assignment	Area (km²)	Percentage related to the agricultural area
correct temperature range	8080	53.4
colder than the Norwegian drainage scenarios	4331	28.6
warmer than the Norwegian drainage scenarios	1967	13.0
sum Norwegian drainage -scenarios	14378	95.0
remaining agricultural area with no drainage potential	759	5.0
total agricultural area	**15137**	**100.0**
no agriculture	308211	
total map area	**323348**	

Table 3-21 demonstrate that the Norwegian scenarios much better describe the climatic situation especially the temperature than the EU FOCUS scenarios. Most of the agricultural fields in Norway have similar climatic conditions as the two scenarios. However, Norway is a big country with a significant temperature shift from north to south. It is not surprising that there are also a lot of fields where the temperature is different compared to the two scenarios. A better impression about the size of the temperature deviation between the two run-off scenarios and actual Norwegian agricultural conditions is given in the following table 3-22 and figure 3-19.

Table 3-22: Deviation of the average spring-autumn-temperatures in Norwegian agricultural conditions compared to the FOCUS drainage scenarios

Scenario	ND1 Rustad km²	ND2 Heia km²	ND-scenarios km²	NDscenarios Percentage related to the agricultural area
>10 °C too cold	0	0	0	
5 °C to 10 °C too cold	49	441	490	3.2
2.5 °C to 5 °C too cold	108	1793	1901	12.6
1 °C to 2.5 °C too cold	976	1954	2930	19.4
maximum 1 °C difference	2435	3857	6292	41.6
1 °C to 2.5 °C too warm	569	2196	2765	18.3
>2.5 °C too warm	0	0	0	0
all ND-scenarios	4137	10241	14378	95.0

The table clearly demonstrates that the Norwegian drainage scenarios well fit to most agricultural fields in Norway with regard to temperature: 41.6% of the fields representative for one the Norwegian drainage scenarios show differences below 1 °C and 79.3% of the fields differences below 2.5 °C compared to the original scenario conditions. This is valid for both Norwegian drainage scenarios.

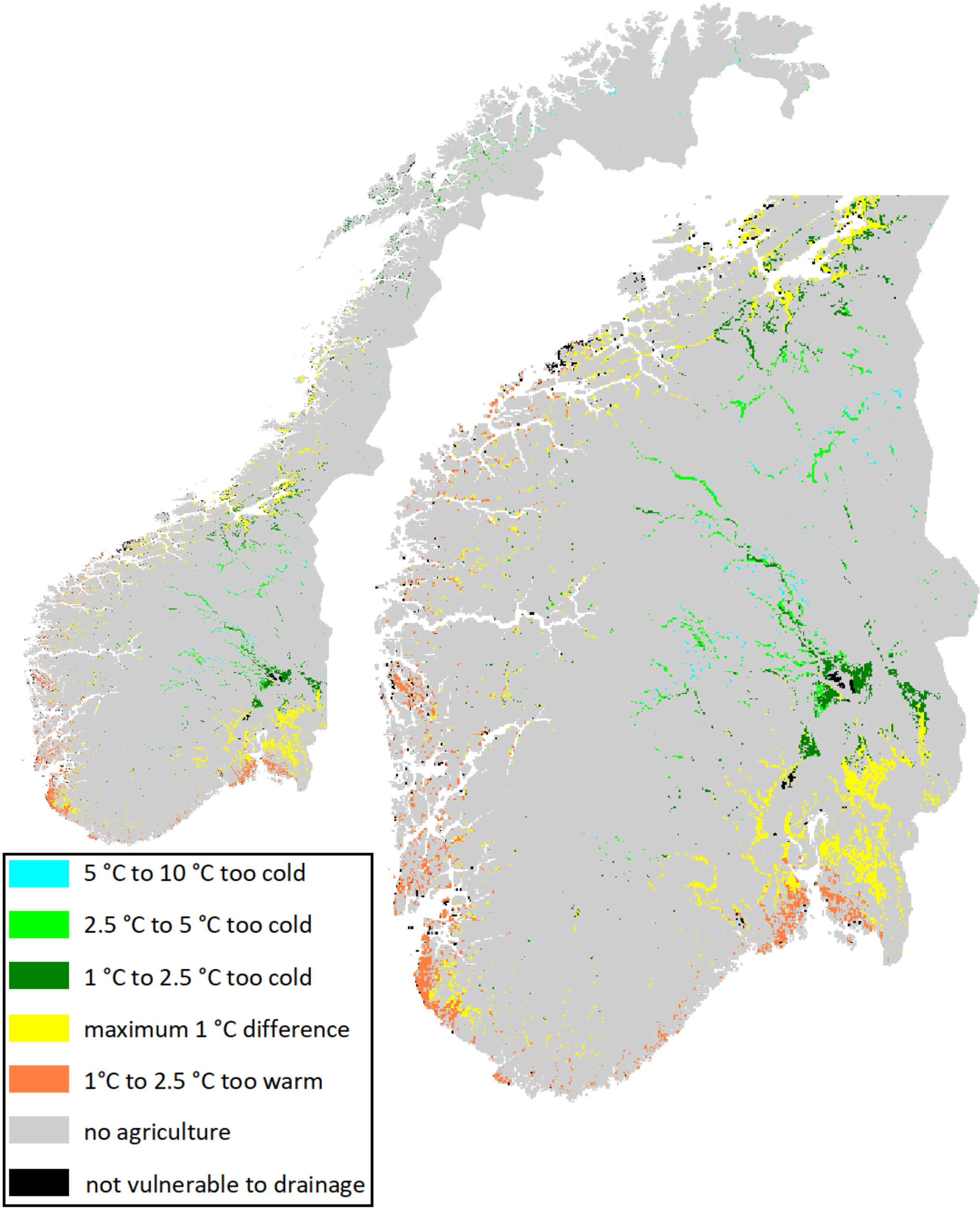

Figure 3-19. Difference of the average spring-autumn-temperatures in Norwegian agricultural conditions compared to the FOCUS drainage scenarios

3.4.2 Overview on the obtained representativeness

The following table 3-23 summarises the main results of the analysis:

1. In this evaluation, it is assumed that the key parameter for drainage is soil texture. Mean annual recharge is not considered because the spatial distribution of this parameter was not available
2. 5.0% of the agricultural area have no drainage potential because the respective soils have not texture (e.g. histosols).
3. Consequently, the remaining 95.0% of the agricultural area may have a drainage potential.
4. When considering soil texture, the two drainage scenarios Rustad and Heia cover only part of the agricultural area. Three major soil texture classes are relevant in Norway ("coarse", "medium" and "medium fine"). However, neither Rustad (soil texture class "medium fine") nor Heia (soil texture class "coarse") can be considered representative for the soil texture class "medium". However, in this analysis the scenario Rustad with its "medium fine" soil texture was considered as a surrogate for the agricultural areas with "medium" soil texture. This choice can be considered a worst-case assumption.
5. Further variations of the two Norwegian drainage scenarios are analysed based on the annual rainfall, slope and organic matter content. This analysis leads to 12 different variations with higher or lower level of protection compared to the original Norwegian drainage scenarios.
6. If a variation meat all scenario definitions it can be assumed that the respective scenario represents the respective location ("equivalent to the scenario").
7. In this analysis, it is assumed that higher rainfall at a representative location than in the original drainage scenarios will reduce the level of protection because it would increase the annual recharge followed by an increase of the drainage water.
8. In this analysis, it is assumed that more slope will increase the level of protection for drainage scenarios because part of the water could reach surface water via run-off instead of drainage system
9. In this analysis, it is finally assumed that higher organic matter contents in the topsoil in the agricultural area than in the Norwegian drainage scenarios will increase the level of protection for drainage scenarios. Higher organic matter content will increase sorption to the soil matrix and reduce pesticide concentrations in the drainage system. This is especially important for ND2 (Heia, coarse soil texture) because in sandy soils (classical) chromatographic flow is dominant. In such a situation organic matter in soil is a main driver for pesticide concentrations in the water of in deeper soil layers.
10. The Norwegian scenarios fit well to the majority of agricultural fields in Norway with regard to temperature: 41% of fields show differences below 1 °C and 79.3% of the field's differences below 2.5 °C compared to the scenario conditions.
11. An additional temperature correction for the Norwegian scenarios (as recommended for the European FOCUS drainage scenarios) is not considered necessary since the differences are relatively small.

The following conclusion can be drawn:

The two Norwegian drainage scenarios Rustad and Heia represent 95% of the agricultural area in Norway (14378 km²) when considering the soil texture class as key parameter. Most relevant is Heia (ND2, soil texture class 1, coarse) corresponding to about two third of the area (10241 km², 67.7%). The other scenario Rustad covers 14% of the agricultural area (2014 km²). 13.3% of the agricultural area (2123 km²) is not covered by the two Norwegian scenarios because the soil texture class (medium) is not met neither by Rustad (medium fine) nor by Heia (coarse). However, the scenario Rustad was considered as a worst-case approach for this area. 5.0% of the agricultural area (759 km²) have no drainage potential because the respective soils have no texture (e.g. histosols).

The analysis showed that similar as the European FOCUS scenarios also the Norwegian drainage scenarios do not fit completely to Norwegian agricultural conditions though for different reasons: whereas the FOCUS scenarios show significant differences with regard to the temperature the Norwegian scenario (Rustad and Heia) were too flat compared to the information provided by the slope map. However, it is assumed that higher slope in a field than in the scenario description will lead to a higher level of protection since more slope will lead to more surface run-off instead of drain flow.

However, not only slope but also the organic matter content often differs in agricultural fields compared to the scenario Rustad and Heia: only 15.3% of the agricultural area have a comparable organic matter content whereas in 79.7% of the agricultural fields higher organic matter have to be considered. It assumed that - similar as higher slope - also higher organic matter would increase the level of protection. The influence of organic matter on pesticide concentrations in drainage system may be limited, especially when macro-pore flow is a dominant process. However, this is different for the scenario ND2 (Heia) and this scenario may be sensitive to organic matter content in soil. Background for this assumption is the sandy soil texture of ND2. Preferential flow should not be that crucial at this location and organic matter would become a very sensitive parameter. As Heia (ND2) is most representative for Norwegian agricultural conditions, the higher organic matter content in Norway (compared to the field at Heia) should be of relevance. Regarding this ND2 scenario and its organic matter content, the original ND2 scenario Heia with its low organic carbon content should be considered significantly more protective for many Norwegian conditions with high organic matter contents.

When finally comparing the rainfall in the different agricultural areas with the rainfall of the two Norwegian drainage scenarios 52% (6238 km²) have similar annual rainfall as the Norwegian drainage scenarios whereas 39.8% (6017 km²) of the areas are characterised by more rainfall than to the original scenario (i.e., > 729 mm for Rustad and >829 mm for Heia). It is assumed that locations with higher rainfall than the original scenario are less protected because more rainfall will increase the drain flow at these locations.

Summarising the level of protection that the two Norwegian drainage scenarios provide, the following conclusions can be drawn:

- If the Norwegian drainage scenarios are considered for the risk assessment 7867 km² (52%) of the agricultural area in Norway are protected by a higher level than the situation described in the original scenario. This is caused by higher organic matter content and higher slope in these areas.
- There are no areas which are definitely less protected than the level provided by the original scenario. However, at 6511 km² (43.1%) of the agricultural area the situation is not clear whether the high rainfall at these locations is compensated by higher slope and/or higher organic matter contents. In so far, the situation is open. In principle, this unfortunate situation could be solved by combining the soil with a station having more rainfall than the original scenario.
- The remaining 5% of the agricultural area have not drainage potential due to its soil texture class ("no soil texture", e.g., histosols).

Table 3-23. Representativeness of the Norwegian-drainage surface water scenarios in agricultural fields

Scenario°	**Texture**	**organic matter**	**precipitation**	**slope**	**distribution (km²)**	**percentage related to the agricultural area**	**Rating**
ND1	analogue	analogue	analogue	higher than the scenario	198	1.3	more protective
ND1	medium	analogue	analogue	higher than the scenario	117	0.8	more protective
ND1	analogue	analogue	higher than the scenario	higher than the scenario	69	0.5	protectiveness open
ND1	medium	analogue	higher than the scenario	higher than the scenario	57	0.4	protectiveness open
ND1	analogue	higher than the scenario	analogue	higher than the scenario	1431	9.5	more protective
ND1	medium	higher than the scenario	analogue	higher than the scenario	1203	7.9	more protective
ND1	analgoue	higher than the scenario	higher than the scenario	higher than the scenario	425	2.8	protectiveness open
ND1	medium	higher than the scenario	higher than the scenario	higher than the scenario	637	4.2	protectiveness open
ND1	**sum**				**4137**	**27.3**	
ND2	analogue	analogue	analogue	higher than the scenario	806	5.3	more protective
ND2	analogue	analogue	higher than the scenario	higher than the scenario	1070	7.1	protectiveness open
ND2	analogue	higher than the scenario	analogue	higher than the scenario	4112	27.2	more protective
ND2	analogue	higher than the scenario	higher than the scenario	higher than the scenario	4253	28.1	protectiveness open
ND2					**10241**	**67.7**	
sum ND*					**14378**	**95.0**	
not vulnerable to drainage					**759**	**5.0**	
total agricultural area					**15137**	**100**	

° ND1: Rustad ND2: Heia

4 Identification of how worst-case the correlated FOCUS scenarios or national scenarios identified in objective 1 are with respect to agricultural land across Norway

4.1 Application of the EU-FOCUS criteria

In this chapter the relative worst-case scenario categories (chapter 2.3) were applied to the EU-FOCUS scenarios (4.1.1) and the Norwegian scenarios (chapter 4.1.2). Based on the analysis of representativity in chapter 3, the distribution of the different scenarios across the agricultural land was identified (chapter 4.1.3). Additional areas considered not directly representative were considered protective because of information about soil texture, precipitation, slope, and content of organic matter.

4.1.1 Agro-environmental characteristics of the EU-FOCUS scenarios

Based on the different categories and classes of the FOCUS scenarios in chapter 2.3 in this report and section 3.2 and 3.5 in FOCUS (2001) characteristics of the EU FOCUS scenarios are given for drainage and surface runoff (table 4-1 and table 4-2).

Table 4-1. Relative inherent worst-case characteristics for FOCUS drainage scenarios

Scenario	Temperature	Recharge	Soil
D1	Extreme worst case	Intermediate case	Worst case
D2	Worst case	Worst case	Extreme worst case
D3	Worst case	Worst case	Worst case
D4	Worst case	Intermediate case	Intermediate case
D5	Intermediate case	Intermediate case	Worst case
D6	Best case	Worst case	Worst case

Table 4-2. Relative inherent worst-case characteristics for non-irrigated run-off scenarios

Scenario	Temperature	Rainfall	Soil	Slope
R1	Worst case	Intermediate case	Worst case	Intermediate case
R2	Intermediate case	Extreme worst case	Intermediate case	Extreme worst case
R3	Intermediate case	Worst case	Worst case	Worst case
R4	Best case	Intermediate case	Worst case	Worst case

4.1.2 Norwegian scenarios classified according to EU-FOCUS scenarios

The same classification of the FOCUS scenarios was applied on the Norwegian surface scenarios (table 4-3) and drainage surface scenarios (table 4-4). Both Syverud and Bjørnebekk belong to the same range of precipitation 800-1000 mm which is the worst case and both sites belong the steep slope more than 10 % slope characterized as extreme worst case. The origin of the soil is marine deposits and temperature in the area is 5.3 characterized as extreme worst case. The overall conclusion for the two scenarios both is extreme worst case using the FOCUS classification.

Table 4-3. Assessment of protection level for the Norwegian surface runoff-scenarios

Scenario	Parameter	Range	Assessment	Justification in FOCUS SW (2001)
Syverud	Average annual rainfall	800 - 1000	Worst case	Table 3.2-2
Syverud	Slope	>10	Extreme worst case	Table 3.2-3
Syverud	Soil characteristics	light loamy soils with small clay and moderate organic matter content	Intermediate case	Table 3.2-5
Syverud	Temperature	5.3	Extreme worst case	Table 3.2-1
Syverud	**Conclusion: extreme worst case**			
Bjørnebekk	Average annual rainfall	800 - 1000	Worst case	Table 3.2-2
Bjørnebekk	Slope	>10	Extreme worst case	Table 3.2-3
Bjørnebekk	Soil characteristics	silty or medium loamy soils with low organic matter content	Worst case	Table 3.2-5
Bjørnebekk	Temperature	5.3	Extreme worst case	Table 3.2-1
Bjørnebekk	**Conclusion: extreme worst case**			

The drainage scenarios from Rustad and Heia are both flat, less than 2 % slope with approximately 800 mm precipitation which worst case according to the FOCUS classification. The soil at Rustad is classified as intermediate and more sandy soil at Heia as worst case. The temperature at both sites is extreme worst case. Concluding that overall classification of Rustad is worst case and Heia extreme worst case (table 4-4). More details about the site are described in chapter 2.2.1.

Table 4-4. Assessment of protection level for the Norwegian surface drainage scenarios

Rustad	**Average annual rainfall***	**800**	**Worst case**	**Table 3.2-2**
Rustad	Slope	< 2		Not a criterion for drainage
Rustad	Soil characteristics	Silty clay loam with small organic matter content	Intermediate case	Table 3.2-4
Rustad	Temperature	5.3	Extreme worst case	Table 3.2-1
Rustad	**Conclusion: worst case**			
Heia	Average annual rainfall*	800	Worst case	Table 3.2-2
Heia	slope	< 2		Not a criterion for drainage
Heia	Soil characteristics	Sands with small organic matter content	Worst case	Table 3.2-4
Heia	Temperature	5.3	Extreme worst case	Table 3.2-1
Heia	**Conclusion: extreme worst case**			

4.1.3 Worst case areas across the Norwegian agricultural land

EU-FOCUS surface runoff scenarios. Applying the worst-case scenarios of the FOCUS surface runoff scenarios on the agricultural land in Norway, the scenario R1 from Weiherbach (Germany) represent the worst case according to the temperature. Despite of this is the worst case for temperature, this scenario and none of the other scenarios cover the Norwegian conditions. The soil texture of R1 (Weiherbach) and R3 (Bologna) are classified as worst case (medium fine with by-pass flow) and this is one of the main soil types of agricultural land across Norway used for cereal production.

Assumed temperature correction have been made, 53.1% of the agricultural area were found to be in line with one of the FOCUS scenarios. Further 45.1% of the agricultural field can be assigned to R2 (Porto) or R4 (Roujan). These fields are characterised by less rainfall than the EU FOCUS scenarios and the EU-FOCUS scenarios can be considered especially protective for these Norwegian agricultural fields. After a temperature correction there are no agricultural fields for which the EU FOCUS scenarios should be less protective than the original FOCUS locations. According to the table 3-2 and map figure 3-2, the area analogue with the FOCUS scenarios 2 (Porto) is the area in Rogaland and the west coast of Norway. The more protected area with less precipitation and same texture is the area outside the morene ridge (raet) close to Oslofjorden and the northern part and valleys of South Eastern Norway and Trøndelag.

After temperature correction R1 (Weiherbach) covers 3.2 % of the vulnerable areas for runoff. The scenario R2 (Porto) covers 67.6 % of the vulnerable soil, which 36.4 % of the area is less vulnerable than the EU FOCUS scenario, because of higher content of organic matter. R3 (Bologna) covers 10.9 % of the area. The scenario R4 (Roujan) covers 13.3 % of the vulnerable soils, while 8.7 % of this area is less vulnerable because of high content of organic matter table 3-5.

EU-FOCUS drainage scenarios. There are no agricultural areas in Norway where all scenario parameters (soil texture, temperature, rainfall, slope, organic matter) are comparable to the EU FOCUS drainage scenarios. According to the temperature the drainage scenarios D1 from Lanna (Sweden) is characterized as extreme worst case. Based on the temperature criterion three EU-drainage scenarios are recommended to be used in Norwegian risk assessment: D1 (Lanna, Sweden), D3 (Vredepeel, The Netherlands) and D4 (Skousbo, Denmark). In order to use the FOCUS scenarios for Norwegian conditions, a temperature correction is recommended either by changing the respective pesticide information (DegT50, easy solution) or by changing the original FOCUS climate files (complicated solution). This is especially important for D3 (original location NL) and D4 (Skousbo) whereas a correction for D1 (Lanna) does not seem to be necessary.

The distribution in of D1, D3 and D4 of the FOCUS drainage scenarios is summarized in table 3-11. In total five different variation rainfall, organic matter or slope are considered. Lanna (D1) represent 22.1% of the Norwegian agricultural area. About 50% of these D1 variations can be considered as more protective. Most important in Norway is the non-preferential flow scenario D3 (Vredepeel) because of its coarse soil type, which is rather common in Norway. D3 is representative for 59.6% of the agricultural fields. Three variations of this scenario were found in Norway due to higher rainfall, organic matter or slope. Two of these variations represent a higher level of protection than the official FOCUS scenario because of higher slope or/and higher organic matter, which is considered as more protective for drainage. The scenario of Skousbo (D4) cover 13.3 % of the agricultural are but 4.6 % of this area the protection level is considered to be open as these areas have more precipitation and also steeper than the FOCUS scenarios, but 8.8 % of the area is more protective. Including all drainage variation, 51.5 % of the agricultural area are considered as being more protective as FOCUS and 35.6 % the protective level is open.

Norwegian scenarios surface run-off. The Norwegian scenarios fit well to the majority of agricultural fields in Norway with regard to temperature: 44% of fields show differences below 1 °C, and 83% of the fields exhibit differences below 2.5 °C compared to the scenario conditions. An additional temperature correction for the Norwegian scenarios is not considered necessary since the differences are relatively small. Further 58.8 % (8883 km²) can be considered less vulnerable than the original scenarios table 3-16 and figure 3-11. Most of the agricultural fields in Norway are characterised by sandy soils (soil texture class coarse). In these soils, limited runoff is expected compared to other soil texture classes. Nevertheless, the scenario Syverud (NR1) was assigned to this class which can be considered a worst-case assumption. The scenarios do clearly not cover 4.3 % of the agricultural area. More details about the distribution of the scenarios on table 3-13.

Norwegian scenarios drainage run-off. The two Norwegian drainage scenarios Rustad and Heia represent 95% of the agricultural area in Norway (14378 km²) when considering the soil texture class as key parameter. Most relevant is Heia (ND2, soil texture class 1, coarse) corresponding to about two third of the area (10241 km², 67.7%). The other scenario Rustad covers 14% of the agricultural area (2014 km²). 13.3% of the agricultural area (2123 km²) is not covered by the two Norwegian scenarios because the soil texture class (medium) is not met neither by Rustad (medium fine) nor by Heia (coarse). However, it was decided to consider the areas with the scenario Rustad as a worst-case approach

If the Norwegian drainage scenarios are considered for the risk assessment 7867 km² (52%) of the agricultural area in Norway are protected by a higher level than the situation described in the original scenario. This is caused by higher organic matter content and higher slope in these areas.

There are no areas which are less protected than the level provided by the original scenario. However, at 6511 km² (43.1%) of the agricultural area the situation is not clear whether the high rainfall at these locations is compensated by higher slope and/or higher organic matter contents. In so far, the situation is open. In principle, this unfortunate situation could be solved by combining the soil with a station having more rainfall than the original scenario.

5 Characteristics and spatial distribution of agricultural land in Norway not represented by any of the ten FOCUS surface water standard scenarios and the four national scenarios

5.1 Agricultural land not represented by the EU FOCUS scenario

As earlier shown, no locations in Norway completely fulfil the FOCUS run-off definitions. The main reason being the low temperature conditions. However, FOCUS surface water simulation may be corrected for temperature either by changing the standard temperature (usually 20 °C) of the respective pesticide information, or by changing the original FOCUS climate files. If temperature correction has been performed and all remaining FOCUS definitions are met, it can be assumed that the FOCUS scenario represents the respective location ("equivalent to FOCUS"). Details about the protectiveness are summarized in chapter 3 and 4.

5.2 Agricultural land not represented by the Norwegian scenarios

Runoff-scenarios. The surface runoff Norwegian scenarios fit well to the majority of agricultural fields in Norway with regard to temperature: 44% of fields show differences below 1 °C and 83% of the fields show differences below 2.5 °C compared to the scenario conditions. This is in principally valid for all Norwegian scenarios. Only to NR1 (Syverud, medium soil texture) there are slightly more fields attached with up to 2.5 °C lower temperatures than the original scenario (817 km²). The scenarios do clearly not cover 4.3 % of the agricultural area (651 km²). The background is that the rainfall which is higher in these areas than in the run-off scenarios. For 28.6% of the area the situation is open because the soils in these agriculture areas are less vulnerable whereas the rainfall is more vulnerable. In principle, this unfortunate situation could be solved by combining the soil with a station having more rainfall than the original scenario. The protectiveness is described in more detail in table 3-16.

For the *Norwegian drainage scenarios*, 13.3% of the agricultural area (2123 km²) is not covered by the two Norwegian drainage scenarios because the soil texture class (medium) is not met neither by Rustad (medium fine) nor by Heia (coarse).

43 % of the Norwegian drainage scenarios have more rainfall than the original scenario (Rustad and for Heia). For locations with higher rainfall than the original scenario, the level of protection may be lower than with respective scenarios with similar rainfall.

In general, the agricultural fields in Norway are characterised by higher organic matter content than the two scenarios Rustad and Heia (12061 km², 79.7%), but considered to give better protection.

The Norwegian drainage scenarios well fit to most agricultural fields in Norway with regard to temperature: 41.6% of the fields representative for one the Norwegian drainage scenarios show differences below 1 °C and 79.3% of the fields differences below 2.5 °C. Additional temperature correction for the Norwegian scenarios is not considered necessary since the differences are relatively small. Protectiveness is more described in table 3-17.

6 Relevance of surface run-off, drainflow and spray drift as routes of aquatic exposure to plant protection products in Norway

Table 6-1 summarize the results from a simulation exercise with the FOCUS drainage D1 from Lanna with no climate adaptation to the Norwegian climate. The results describe the concentration (PEC) of the dummy variables table 2-23 in the stream according to the procedure and parameters for the FOCUS test runs (chapter 2.9). Appendix II gives the results from several simulations, calculating the dilution and concentration in streams, ditch, and pond according to the FOCUS guidance using different drainage and runoff scenarios. Different temperature corrections are made for Norwegian conditions.

Table 6-1. Results of FOCUS example calculation (concentrations in µg/L) for the drainage scenario Lanna (D1) stream scenario (no temperature correction)

FOCUS	Original FOCUS results				Adapted to Norwegian conditions				Difference in Percent			
Substance	PECsw max	TWA 7d	TWA 21d	PECsed max	PECsw max	TWA 7d	TWA 21d	PECsed max	PECsw max	TWA 7d	TWA 21d	PECsed max
A	0.604	0.478	0.252	0.124	0.604	0.478	0.252	0.124	0.00	0.00	0.00	0.00
B	0.561	0.306	0.177	0.174	0.561	0.306	0.177	0.174	0.00	0.00	0.00	0.00
C	0.561	0.061	0.020	0.196	0.561	0.061	0.020	0.196	0.00	0.00	0.00	0.00
D	3.655	3.152	2.112	0.952	3.655	3.152	2.112	0.952	0.00	0.00	0.00	0.00
E	4.128	3.659	2.547	2.495	4.128	3.659	2.547	2.495	0.00	0.00	0.00	0.00
F	0.705	0.651	0.546	1.739	0.705	0.651	0.546	1.739	0.00	0.00	0.00	0.00
G	5.422	4.879	4.148	2.781	5.422	4.879	4.148	2.781	0.00	0.00	0.00	0.00
H	6.652	5.984	4.705	5.891	6.652	5.984	4.705	5.891	0.00	0.00	0.00	0.00
I	3.065	2.954	2.733	13.000	3.065	2.954	2.733	13.000	0.00	0.00	0.00	0.00

Contribution from drift

Though spray drift deposition is dependent on a variety of environmental and application factors like wind speed, driving speed, spray boom height, nozzle types, spray pressure and air assisted techniques, the estimation of spray drift deposition in the FOCUS scenarios do not depend on most of these factors. Instead, they are based on a statistical analysis of a German drift database (Ganzelmeier et al., 1995; Rautmann et al., 2001). This database is frequently used in the EU evaluation process. These spray drift values which are dependent on the crop type (*e.g.,* field crops, fruit trees, vine, hop) and the distance to the surface water body. Furthermore, different percentiles are used for single and multiple application. Due to this reduction of complexity, it is rather simple to estimate the contribution from drift for a given FOCUS surface water scenario. The peak caused by drift can be roughly estimated using the following equation:

$$PEC_{drift} = \frac{App \cdot SD}{100 \cdot D}$$

PEC_{drift}: Predicted environmental concentrations cause by drift (µg/L)

App: Rate of application (mg/m²)

D: Depth of the surface water (m)

SD: Crop and distance dependent spray drift value (%)

Example simulations which are based on simulations in maize and winter cereals are presented in Appendix II. The following table 6-2 gives an estimate of the spray drift contribution in winter cereal crops for the three surface water bodies, given the standard FOCUS Step 3 distance of 1 m for ditches, 1.5 m for stream and 3.5 m for ponds with an application rate of 100 g/ha (=10 mg/m²). These numbers can in principle be used for all drainage and run-off locations. They may vary slightly with the actual depth of the surface water at the time of application.

Table 6-2. Contribution of drift to the FOCUS step 3 scenarios (application rate: 100 g/ha, crop: winter cereals)

Drift value (%)	Depth (m)	water body	PEC (µg/L)
1.9274	0.3	ditch	0.6425
1.4304	0.3	stream	0.4768
0.2191	1.0	pond	0.0219

The values in table 6-1 represent the minimum values caused by drift. Significantly higher PECmax values in the appendix example simulations, may therefore be attributed to drainage or run-off. The date of peak forms also an indication for the origin of the peak PECsw: if the peak is on the application day: spray drift is the origin, if on a later day: run-off or drainage event (simplified, without stacking drift on top of e.g., longer lasting drain flow).

Contribution from dissolved and particulate transport

Pesticide transport from run-off events may be through dissolved (water/run-off) and/or particulate phases (sediment/erosion). However, the contribution from run-off events is distributed between the water phase (run-off) and the sediment phase (erosion). In general, transport via the water phase is dominant. Only if the chemicals are strongly sorbed to soil (Koc > 2000 L/kg) the entry route via soil erosion may by relevant. The FOCUS Step 3 models do not provide information on the distribution between water and sediment directly. However, Reichenberger et al. (2007a) evaluated this distribution based on a high number of PRZM calculations. The model Exposit (UBA, 2017) uses the evaluation by Reichenberger et al. (2007a) for the calculation of run-off entries based on the following table which may give an indication of this distribution (table 6-3). The percentages are related to the 90 percentiles of run-off and erosion entries. According to the results from these simulations the contribution in surface water from runoff has a maximum for pesticide with Koc close to 200. The contribution from the erosion increases with even higher sorption, Koc more than 50000 often the case with positive charged pesticides.

Table 6-3. Percentage of substance in surface water by run-off and drainage according to Exposit 3.02 (UBA, 2017)

Koc-class (in L/kg)	Run-off	Erosion	Total
0-20	0.110	0.000	0.110
>20-50	0.151	0.000	0.151
>50-100	0.197	0.000	0.197
>100-200	0.248	0.001	0.249
>200-500	0.224	0.004	0.228
>500-1000	0.184	0.020	0.204
>1000-2000	0.133	0.042	0.175
>2000-5000	0.084	0.091	0.175
>5000-10000	0.037	0.159	0.196
>10000-20000	0.031	0.192	0.223
>20000-50000	0.014	0.291	0.305
>50000	0.001	0.451	0.452

Effect of temperature on the concentration in surface water

Generally, temperature influences many processes in the environment. However, the most relevant temperature dependent process for the FOCUS scenarios is degradation, mainly due to abundance of microorganisms in soil. To address this dependency, all FOCUS models consider the Arrhenius equation where an exponential function is used to estimate the effect of temperature on the degradation rate as shown in the following equation:

$$f = \exp\left(\frac{-E}{R}\left[\frac{1}{T_{scen} + 273.15} - \frac{1}{T_0 + 273.15}\right]\right)$$

f: temperature correction factor (-)

T_{scen}: actual daily temperature in the scenario (°C)

T_0: Reference temperature during the degradation study

E: Arrhenius activation energy, (65 kJ mol-1)

R: Gas constant (8.3143 J mol^{-1} K^{-1})

In the above equation, the effect of a temperature shift of 7 °C would be 0.5 (nearly), regardless of the actual temperature of the scenario. This means that degradation will be reduced every day by about 50% if the temperatures in Norway are on average 7 °C below the respective FOCUS EU scenario.

As this effect mainly depends on the shift of 7 °C, and not very much on the actual temperatures, two very simple corrections could be done in the FOCUS pesticide input files to account for temperature:

a) entering a reduction of 50% for the degradation rate or
b) entering an adapted reference temperature of 27 °C instead of 20 °C.

The second procedure (b) has been used in the example simulations presented in table 12-2 - table 12-16 annex II. The aim was to estimate the effect of the temperature difference in different situations (different scenarios, different compound properties). For this analysis, the same example compounds were used that were already described in the FOCUS surface water report (FOCUS 2001). Some information on the properties of these compounds is given in table 2-23 copied from the respective FOCUS report. The model compounds have large variability in sorption constants and half-lives, covering 2 orders of magnitude. The idea was to consider the complete range of expected pesticide substances.

6.1 The effect of temperature on the FOCUS-scenario calculations

The same application rate (100 g/ha) and the same crop (winter cereals) was used for all compounds. As for R2, winter cereals were not defined, but FOCUS maize was considered as a surrogate. The time of application was always pre-emergence for all simulations. Some results are presented for the D2 scenarios (table 6-4). The original location of this scenario is Brimstone in the UK. The climate is relatively cold for the central zone as shown by the small temperature correction of only 1 °C compared to Norway.

Table 6-4. Results of FOCUS example calculation (concentrations in µg/L) for D2 ditch scenario (temperature correction: -1 °C)

FOCUS	Original FOCUS results				Adapted to Norwegian conditions				Difference in Percent			
Substance	PECsw max	TWA 7d	TWA 21d	PECsed max	PECsw max	TWA 7d	TWA 21d	PECsed max	PECsw max	TWA 7d	TWA 21d	PECsed max
A	8.169	3.035	1.559	0.710	8.670	3.314	1.736	0.773	6.13	9.19	11.35	8.91
B	6.500	1.537	1.124	0.879	6.996	1.757	1.286	1.026	7.63	14.31	14.41	16.75
C	0.642	0.245	0.085	0.364	0.642	0.260	0.090	0.381	0.00	6.05	6.59	4.78
D	16.620	8.767	6.125	2.518	16.730	8.867	6.220	2.573	0.66	1.14	1.55	2.18
E	15.590	7.612	6.244	6.555	15.720	7.733	6.368	6.751	0.83	1.59	1.99	2.99
F	2.268	1.057	0.757	3.192	2.407	1.129	0.809	3.495	6.13	6.81	6.91	9.49
G	18.890	10.85	8.243	4.295	18.940	10.90	8.297	4.356	0.26	0.46	0.66	1.42
H	18.380	10.12	8.837	12.630	18.450	10.18	8.901	12.840	0.38	0.59	0.72	1.66
I	5.752	3.327	2.547	23.960	5.851	3.396	2.606	24.860	1.72	2.07	2.32	3.76

Table 6-4 presents results for all nine model compounds (A to I). First, the results of the original FOCUS scenario a presented (columns 2 to 5). Columns 6 to 9 show the respective results for Norwegian conditions (including temperature correction according to the Arrhenius equation, as presented above). The final 4 columns present the differences (%) between FOCUS results and the adapted result. The maximum concentrations (sw) were affected by up to 7.63% (compound B). This is a significant effect considering the temperature change was only -1 °C. The temperature effect for longer time periods is even bigger (see e.g., the 21 days, Time Weighted Average (TWA) concentrations or the concentrations in sediment). In general, the effect for short-lived compounds (A, B, C) was found to be higher than for more persistent compounds (G, H, I). However, independent of the temperature shift, the general pattern of the concentrations was similar.

Low concentrations under the FOCUS weather conditions also remain relatively low under Norwegian conditions, and vice versa. The results for the other scenarios can be found in Appendix II.

6.2 The effect of temperature on the Norwegian scenarios

By running the different scenarios with endpoints agreed upon in EU and climate files from Norway, Bolli et al. (2011) were able to examine the direct effect of precipitation on transport, and temperature on degradation. Leaching increased (80th percentile) for all pesticides tested (propiconazole, isoproturon and metalaxyl) at almost all the sites (locations), when using Norwegian climate data in comparison to simulations using site specific climate data (figure 6-1, figure 6-2 and figure 6-3). However, the direct effect of using the Norwegian climate file in the simulations was relatively low, especially for the mobile fungicide metalaxyl. The pesticide PEC in the Swedish scenario Krusenberg was the most affected by the Norwegian climate file. Using Norwegian endpoints for degradation and sorption gave more effects on the leaching. This increased leaching for all sites. The leaching of metalaxyl was most increased by the Norwegian endpoints, while the leaching of isoproturon was less increased. When applying the Norwegian climate file and Norwegian endpoints, the leaching of all pesticides increased even more (figure 6-1, figure 6-2, Figure 6-3).

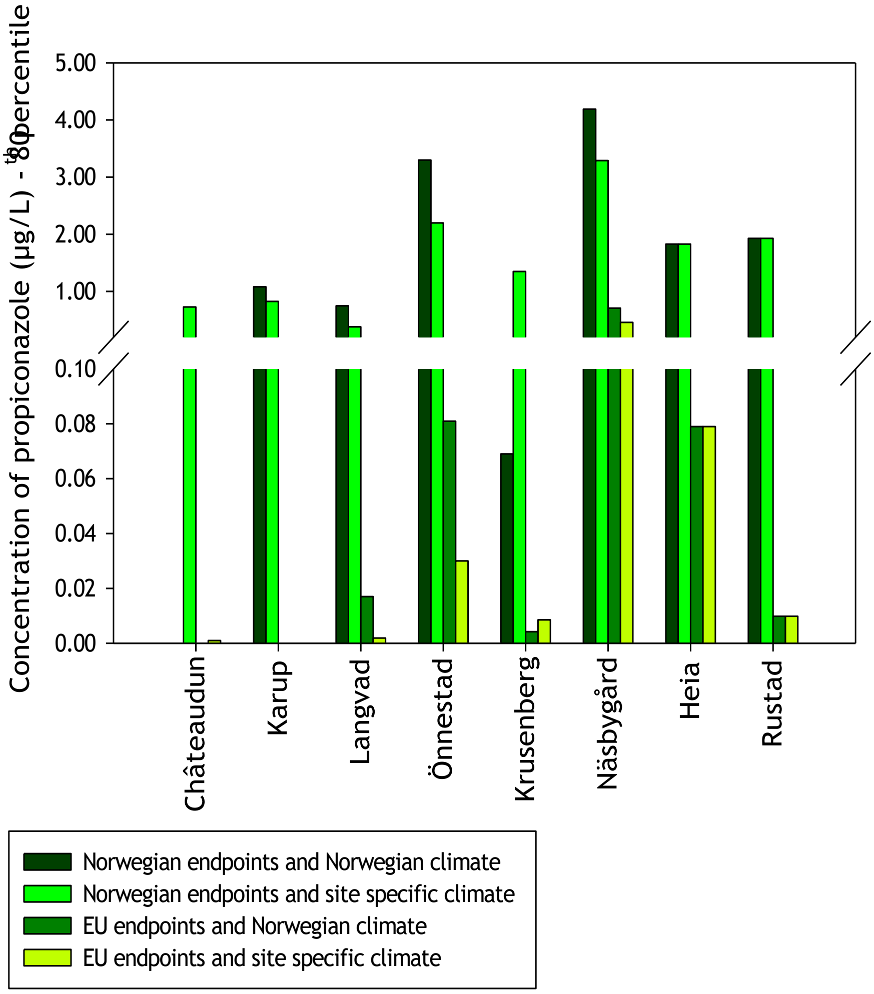

Figure 6-1. Leaching of propiconazole (80th percentile) from different scenarios, using Norwegian endpoints and EU endpoints together with Norwegian climate file and scenario specific climate files simulated with MACRO (Bolli et al., 2011). (EU endpoints table 2-23, and Norwegian endpoints table 2-25 and table 2-26).

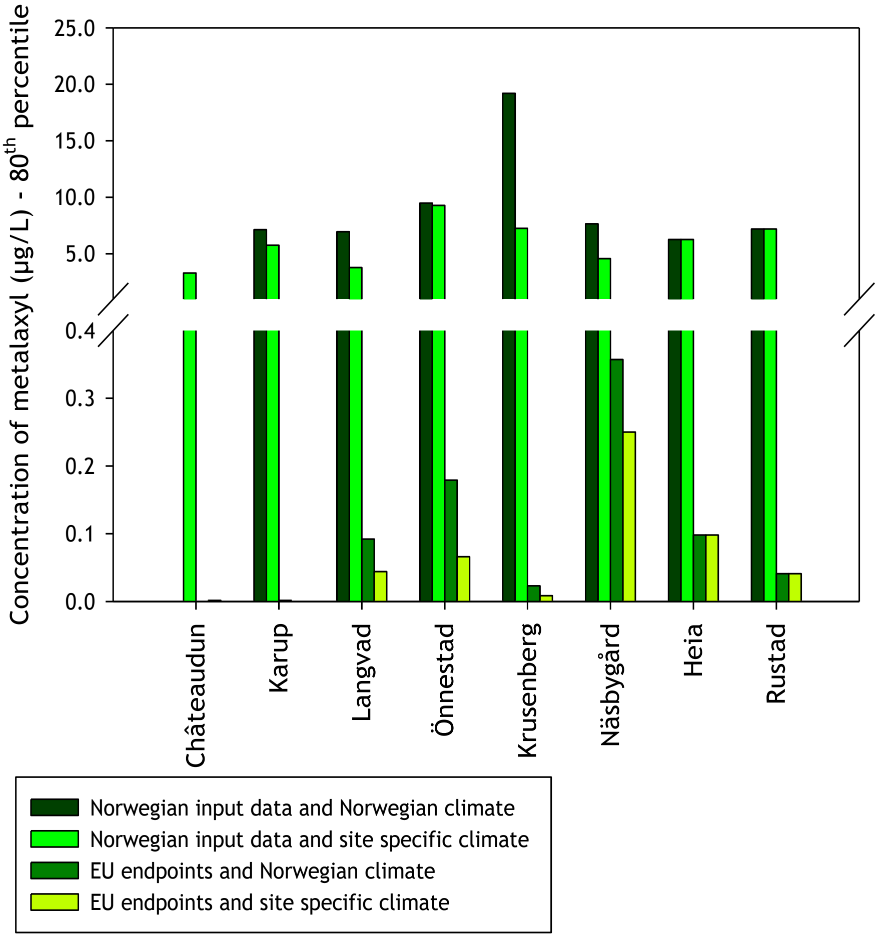

Figure 6-2. Leaching of metalaxyl (80th percentile) from different scenarios, using Norwegian endpoints and EU endpoints together with a Norwegian climate file and scenario specific climate files simulated with MACRO (Bolli et al., 2011). (EU endpoints table 2-23 and Norwegian endpoints table 2-25 and table 2-26).

Figure 6-3. Leaching of propiconazole (80th percentile) from the Norwegian scenarios, using Norwegian endpoints and EU endpoints together with a Norwegian climate file. Heia and Rustad simulated with MACRO. Syverud simulated with WISPE (Bolli et al., 2011).

NIBIO and Waterborne recently compared WISPE and FOCUS SWASH with the EU scenarios and the Norwegian scenarios by simulating PEC min and max values of the total load into the waterbody (Ritter, 2021). In general, the annual pesticide mass loadings are within the same range when comparing WISPE to SWASH. As expected, as the Koc increases, the mass dissolved in the runoff decreases and the mass in the eroded sediment increases (table 6-5).

Table 6-5. Summary of minimum and maximum annual total loadings (kg/ha) of pesticide in the surface water from winter cereals (WC) and potatoes simulated with WISPE and SWASH (Ritter, 2021)

Model	Scenario	koc=10 min	koc=10 max	koc=1000 min	koc=1000 Max	koc=10000 min	koc=10000 max
WISPE	Bjornebekk_WCereal_SW	9.77E-06	2.70E-03	5.71E-04	3.07E-03	6.64E-04	2.53E-03
WISPE	Syverud_WCereal_SW	5.86E-05	3.26E-03	6.93E-04	3.08E-03	9.77E-04	4.02E-03
WISPE	Heia_Wcereal_SW	3.12E-05	2.83E-03	5.82E-04	2.77E-03	1.29E-04	7.90E-04
SWASH	Weiherbach, Germany -R1_WC	7.82E-09	1.10E-03	7.30E-05	6.95E-04	1.80E-05	7.28E-04
SWASH	Bologna, Italy – R3_WC	4.48E-06	4.64E-03	1.06E-04	2.67E-03	3.50E-05	1.70E-03
SWASH	Roujan, France – R4_WC	1.56E-06	8.82E-03	3.56E-04	5.45E-03	1.07E-04	2.44E-03
WISPE	Bjornebekk_Potatoes_SW	3.11E-06	4.19E-03	6.67E-04	3.21E-03	5.94E-04	3.31E-03
WISPE	Syverud_Potatoes_SW	4.54E-06	5.02E-03	6.31E-04	3.61E-03	9.65E-04	3.97E-03
SWASH	Weiherbach, Germany -R1_Potatos	9.21E-09	3.82E-03	1.95E-04	2.65E-03	2.22E-04	2.07E-03
SWASH	Porto, Portugal – R2_Potatoes	2.25E-07	2.29E-03	1.72E-04	1.96E-03	1.97E-04	2.12E-03
SWASH	Bologna, Italy – R3_Potatoes	6.82E-06	5.53E-03	3.20E-04	2.41E-03	2.58E-04	1.66E-03

Table 6-6 Results from SWASH simulations with use of metalaxyl in vegetables. Route of exposure is based on when the peak concentration (PEC global max concentration) happens and the date of application (Holten, 2021).

Substance	Crop	Scenario	Water body	Application window	Application date	Results, PECsw, global max, µg/L	Global max, date	Route of exposure D=Drainage, A=Spray drift, R=Runoff
Metalaxyl	Root vegetables/ carrot	D3	Ditch	17/4-17/5[1] (107-137)	20.apr	2.299	20.apr	A
		D6	Ditch	17/2-19/3[2] (48-78)	27.feb	2.392	27.feb	A
		R1	Pond	7/4-12/5[3] (97-132)	23.apr	0.717	07.mai	R
		R1	Stream	7/4-12/5[3] (97-132)	23.apr	8.919	04.mai	R
		R2	Stream	20/2-22/3[4] (51-81)	06.mar	4.619	16.mar	R
		R3	Stream	7/4-7/5[5] (97-127)	11.apr	9.674	20.apr	R
		R4	Stream	7/4-7/5[6] (97-127)	11.apr	14.865	17.apr	R

Concluding remarks: Simulation with the FOCUS scenarios and Norwegian scenarios give indication that the contribution from spray-drift, surface and drainage runoff can be assessed and based on the time of the peak concentration. The contribution of drift, surface runoff and drainage have to be evaluated from case-to-case dependent on crop, pesticide property and climate. Using FOCUS scenarios for Norwegian conditions temperature correction are necessary. WISPE which is calibrated for the Norwegian conditions can be a good alternative to the FOCUS SWASH scenario.

7 Uncertainties

Uncertainties regarding the surface scenarios in EU has been outlined in detail in the document FOCUS Surface Water Scenarios Final 03 March 2009 (FOCUS, 2001). The Norwegian scenarios are described in detail in Bolli et al. (2013). In the EU FOCUS scenarios, uncertainty is discussed with respect to the selection and characterization of the scenarios, and with respect to the models themselves to simulate exposure. The procedure of approving new pesticides is based on a tiered approach (step 1 -4). Step 1 and 2 is not meant to incorporate any realistic environmental characteristics, but to include simple conservative degradation mechanisms within a simplified water body. In step 3, an attempt has been made to identify a set of realistic worst-case environmental scenarios based on a range of climatic, topographic, soil, cropping and surface water characteristics. According to the FOCUS document it is not possible to represent all agronomic situations that result in the transport of agricultural chemicals to the surface water bodies. To make the scenarios as broadly applicable as possible, maps of geographic locations that were reasonably similar to the specific situation being modelled were developed. The same strategy has been used for the Norwegian situation to identify locations based on seasonal values for temperature which influence the degradation rate, seasonal rainfall is used for drainage scenarios and seasonal rainfall for run-off scenarios as recharge was not available. Similarly, soil characteristics were used to identify areas susceptible for preferential flow and soil hydrology group.

These characteristics have then been used to parameterize the model and especially two sources of uncertainty arise from the process: spatial variability of environmental characteristics and the choice of input parameters for the modelling.

7.1 Spatial variability

The environmental characteristics include local weather, crop growth, slope and soil characteristics and water body hydrology. The FOCUS methodology is mainly based on topsoil characteristics, but the horizon below the plow layer in not considered as used by WRB system for soil description not used in this analysis. In most cases the selected parameters were based on actual measurements from the representative sites, but often represent average field values with local spatial variability and analytical uncertainty. Minor changes to properties can change model prediction especially for model-sensitive parameters.

Weather data represent a special case of uncertainty with variation from one year to another to select a representative year for the model simulation. For some regions (in Norway), the average measurement of climate for the last 20 years has changed compared to the weather 30 year normal (Appendix V). To examine this uncertainty the users are recommended to select a number of representative long-term weather datasets. Timing of pesticide application is one of the most sensitive parameters for both drainage and run-off.

Due to an additional aggregating procedure of the landcover map in order to harmonise the spatial resolution in the different thematic maps the agricultural area was overrepresented in the analysis at the cost of natural vegetation and complex cultivation patterns. The consequence was that the total agricultural area of 15137 km² considered in the map was too high compared to the real situation in Norway. It is not considered that the additional area would discredit the results of the evaluation. In contrast, it guarantees that all environmental conditions in Norwegian agriculture are indeed considered.

7.2 Model parameterization

Some of the parameters used in the models require measurement or are derived by algorithms. These are often difficult to measure or sometimes not measured at the representative site. Each model has uncertainties associated with parameterization of the specific model, rule-based estimation or expert judgement. The FOCUS report (FOCUS, 2001) recommend undertaking a model sensitivity analysis to identify the parameters that are most likely to affect prediction because of the uncertainty of their derivation. Errors in model simulations arise from two sources: model error and parameter error. Model errors are caused either by incorrect or oversimplified description of the process in the model, or neglecting significant processes (Loague and Green, 1991).

7.2.1 Drainage scenarios

In the EU FOCUS report (FOCUS, 2001), revised in 2009, parameter errors are discussed for the MACRO model which is used for the 6 FOCUS drainage scenarios. Whenever possible, the scenarios have been parameterized from a combination of direct measurements and model calibration. Four of the six have been pre-calibrated, while the remaining represent blind simulations. Comparing tests and experimental data indicated that leaching was generally underestimated due to sorption in the macropore region (Beulke et al., 1999). Water balance has been calibrated and tested in four of the scenarios, but only for one crop. Crop parameters have been obtained from literature and included in the WISPE mode.

7.2.2 Surface scenarios

Several factors which cause uncertainty in the simulation of run-off with PRZM are summarized in the FOCUS report. These factors include limited calibration, temporal resolution of precipitation run-off and erosion, using edge of field run-off and erosion, using deterministic modelling and conceptual description of run-off scenarios.

Daily weather data due to lack of information of each run-off events and can influence the simulation of chemical losses. Run-off and erosion values represent volumes and concentrations at the edge of the field and does not include effects of the landscape and vegetated zones, but post-processing tools have been provided to evaluate the effect of such mitigation tools.

7.2.3 Spray drift deposition

Spray drift deposition depend on a variety of environmental and application factors like wind speed, driving speed, spray boom height, nozzle types, spray pressure and air assisted techniques. All these factors influence the spray drift data and, in this way, introduce uncertainty. In the FOCUS scenarios, spray drift depositions are based on a German drift database (Ganzelmeier et al., 1995; Rautmann et al., 2001). This database is frequently used in the EU evaluation process. Especially during the last year, more focus has been on nozzle types and crop height related to spray boom and speed. The FOCUS group recommend standardizing the methods for measuring drift deposition and drift reduction. National guidance has been established to reduce spray drift deposition in most of the European countries (Germany, the Netherlands, United Kingdom, Denmark, Sweden etc.). Also, in Norway such guidance has been established (Mattilsynet, 2020).

The uncertainties in modelling surface water has been described in the FOCUS document (FOCUS, 2001) and later in documents from Germany (Bach et al., 2016; Klein, 2011) and England (DEFRA, 2008; Hollis, 2007). These sources are mainly split in two categories: conceptual or the usage of the different models. Conceptual may be selection of scenario, configuration of field, tile drainage network, water bodies and watershed, and/or selection of representative weather years. The use of different models includes selection of parameters, limitations of the algorithms in the model and limitations of the model, temporal and spatial. Specific details are described in the FOCUS report.

8 Conclusions (with answers to the terms of reference)

1. ToR1. To identify agricultural areas in Norway that are «represented» by soil and climate conditions in the ten FOCUS surface water standard scenarios or the four national scenarios and quantify the size and spatial distribution of these areas.

Surface run-off

FOCUS-scenarios. There are no locations in Norway which completely fulfil the 4 FOCUS surface run-off definitions. This is mainly due to the low temperature conditions. However, FOCUS surface water simulation could be corrected for temperature either by changing the respective pesticide information (half-life of the pesticide) or by changing the original FOCUS climate files. After temperature correction, there are no agricultural fields for which the EU FOCUS scenarios should be less protective than the original FOCUS locations. 5% of the agricultural area cannot be assigned to any of the FOCUS scenarios, because the soils do not have texture and high content of organic matter (e.g., histosols). An overview of the spatial distribution of the level of protection when using the EU-FOCUS runoff scenarios is presented in figure 8-1.

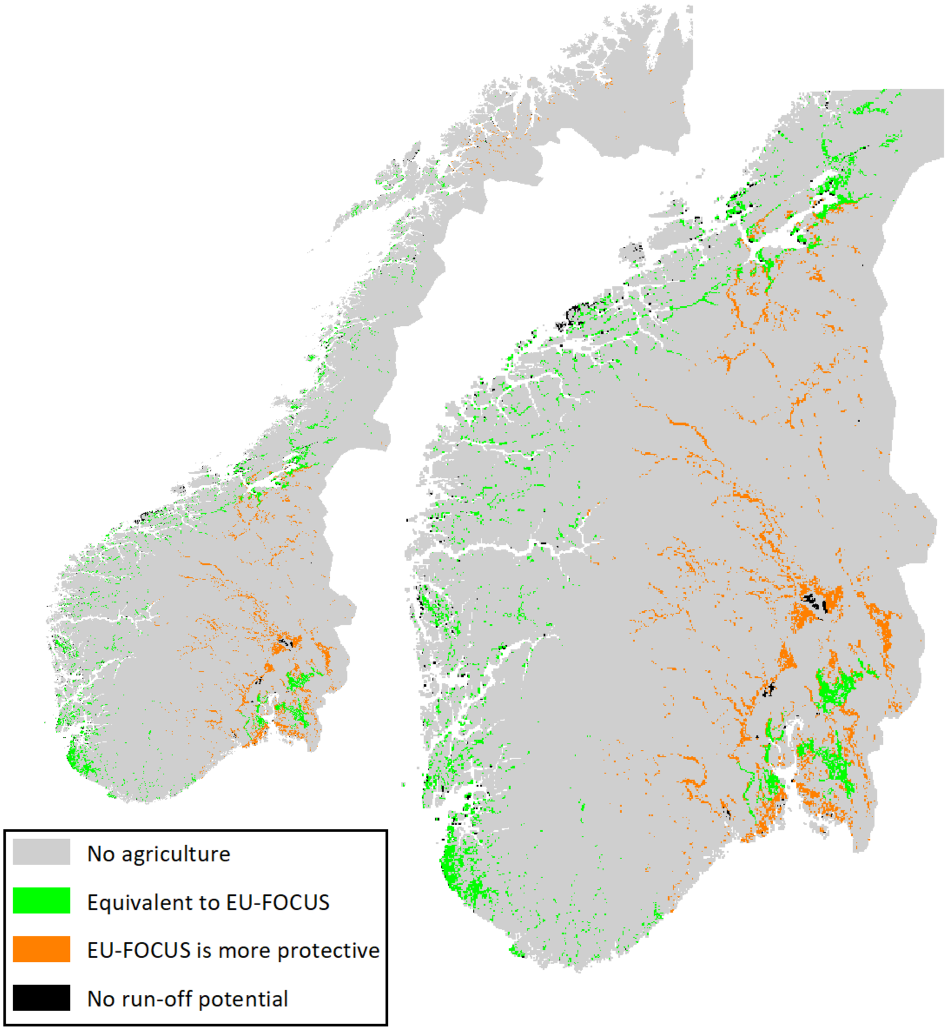

Figure 8-1. Assignment of agricultural areas to FOCUS run-off scenarios with regard to the level of protection after temperature correction

Norwegian scenarios. In contrast to the European FOCUS scenarios, which did not completely fit to the Norwegian conditions (mainly because of the scenario temperature), the Norwegian run-off scenarios fit much better to the temperatures observed in Norwegian agricultural areas: 44% of fields show differences below 1 °C, whereas 83% of the fields show differences below 2.5 °C compared to the scenario conditions.

However, apart from the satisfying temperature match, only 3.4% of the agricultural area (515 km²) have the same properties regarding rainfall and texture as the two scenarios Syverud (NR1) or Bjørnebekk (NR2). Further 58.8% of the fields (8883 km²) can be considered less vulnerable than the original scenarios. Nevertheless, a certain scenario can always be assigned to this area. Using the Norwegian scenarios in these fields should guarantee a higher level of protection than the original scenarios. That means the Norwegian run-off scenarios Syverud (NR1) and Bjørnebekk (NR2) are able to protect 62.2% (i.e. 3.4% + 58.8%) of the Norwegian agricultural land. The scenarios do for sure not cover 4.3 % of the agricultural area (651 km²). For 28.6% of the area, the situation is open because the soils in these agricultural areas are less vulnerable, whereas rainfall is higher. In principle, this unfortunate situation could be solved by combining the soil with a station having more rainfall than the original scenario. An overview of the spatial distribution of the level of protection when using the Norwegian run-off scenarios is presented in figure 8-2.

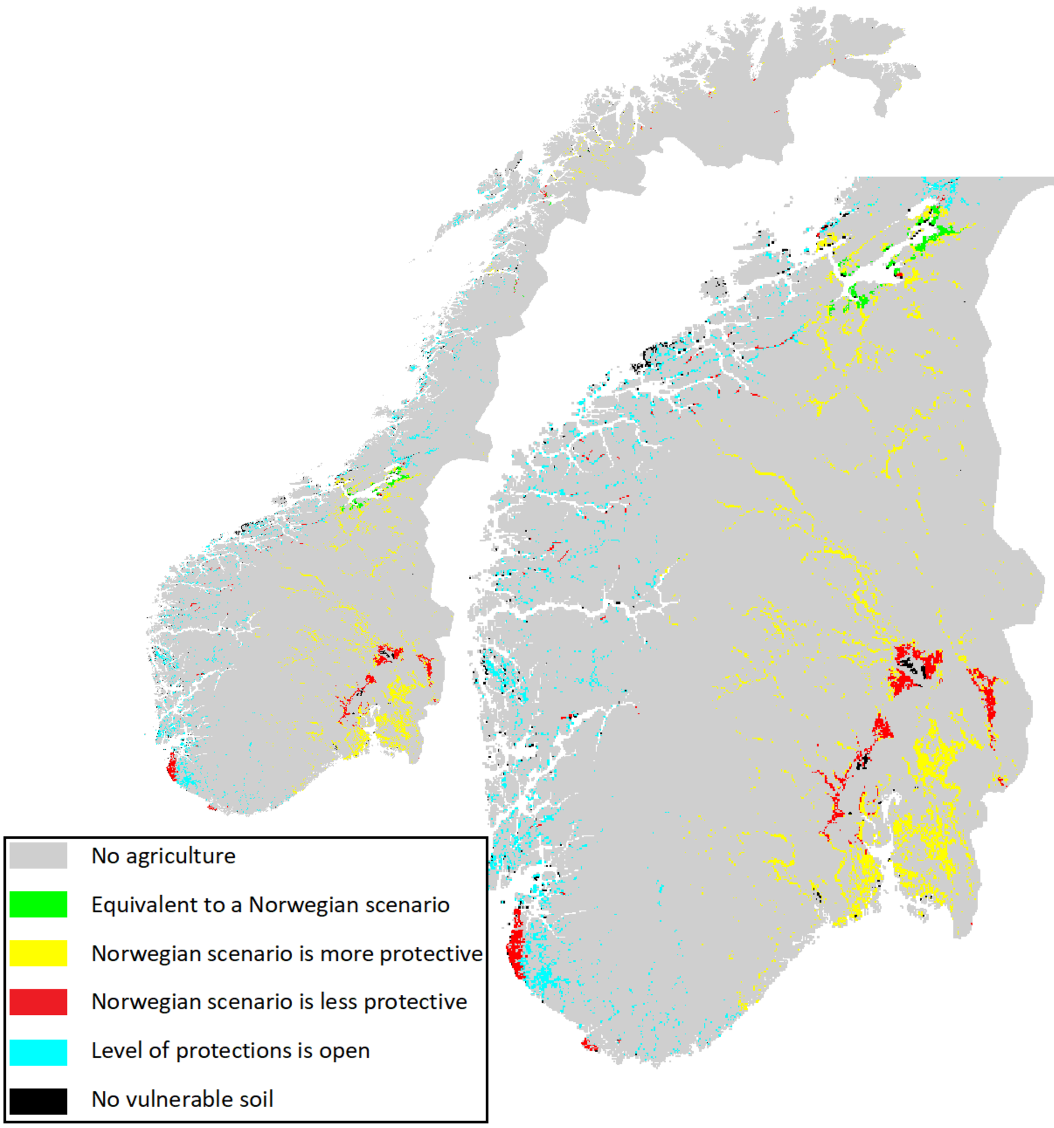

Figure 8-2. Assignment of agricultural areas to Norwegian run-off scenarios with regard to the level of protection

Drainage to surface water

FOCUS scenarios. There are no agricultural areas in Norway where all scenario parameters (soil texture, temperature, rainfall, slope, organic matter) are comparable to the EU FOCUS drainage scenarios. The main reasons for these differences are steep slopes, high rainfall and low temperature conditions. However, at least FOCUS surface water simulation can be adjusted for temperature either by changing the standard temperature (usually 20 °C) of the respective pesticide information or by changing the original FOCUS climate files. 5.0% of the agricultural area have high content of organic matter, and cannot be assigned to any FOCUS scenario, e.g. histosols). In order to use the FOCUS scenarios for Norwegian conditions, temperature correction is recommended either by changing the respective pesticide information (DegT50, easy solution) or by changing the original FOCUS climate files (complicated solution). This is especially important for D3 (original location NL) and D4 (Skousbo), whereas a correction for D1 (Lanna) doesn't seem to be necessary. After having adapted the FOCUS scenarios to Norwegian conditions, many locations in Norway fulfil at least part of the FOCUS drainage definitions. For these locations, the EU-FOCUS scenarios could represent either a higher or lower protection level. In this analysis, it is assumed that higher organic matter contents in the topsoil compared to the EU drainage scenarios, will increase the level of protection for drainage scenarios. Assuming that the EU FOCUS drainage scenarios can be used for Norwegian agricultural areas if they represent either a similar or a higher level of protection. 51.5% of the agricultural land in Norway is covered by the EU FOCUS drainage scenarios. An overview of the spatial distribution of the level of protection when using the EU-FOCUS drainage scenarios is presented in figure 8-3.

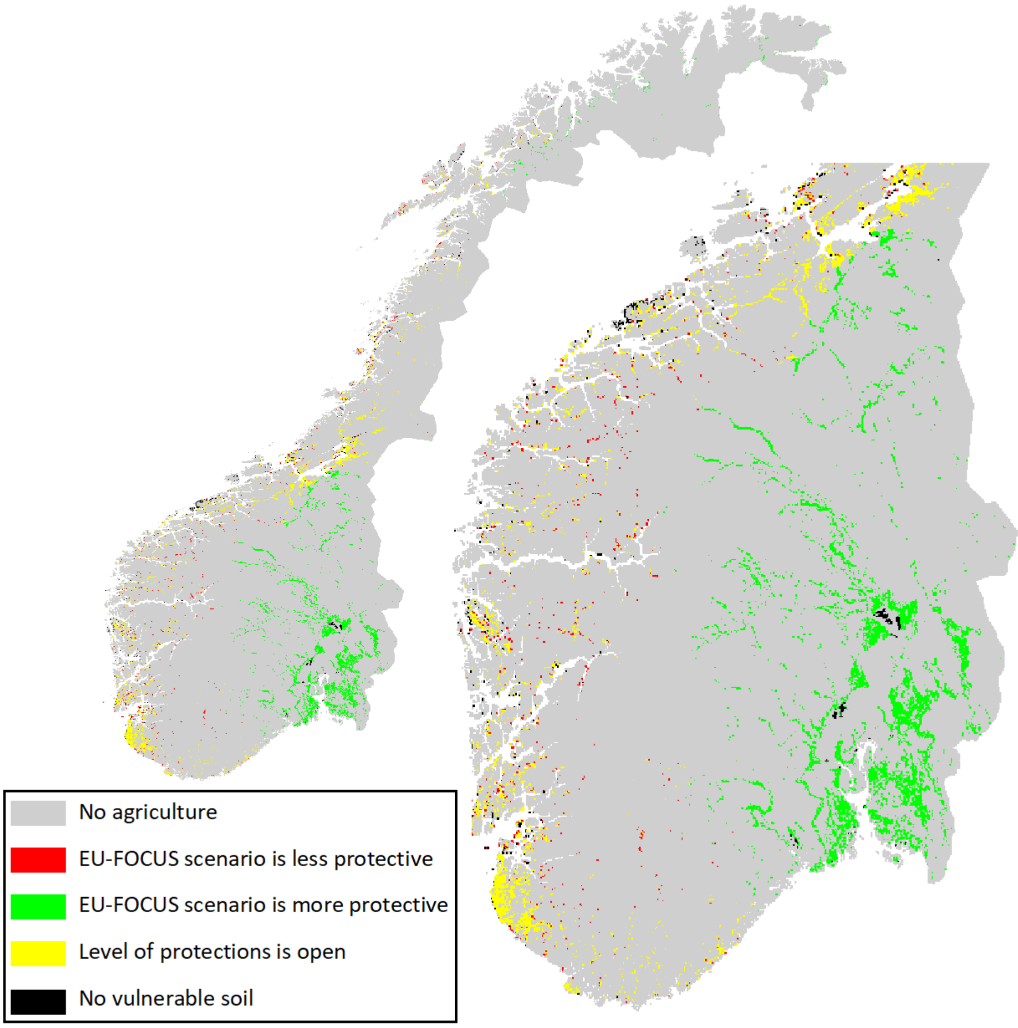

Figure 8-3. Assignment of agricultural areas to FOCUS drainage scenarios with regard to the level of protection

Norwegian scenarios. The two Norwegian drainage scenarios Rustad and Heia represent 95% of the agricultural area in Norway (14378 km²) when considering the soil texture class as key parameter. The most relevant is Heia (ND2, soil texture class 1, coarse) corresponding to about two-thirds of the area (10241 km², 67.7%). The other scenario Rustad covers 14% of the agricultural area (2014 km²). 13.3% of the agricultural area (2123 km²) is not covered by the two Norwegian scenarios because the soil texture class (medium) is not met neither by Rustad (medium fine) nor by Heia (coarse). However, it was decided to consider the scenario Rustad for these areas as a worst-case approach. 5.0% of the agricultural area (759 km²) have no drainage potential because the respective soils have no texture (e.g., histosols).

15.3% of the agricultural area have a comparable organic matter content whereas in 79.7% of the agricultural fields higher organic matter must be considered. It is assumed that - similar to a steeper slope - higher organic matter would also increase the level of protection. Comparing the rainfall in the different agricultural areas with the rainfall of the two Norwegian drainage scenarios 52% (6238 km²) have similar annual rainfall as the Norwegian drainage scenarios whereas 39.8% (6017 km²) of the areas are characterised by more rainfall than to the original scenario (i.e., > 729 mm for Rustad and >829 mm for Heia). It is assumed that locations with higher rainfall than the original scenario are less protected because more rainfall will increase the drain flow at these locations.

If the Norwegian drainage scenarios are considered for the risk assessment, 7867 km² (52%) of the agricultural area in Norway are protected by a higher level than the situation described in the original scenario. This is caused by higher organic matter content and steeper slopes in these areas. An overview of the spatial distribution of the level of protection when using the Norwegian drainage scenarios is presented in figure 8-4.

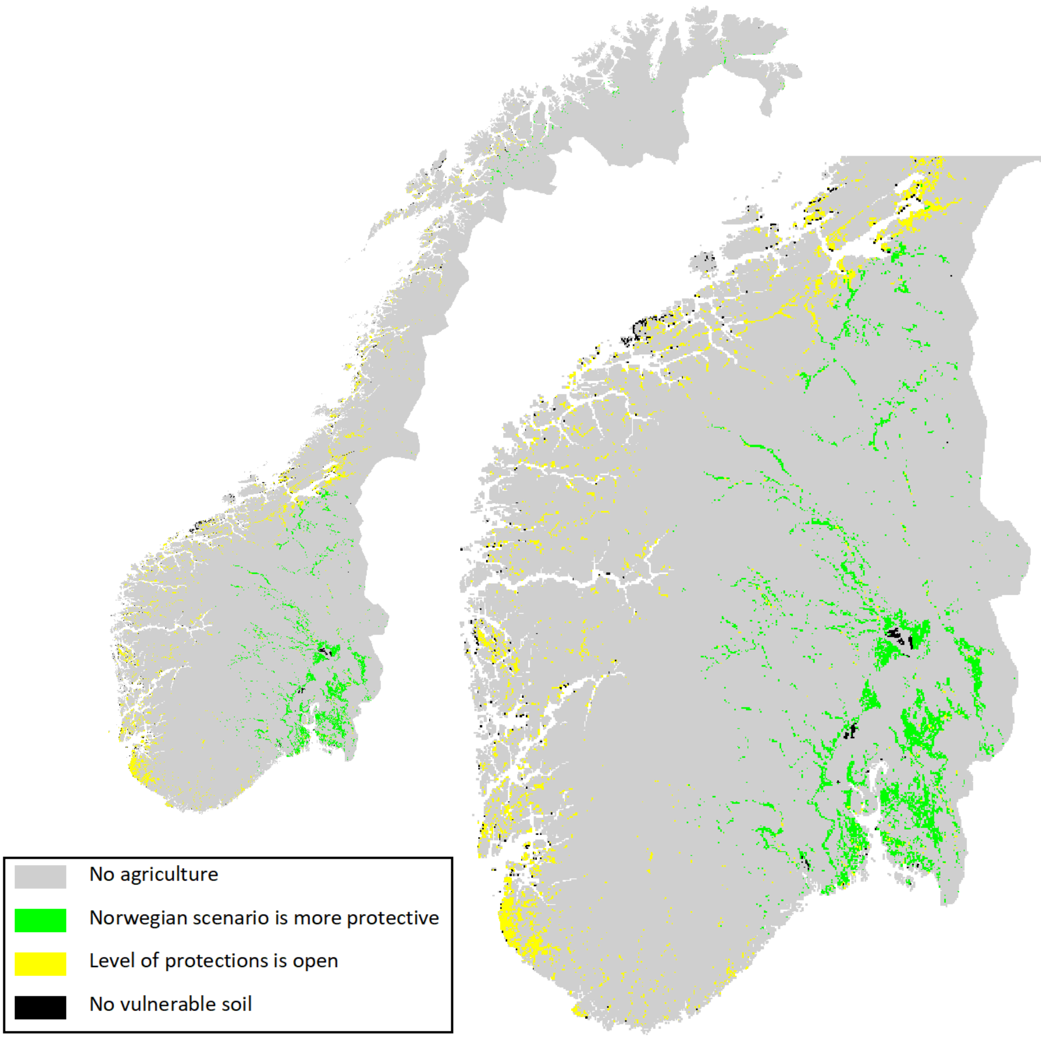

Figure 8-4. Assignment of agricultural areas to FOCUS drainage scenarios with regard to the level of protection

2. ToR2. Determine how worst-case the areas identified in objective 1 are in terms of surface water exposure potential compared to agricultural land across Norway, and if they could be considered protective of additional areas, even if they are not directly representative. Please see section 3.2 and 3.5 in FOCUS (2001) for an example «worst case assessment».

EU-FOCUS scenarios.

Run-off. Applying the worst-case scenarios of the FOCUS surface runoff scenarios on the agricultural land in Norway, the scenario R1 from Weiherbach (Germany) represent the worst case according to the temperature. Despite the fact that R1is the worst case for temperature in EU, this scenario and none of the other scenarios cover the Norwegian conditions. The soil texture of R1 (Weiherbach) and R3 (Bologna) are classified as worst-case (medium fine with by-pass flow) and this is one of the main soil types of agricultural land across Norway used for cereal production.

53.1% of the agricultural area were found to be in line with one of the FOCUS surface runoff scenarios assumed temperature correction have been made. Further 45.1% of the agricultural field can be assigned to R2 or R4 but the fields are characterised by less rainfall than the EU FOCUS scenarios. Therefore, the EU-FOCUS scenarios can be considered especially protective for these Norwegian agricultural fields. After a temperature correction there are no agricultural fields for which the EU FOCUS scenarios should be less protective than the original FOCUS locations.

The area in Norway which is the analogue of the FOCUS scenarios R2 (Porto) is the area in Rogaland and the west coast of Norway. More protected area with less precipitation and same texture is the area outside the morene ridge (raet) close to Oslofjorden and the northern part and valleys of South Eastern Norway and Trøndelag.

After temperature correction and excluding non-vulnerable areas and flat areas, R1 (Weiherbach) cover 3.2 % of the vulnerable areas for run-off and equivalent to the FOCUS scenario. The scenario R2 (Porto) cover 67.6 % of the vulnerable soil, of which 36.4 % of the area is more protective compared to the EU FOCUS scenario, because of higher organic matter content. The R3 from Bologna cover 10.9 % of the area, which is equivalent to the FOCUS scenario. The scenario from Roujan (R4) cover 13.3 % of the vulnerable soils, while 8.7 % of this area is more protective because of high content of organic matter (table 3-5).

Drainage. Regarding temperature, the drainage scenarios D1 from Lanna (Sweden) is characterized as extreme worst case in the EU context. Based on the temperature criterion three EU-drainage scenarios are recommended to be used in Norwegian risk assessment: D1 (Lanna, Sweden), D3 (Vredepeel, The Netherlands) and D4 (Skousbo, Denmark).

Based on the temperature criterion, three EU-drainage scenarios are recommended to be used in Norwegian risk assessment: D1 (Lanna, Sweden), D3 (Vredepeel, The Netherlands) and D4 (Skousbo, Denmark).

The Norwegian scenarios. All the Norwegian scenarios are better reflecting temperature conditions in Norway than the EU FOCUS scenarios. However, they nevertheless do not describe worst case conditions for all agricultural areas in Norway. Especially, the agricultural areas close to the west coast are not protected because the rainfall of the scenarios is significantly lower than the rainfall at these areas.

Run-off. The scenario Syverud (NR1) was assigned to this class which can be considered a worst-case assumption. The scenarios do clearly not cover 4.3 % of the agricultural area.

Drainage. 13.3 % of the agricultural area (2123 km²) is not covered by the two Norwegian scenarios because the soil texture class (medium) is not met, neither by Rustad (medium fine) nor by Heia (coarse). However, the Rustad scenario was considered for these areas as a worst-case approach. However, neither Rustad (soil texture class "medium fine") nor Heia (soil texture class "coarse") can be considered representative for the soil texture class "medium". Nevertheless, in this analysis the scenario Rustad with its "medium fine" soil texture was considered as a surrogate for the agricultural areas with "medium" soil texture. This choice can be considered a worst-case assumption.

3. To identify the characteristics and spatial distribution of all agricultural land in Norway that is not represented by any of the ten FOCUS surface water scenarios or the four national scenarios.

FOCUS runoff. There are no locations in Norway, which completely fulfil the FOCUS surface water definitions insofar that, it could be assumed that the complete agricultural area is not represented by any of the ten FOCUS surface water scenarios.

There is no agricultural area that can be excluded due to rainfall alone as criterion for surface run-off. When applying the strict FOCUS definition of the soil texture and annual precipitation, all FOCUS scenarios can be located in Norway. When run-off is classified/grouped based on both rainfall and soil texture, about two-thirds (1100 km^2) of the agricultural area in Norway did not meet the FOCUS key properties probably because the Norwegian soils were too sandy compared to the FOCUS definitions. If organic matter content is used as an additional parameter for the analysis, only 7.3 % of the vulnerable agricultural area in Norway can be assigned to one of the FOCUS-run-off scenarios including exact organic matter class. No locations were identified where the temperature range was comparable to the FOCUS definition.

However, FOCUS surface water simulations could be temperature corrected either by changing the respective pesticide standard temperature information (usually 20 °C) or by changing the original FOCUS climate files. After adapting the FOCUS scenario temperatures to Norwegian conditions, many locations in Norway fulfil at least part of the FOCUS run-off definitions. It is generally assumed that a scenario, which describes a worst-case situation compared to the agricultural area (e.g., because higher levels of rainfall is defined in the scenario than typical for the location) it is considered that the region is "covered by the scenario" and the level of protection is especially high. Consequently, agricultural areas where no scenario could be found equivalent or more protective are not covered. According to information provided in table 3-5 these areas do not exist for the entry path "run-off" (see also figure 8-1).

FOCUS drainage. However, the situation is different for the FOCUS drainage scenarios (table 3-11): 1217 km^2 (8%) of the agricultural land is surely less protected because these areas are too wet, compared to the most representative EU FOCUS drainage scenario (D3). For an additional 35.6% of the agricultural land, the level of protection is open because the locations are too wet compared to FOCUS, but it could not be evaluated whether the additional rainfall could be compensated for, by higher organic matter content or steeper slopes in this area. The spatial distribution of these areas can be found in figure 8-3. More detailed information is also given in table 3-11.

Norwegian run-off. In contrast to the European FOCUS scenarios, which did not completely fit the Norwegian conditions (mainly because of the scenario temperature), the temperature conditions of the Norwegian run-off scenarios Syverud, and Bjørnebekk fit the agricultural area in Norway much better. However, as shown in table 3-16, 4.3% of the agricultural land are surely less protected, because these areas are having more rainfall than the most representative Norwegian scenario. For an additional 28.6% of the Norwegian agricultural land, the protectiveness is open because it was not possible to evaluate whether the additional rainfall could be compensated for, by higher organic matter content or more slopes in this area. The spatial distribution of these agricultural areas is presented in figure 8-2.

In conclusion, regarding the Norwegian run-off scenarios, their representativeness is lower than the EU FOCUS run-off scenarios because they are drier than many Norwegian fields and an easy correction (as for temperature) cannot be made for rainfall.

Norwegian drainage. With regard to the Norwegian drainage (originally groundwater) scenarios, Rustad and Heia, there are no areas which are definitely less protected than the level provided by the original scenario. However, for 6511 km² (43.1%) of the agricultural area, the situation is not clear as to whether the high rainfall at these locations is compensated for by higher slopes and/or higher organic matter contents. Thus, the situation is open and rather similar to the representativeness of the EU FOCUS scenario (after temperature correction). The spatial distribution of these agricultural areas is presented in figure 8-4.

In order to increase the representativeness of the Norwegian (or EU drainage) scenarios, an additional scenario should be defined which is located in a Norwegian agricultural region with a significantly higher level of rainfall than the existing scenarios.

4. To assess the relative importance of surface run-off (both dissolved and particulate phases), drain flow and spray drift as routes of aquatic exposure to pesticides in Norway based on pedoclimatic characteristics.

In this evaluation, several maps were used to analyze the representativeness of the EU FOCUS and the Norwegian surface water scenarios for Norwegian agricultural conditions. The procedure mainly followed the principles described in the FOCUS surface water report (FOCUS, 2001). This means that the evaluation compared the scenarios conditions (e.g., rainfall, temperature, soil type, slope) with spatial information from the Norwegian agricultural land. Furthermore, as a general principle, FOCUS presumes that surface water scenarios (ditches, streams, ponds) are always in existence, close to the agricultural area. This principle was followed in this evaluation as well, and no special maps, which show the true distribution and dimension of surface water bodies, were considered. The consequence is that a definite statement about the relative importance of surface run-off (both dissolved and particulate phases), drain flow and spray drift as routes of aquatic exposure could not be made. For information on the general importance and representativeness of run-off and drainage, please consider answers to ToR 1 - ToR 3. With regards to the relative importance of entry routes (independent on the spatial distribution of surface water bodies), test simulations were performed that show the influence of pesticide properties on the maximum concentration in default surface water bodies caused by the drainage, spray-drift and run-off events. The following results were obtained:

Transport through the drainage system is assumed in the FOCUS models, to occur purely via the dissolved phase. Contribution from run-off events is distributed between the water phase (run-off) and the sediment phase (erosion). Input via the water phase is dominant. Only if the chemicals are strongly sorbed to soil (Koc > 2000 L/kg), may the entry route via soil erosion be relevant. The FOCUS models do not provide information about the distribution between water and sediment directly. The model Exposit (Bach et al., 2017), uses the evaluation by Reichenberger et al. (2007b) for the calculation of run-off entries (table 6-3).

In the FOCUS scenarios, spray drift depositions are based on a German drift database (Ganzelmeier et al., 1995; Rautmann et al., 2001). This database is frequently used in the EU evaluation process. Especially during the last year, more focus has been on the nozzle types and crop height related to spray boom and speed. The FOCUS group recommend standardizing the methods for measuring drift deposition and drift reduction. National guidance has been established to reduce spray drift deposition in most of the European countries (Germany, the Netherlands, United Kingdom, Denmark, Sweden etc). Also, in Norway such guidance was established in 2020 (Mattilsynet, 2020).

Generally, temperature influences many processes in the environment. The most relevant process for the FOCUS scenarios is its influence on degradation. That means that degradation will be reduced by approximately 50% on a given day / daily basis? if the temperatures in Norway are on average 7 °C below the respective FOCUS EU scenario. A simple correction would be to apply a reduction of 50 % for the degradation rate.

The NFSA would also like the Scientific Committee to give their opinion on these questions:

a) Considering the protection goals for human health and the environment set down in relevant legislation, as well as the findings of this study, which FOCUS scenarios and/or national scenarios should companies use when calculating predicted environmental concentrations (PECs) for Norwegian risk assessments?

The analysis showed that drainage as an entry route to Norwegian surface water bodies does not usually play a dominant role. Reasons behind this conclusion are the sandy soils and the steep fields in Norway. Nevertheless, D3 (sandy soil, location NL) or Heia (sandy soil, location NOR) could be used as most relevant scenarios to address the drainage situation in Norway in sandy soils. However, an adequate correction to Norwegian temperature conditions would be essential when using D3.

With regards to loamy or clay soils in Norwegian agricultural areas where artificial drainage is prevalent, it is recommended to use D1 (Lanna, location Sweden) or Rustad (location Norway), both silty clay loams, as representative drainage scenarios.

b) How confident is the Scientific Committee that the scenarios recommended in question a) provide a sufficiently high level of protection for Norwegian agricultural areas as a whole?

Norwegian agricultural fields are in general characterized by sandy soils with high organic matter contents. In contrast, most of the FOCUS scenarios describe more vulnerable situations as they are considered to be heavy soils with low organic matter contents. Assuming that – compared to Norway – too warm FOCUS temperatures are corrected; the European FOCUS scenario would therefore guarantee a sufficient level of protection for Norwegian conditions.

c) For areas that are not sufficiently protected, or if risk assessments are uncertain, what supplementary information could be requested from companies to support PEC calculations?

The most critical parameters for the Norwegian risk assessment seem to be degradation half-life of the pesticide or temperature in the climate file. To use the FOCUS scenarios for Norwegian conditions a temperature correction is essential either by changing the respective pesticide information (DegT50, easy solution) or by changing the original FOCUS climate files (complicated solution). If temperature correction has been performed and all remaining FOCUS definitions are met it can be assumed that the FOCUS scenario represents the respective location ("equivalent to FOCUS").

d) In the context of approval of plant protection products for certain areas only, in those cases where they cannot be approved based on the regular risk assessment: Based on VKM's findings in this assessment, are there any clearly defined areas (either based on administrative units such as municipalities, or areas with a certain soil and climate) that are very well covered (with a high level of protection for health and environment) by one scenario or a combination of scenarios?

About three quarters of the Norwegian agricultural area (72.7%) has no run-off potential because the respective soils are too sandy. 86.4% of the agricultural area have no drainage potential. When only considering soil texture 95% of the agricultural area in Norway can be attributed to one of the drainage scenarios with D3 as the most relevant. If locations in Norway are characterised by more organic matter than the respective FOCUS scenario, it can be assumed that the FOCUS scenario is more protective for the specific location. In Norwegian agricultural fields compared to FOCUS, 70% of the fields have higher contents of organic matter than the FOCUS scenario.

According to the FOCUS Working Group on Surface Water Scenarios, the FOCUS scenarios were not meant to represent national scenarios for the registration of the pesticides. The intention was to develop separate national risk assessment scenarios. This exercise comparing the FOCUS scenarios with Norwegian conditions demonstrate necessary climatic correction to be relevant for Norway. This is also confirmed by development of the four

Norwegian scenarios using local climate and Norwegian endpoints (DT50) based on field experiments in Norway.

9 Data gaps

Data gaps	**Expected impact in the event of filled data gaps** **(for VKM, the assigner, and/or the society)**
For the run-off scenarios (R1-R4), there are no locations in Norway which completely fulfil the FOCUS run-off definitions. The annual temperatures in Norway are 2 to 8°C lower than the respective FOCUS scenarios. This deviation is dependent on the FOCUS scenario.	R-scenarios. In order to use the FOCUS scenarios for Norwegian conditions a temperature correction is essential either by changing the respective pesticide information (DegT50, easy solution) or by changing the original FOCUS climate files (complicated solution).
For the drainage scenarios (D1-D6), only 13.5% of the respective locations show a similar temperature range as FOCUS, and there are no fields in Norway where the spring and autumn temperatures are above the respective FOCUS scenario. The annual temperatures in Norway are 0 to 10°C lower than the respective FOCUS scenarios. This deviation is dependent on the FOCUS scenario.	D-scenarios. In order to use the FOCUS scenarios for Norwegian conditions a temperature correction is essential either by changing the respective pesticide information (DegT50, easy solution) or by changing the original FOCUS climate files (complicated solution).
The four Norwegian scenarios cover 31 % of the dominating soil type (WRB units) with representative climate in the south eastern area of Norway. The other areas have wrong soil type or different climate, especially precipitation.	To cover remaining areas, developing local climate files for these areas is necessary.
The WISPE software use the model EXAM for calculating concentration in the water (pond, ditch and stream).	Necessary to harmonize WISPE with the FOCUS scenarios. Ongoing work at NIBIO, but Authorities and Companies will decide the use
Effects of soil freezing and thawing for the Norwegian climate conditions are missing in all models used for PEC calculations.	Incorporate and develop models including these processes to have a better estimation of run-off and drainage to calculate PEC.

Data gaps	**Expected impact in the event of filled data gaps** **(for VKM, the assigner, and/or the society)**
Effects of vegetated buffer-zones are missing or are not verified in the models.	Vegetated buffer-zones are not included in the FOCUS scenarios. This is included in models like SYNOPS (using PRZM/VFSMOD), but not tested in field scale or verified. Also, SWAN which is currently used for FOCUS Step 4 simulation consider vegetated buffer zones based on the recommendations of FOCUS landscape and mitigation.
Aged sorption is not included in the FOCUS scenarios.	This will give a better estimation of degradation of the pesticides and calculation of PEC. Within the scope of the current FOCUS SW repair action, aged sorption will be included in the MACRO and PRZM models which may also improve results obtained from the FOCUS scenarios.
New data for climate show increased temperature and precipitation (annex V)	Increased temperature can change winter conditions increasing runoff and drainage, but also degradation rate of pesticides

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11 Appendix I

11.1 Litterature search from the library for healthcare administration

Kontaktperson:	Nana Yaa Boahene og Ole Martin Eklo (NMBU)
Søk:	Marita Heintz
Fagfelle:	Trude Anine Muggerud
Kommentar:	Treffene i kildene til grå litteratur er ikke eksportert til EndNote. Trefflister nedenfor.
Dublettsjekk i EndNote:	Før dublettkontroll: 328 Etter dublettkontroll: 169

Database: **Ovid MEDLINE(R) and Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Daily and Versions(R) <1946 to May 15, 2020>**

Dato: 18.05.2020

Antall treff: 72

1	exp Pesticides/ or pesticide?.tw,kf.	180817
2	(scenario? or focus).tw,kf.	524820
3	(runof* or (run adj of*) or "spray drift?" or drainage?).tw,kf.	104757
4	exp Europe/ or (Abkhazia* or Abkhaz or Albania or Albanian? or Andorra or Andorran? or Armenian? or Austria* or Azerbaijan* or balkan or Basque? or Belarus or Belarusian? or Belgium or Bosnia or Herzegovina or Bosnian? or Bulgaria* or Catalan? or Croatia or Croatian? or Czech Republic or Czech? or Danish or Denmark or Dutch or Estonia or Estonian? or europe* or Faroe Islands or Faroes* or Finland or Finnish or France or French or Georgia or Georgian? or German? or Germany or Greece or Greek? or Greenland or Guernsey or Hebrides or Hungarian? or Hungary or Iceland or Icelandic? or Ireland or Irish or "Isle of Man" or Italian? or Italy or Jan mayen or Jersey or Kazakh* or Kosovo or Kosovar? or Kosovan? or Latvia or Latvian? or Liechtenstein or Lithuania or Lithuanian? or Luxembourg* or Macedonia* or Malta or Maltes* or Mediterranean or Mingrelian? or Moldova or Moldovian? or Monaco or Monegasque? or Monacan? or Montenegrin? or Montenegro or Netherland* or nordic or Norway or Norwegian? or Poland or Polish or Portugal or Portuguese or Romania or Romanian? or Russia or Russian? or San Marino or Sammarinese or scandinavi* or Scots or Scottish or Serbia or Serbian? or Sicily or Sicilian? or Slovak* or Slovakia or Sloven* or Slovenia or South Ossetia or "South* Caucasus" or Spain or Spanish or Svalbard or Sweden or Swedish or Switzerland or Transcaucasia or Turkey or Turkish or Ukraine or Ukrainian? or United Kingdom or britain or british or england or Vatican City or Wales or Welsh or aaland or aalandi*).tw,in,kf.	7372236

5	1 and 2 and 3 and 4	73
6	limit 5 to yr="2000 -Current"	72

Database: **Embase 1974 to 2020 May 15**

Dato: 18.05.2020

Antall treff: 82

1	exp pesticide/ or pesticide?.tw,kw.	350912
2	(scenario? or focus).tw,kw.	658792
3	run-off/ or (runof* or (run adj of*) or "spray drift?" or drainage?).tw,kw.	143638
4	exp Europe/ or (Abkhazia* or Abkhaz or Albania or Albanian? or Andorra or Andorran? or Armenian? or Austria* or Azerbaijan* or balkan or Basque? or Belarus or Belarusian? or Belgium or Bosnia or Herzegovina or Bosnian? or Bulgaria* or Catalan? or Croatia or Croatian? or Czech Republic or Czech? or Danish or Denmark or Dutch or Estonia or Estonian? or europe* or Faroe Islands or Faroes* or Finland or Finnish or France or French or	13092008

	Georgia or Georgian? or German? or Germany or Greece or Greek? or Greenland or Guernsey or Hebrides or Hungarian? or Hungary or Iceland or Icelandic? or Ireland or Irish or "Isle of Man" or Italian? or Italy or Jan mayen or Jersey or Kazakh* or Kosovo or Kosovar? or Kosovan? or Latvia or Latvian? or Liechtenstein or Lithuania or Lithuanian? or Luxembourg* or Macedonia* or Malta or Maltes* or Mediterranean or Mingrelian? or Moldova or Moldovian? or Monaco or Monegasque? or Monacan? or Montenegrin? or Montenegro or Netherland* or nordic or Norway or Norwegian? or Poland or Polish or Portugal or Portuguese or Romania or Romanian? or Russia or Russian? or San Marino or Sammarinese or scandinavi* or Scots or Scottish or Serbia or Serbian? or Sicily or Sicilian? or Slovak* or Slovakia or Sloven* or Slovenia or South Ossetia or "South* Caucasus" or Spain or Spanish or Svalbard or Sweden or Swedish or Switzerland or Transcaucasia or Turkey or Turkish or Ukraine or Ukrainian? or United Kingdom or britain or british or england or Vatican City or Wales or Welsh or aaland or aalandi*).in,ad,tw,kw.	
5	1 and 2 and 3 and 4	113
6	limit 5 to (conference abstracts or embase)	89
7	limit 6 to yr="2000 -Current"	82

Database: **Web of Science**

Dato: 18.05.2020

Antall treff: 80

# 6	**80**	#4 AND #3 AND #2 AND #1 *Indexes=SCI-EXPANDED, SSCI, A&HCI, ESCI Timespan=2000-2020*
# 5	**85**	#4 AND #3 AND #2 AND #1 *Indexes=SCI-EXPANDED, SSCI, A&HCI, ESCI Timespan=All years*
# 4	**3,669,086**	**TOPIC:** ("Abkhazia*" or "Abkhaz" or "Albania" or "Albanian$" or "Andorra" or "Andorran$" or "Armenian$" or "Austria*" or "Azerbaijan*" or "balkan" or "Basque$" or "Belarus" or "Belarusian$" or "Belgium" or "Bosnia" or "Herzegovina" or "Bosnian$" or "Bulgaria*" or "Catalan$" or "Croatia" or "Croatian$" or "Czech Republic" or "Czech$" or "Danish" or "Denmark" or "Dutch" or "Estonia" or "Estonian$" or "europe*" or "Faroe Islands" or "Faroes*" or "Finland" or "Finnish" or "France" or "French" or "Georgia" or "Georgian$" or "German$" or "Germany" or "Greece" or "Greek$" or "Greenland" or "Guernsey" or "Hebrides" or "Hungarian$" or "Hungary" or "Iceland" or "Icelandic$" or "Ireland" or "Irish" or "Isle of Man" or "Italian$" or "Italy" or "Jan mayen" or "Jersey" or "Kazakh*" or "Kosovo" or "Kosovar$" or "Kosovan$" or "Latvia" or "Latvian$" or "Liechtenstein" or "Lithuania" or "Lithuanian$" or "Luxembourg*" or "Macedonia*" or "Malta" or "Maltes*" or "Mediterranean" or "Mingrelian$" or "Moldova" or "Moldovian$" or "Monaco" or "Monegasque$" or "Monacan$" or "Montenegrin$" or "Montenegro" or "Netherland*" or "nordic" or "Norway" or "Norwegian$" or "Poland" or "Polish" or "Portugal" or "Portuguese" or "Romania" or "Romanian$" or "Russia" or "Russian$" or "San Marino" or "Sammarinese" or "scandinavi*" or "Scots" or "Scottish" or "Serbia" or "Serbian$" or "Sicily" or "Sicilian$" or "Slovak*" or "Slovakia" or "Sloven*" or "Slovenia" or "South Ossetia" or "South* Caucasus" or "Spain" or "Spanish" or "Svalbard" or "Sweden" or "Swedish" or "Switzerland" or "Transcaucasia" or "Turkey" or "Turkish" or "Ukraine" or "Ukrainian$" or "United Kingdom" or "britain" or "british" or "england" or "Vatican City" or "Wales" or "Welsh" or "aaland" or "aalandi*") *Indexes=SCI-EXPANDED, SSCI, A&HCI, ESCI Timespan=All years*
# 3	**190,927**	**TOPIC:** ("runof*" or "run of*" or "spray drift$" or "drainage$")

		Indexes=SCI-EXPANDED, SSCI, A&HCI, ESCI Timespan=All years
# 2	**1,093,812**	**TOPIC:** ("scenario$" or "focus") *Indexes=SCI-EXPANDED, SSCI, A&HCI, ESCI Timespan=All years*
# 1	**99,779**	**TOPIC:** ("pesticide$") *Indexes=SCI-EXPANDED, SSCI, A&HCI, ESCI Timespan=All years*

Database: **Scopus**

Dato: 18.05.2020

Antall treff: 94

1	**pesticide or pesticides**	**141,745**
2	scenario or scenarios or focus	2,564,623
3	runof* or "run of*" or "spray drift*" or drainage*	378,643
4	Abkhazia* or Abkhaz or Albania or Albanian or Albanian? or Andorra or Andorran or Andorran? or Armenian or Armenian? or Austria* or Azerbaijan* or balkan or Basque or Basque? or Belarus or Belarusian or Belarusian? or Belgium	192,540
5	Bosnia or Herzegovina or Bosnian or Bosnian? or Bulgaria* or Catalan or Catalan? or Croatia or Croatian or Croatian? or Czech or Czech? or Danish or Denmark or Dutch or Estonia or Estonian or Estonian? or europe* or "Faroe Islands" or Faroes*	1,770,358

1	**pesticide or pesticides**	**141,745**
6	Finland or Finnish or France or French or Georgia or Georgian? or German? or Germany or Greece or Greek or Greek? or Greenland or Guernsey or Hebrides or Hungarian or Hungarian? or Hungary or Iceland or Icelandic or Icelandic? or Ireland or Irish	1,680,636
7	"Isle of Man" or Italian or Italian? or Italy or "Jan mayen" or Jersey or Kazakh* or Kosovo or Kosovar or Kosovar? or Kosovan or Kosovan? or Latvia or Latvian or Latvian? or Liechtenstein or Lithuania or Lithuanian or Lithuanian? or Luxembourg*	525,483
8	Macedonia* or Malta or Maltes* or Mediterranean or Mingrelian or Mingrelian? or Moldova or Moldovian or Moldovian? or Monaco or Monegasque or Monegasque? or Monacan or Monacan? or Montenegrin or Montenegrin? or Montenegro or Netherland* or nordic	419,246
9	Norway or Norwegian or Norwegian? or Poland or Polish or Portugal or Portuguese or Romania or Romanian or Romanian? or Russia or Russian or Russian? or "San Marino" or Sammarinese or scandinavi* or Scots or Scottish or Serbia or Serbian or Serbian?	939,672
10	Sicily or Sicilian or Sicilian? or Slovak* or Slovakia or Sloven* or Slovenia or "South Ossetia" or "South* Caucasus" or Spain or Spanish or Svalbard or Sweden or Swedish or Switzerland or Transcaucasia or Turkey or Turkish	1,533,379
11	Ukraine or Ukrainian or Ukrainian? or "United Kingdom" or britain or british or england or "Vatican City" or Wales or Welsh or aaland or aalandi*	1,211,293
12	#4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11	6,949,626
13	#1 AND #2 AND #3 AND #12	103
14	#1 AND #2 AND #3 AND #12 Limit to 2000-2020	94

Database: **Epistemonikos**

Dato: 18.05.2020

Antall treff: 0 treff

(pesticide or pesticides) AND (scenario or scenarios or focus) AND (runof* or "run of" or "run off" or "run ofs" or "run offs" or "spray drift" or "spray drifts" or drainage*) AND (Abkhazia* or Abkhaz or Albania or Albanian* or Andorra or Andorran* or Armenian* or Austria* or Azerbaijan* or balkan or Basque* or Belarus or Belarusian* or Belgium or Bosnia or Herzegovina or Bosnian* or Bulgaria* or Catalan* or Croatia or Croatian* or Czech* or Danish or Denmark or Dutch or Estonia or Estonian* or europe* or "Faroe Islands" or Faroes* or Finland or Finnish or France or French or Georgia or Georgian* or German* or Germany or Greece or Greek* or Greenland or Guernsey or Hebrides or Hungarian* or Hungary or Iceland or Icelandic* or Ireland or Irish or "Isle of Man" or Italian* or Italy or "Jan mayen" or Jersey or Kazakh* or Kosovo or Kosovar* or Kosovan* or Latvia or Latvian* or Liechtenstein or Lithuania or Lithuanian* or Luxembourg* or Macedonia* or Malta or Maltes* or Mediterranean or Mingrelian* or Moldova or Moldovian* or Monaco or Monegasque* or Monacan* or Montenegrin* or Montenegro or Netherland* or nordic or Norway or Norwegian* or Poland or Polish or Portugal or Portuguese or Romania or Romanian* or Russia or Russian* or "San Marino" or Sammarinese or scandinavi* or Scots or Scottish or Serbia or Serbian* or Sicily or Sicilian* or Slovak* or Slovakia or Sloven* or Slovenia or "South Ossetia" or Caucasus or Spain or Spanish or Svalbard or Sweden or Swedish or Switzerland or Transcaucasia or Turkey or Turkish or Ukraine or Ukrainian* or "United Kingdom" or britain or british or england or "Vatican City" or Wales or Welsh or aaland or aalandi*)

Kilder til grå litteratur. Ikke eksportert til EndNote

Database: Open Grey System for Information on Grey Literature in Europe

Dato: 19.05.2020

Antall treff: 2 treff

Søkestreng:

(pesticide*) AND (scenario* OR focus) AND (runof* OR "run of*" OR "spray drift*" OR drainage*)

Lenke til treffliste:

http://www.opengrey.eu/search/request?q=%28pesticide*%29+AND+%28scenario*+OR+focus%29+AND+%28runof*+OR+%22run+of*%22+OR+%22spray+drift*%22+OR+drainage*%29+

Database: WorldCat (med resultater fra Oister)

Dato: 19.05.2020

Antall treff: 208 og 7 treff

Søkestrenger:

kw:(pesticide*) AND (scenario* OR focus) AND (runof* OR "run of*" OR "spray drift*" OR drainage*) 2000-2020 Avgrenset på Book, eBook, Print book, Thesis/dissertation, Microform, Downloadable achival material, computer file, Video, eVideo, DVD, VHS

ti:(pesticide*) AND (scenario* OR focus) AND (runof* OR "run of*" OR "spray drift*" OR drainage*) 2000-2020 Avgrenset på Book, eBook og Cmputer file

Lenke til trefflister:

https://www.worldcat.org/search?q=kw%3A%28pesticide*%29+AND+%28scenario*+OR+focus%29+AND+%28runof*+OR+%22run+of*%22+OR+%22spray+drift*%22+OR+drainage*%29+&fq=yr%3A2000..2020+%3E&qt=advanced&dblist=638#x0%253Abook-%2C%2528x0%253Abook%2Bx4%253Adigital%2529%2C%2528x0%253Abook%2Bx4%253Aprintbook%2529%2C%2528x0%253Abook%2Bx4%253Athsis%2529%2C%2528x0%253Abook%2Bx4%253Amic%2529%2C%2528x0%253Aarchv%2Bx4%253Adigital%2529%2Cx0%253Acompfile-%2Cx0%253Avideo-%2C%2528x0%253Avideo%2Bx4%253Adigital%2529%2C%2528x0%253Avideo%2Bx4%253Advd%2529%2C%2528x0%253Avideo%2Bx4%253Avhs%2529format

https://www.worldcat.org/search?q=ti%3A%28pesticide*%29+AND+%28scenario*+OR+focus%29+AND+%28runof*+OR+%22run+of*%22+OR+%22spray+drift*%22+OR+drainage*%29&fq=yr%3A2000..2020+%3E&qt=advanced&dblist=638#x0%253Abook-%2C%2528x0%253Abook%2Bx4%253Adigital%2529%2Cx0%253Acompfile-format

Database: Oria

Dato: 19.05.2020

Antall treff: 541 treff

Søkestreng:

Alle felt inneholder: pesticide* OG Alle felt inneholder: scenario* OR focus OG Alle felt inneholder: runof OR run-off OR "run off" OR "run ofs" OR "run offs" OR "spray drift*" OR drainage* OG Alle felt inneholder: EU OR european

Avgrensinger: ekskludert Fra fagfelleveruderte tidsskrift, Artikler, Avisartikler, Artikler fra oppslagsverk. Årstall 2000-2020

Lenke til treffliste:

https://bibsys-almaprimo.hosted.exlibrisgroup.com/primo-explore/search?query=any,contains,pesticide*,AND&query=any,contains,scenario*%20OR%20focus,AND&query=any,contains,runof%20OR%20run-off%20OR%20%22run%20off%22%20OR%20%22run%20ofs%22%20OR%20%22run%20offs%22%20OR%20%22spray%20drift*%22%20OR%20drainage*,AND&query=any,contains,EU%20OR%20european,AND&tab=default_tab&search_scope=blended_scope&vid=SIRUS&facet=tlevel,exclude,peer_reviewed&facet=rtype,exclude,articles&facet=rtype,exclude,newspaper_articles&facet=rtype,exclude,reference_entrys&facet=searchcreationdate,include,2000%7C,%7C2020&lang=no_NO&mode=advanced&offset=0

12 Appendix II

12.1 Test runs of FOCUS drainage and surface run-off scenarios compared and adapted with Norwegian conditions

Table 12-1. Application dates to winter wheat (& maize) for first group of test compounds (Compounds A to I)

Scenario	Autumn (pre-emergence)	Spring (post-emergence)	Summer (post-emergence)
D1	23 September (266)	6 May (126)	23 June (174)
D2	23 October (296)	4 April (94)	30 June (181)
D3	19 November (323)	16 April (106)	24 July (205)
D4	20 September (263)	18 March (77)	21 June (172)
D5	19 October (292)	14 March (73)	31 May (151)
D6	28 November (332)	16 February (47)	30 March (89)
R1	10 November (314)	1 April (91)	10 June (161)
R2[a]	28 April (118)	30 May (150)	15 August (227)
R3	28 November (332)	16 March (75)	10 May (130)
R4	4 November (308)	3 March (62)	27 April (117)

[a] Maize. Winter wheat not grown at R2

Table 12-2. Results of FOCUS example calculation (concentrations in µg/L) for D1 ditch scenario (no temperature correction)

FOCUS	Original FOCUS results				Adapted to Norwegian conditions				Difference in Percent			
Substance	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**
A	0.786	0.569	0.280	0.147	0.786	0.569	0.280	0.147	0.00	0.00	0.00	0.00
B	0.641	0.383	0.213	0.215	0.641	0.383	0.213	0.215	0.00	0.00	0.00	0.00
C	0.641	0.232	0.087	0.349	0.641	0.232	0.087	0.349	0.00	0.00	0.00	0.00
D	5.473	4.428	3.004	1.314	5.473	4.428	3.004	1.314	0.00	0.00	0.00	0.00
E	6.326	5.370	3.649	3.579	6.326	5.370	3.649	3.579	0.00	0.00	0.00	0.00
F	1.088	0.991	0.838	2.958	1.088	0.991	0.838	2.958	0.00	0.00	0.00	0.00
G	8.399	7.330	6.458	4.792	8.399	7.330	6.458	4.792	0.00	0.00	0.00	0.00
H	10.360	9.199	7.094	10.280	10.360	9.199	7.094	10.280	0.00	0.00	0.00	0.00
I	4.808	4.666	4.324	23.060	4.808	4.666	4.324	23.060	0.00	0.00	0.00	0.00

Table 12-3. Results of FOCUS example calculation (concentrations in µg/L) for D1 stream scenario (no temperature correction)

FOCUS	Original FOCUS results				Adapted to Norwegian conditions				Difference in Percent			
Substance	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**
A	0.604	0.478	0.252	0.124	0.604	0.478	0.252	0.124	0.00	0.00	0.00	0.00
B	0.561	0.306	0.177	0.174	0.561	0.306	0.177	0.174	0.00	0.00	0.00	0.00
C	0.561	0.061	0.020	0.196	0.561	0.061	0.020	0.196	0.00	0.00	0.00	0.00
D	3.655	3.152	2.112	0.952	3.655	3.152	2.112	0.952	0.00	0.00	0.00	0.00
E	4.128	3.659	2.547	2.495	4.128	3.659	2.547	2.495	0.00	0.00	0.00	0.00
F	0.705	0.651	0.546	1.739	0.705	0.651	0.546	1.739	0.00	0.00	0.00	0.00
G	5.422	4.879	4.148	2.781	5.422	4.879	4.148	2.781	0.00	0.00	0.00	0.00
H	6.652	5.984	4.705	5.891	6.652	5.984	4.705	5.891	0.00	0.00	0.00	0.00
I	3.065	2.954	2.733	13.000	3.065	2.954	2.733	13.000	0.00	0.00	0.00	0.00

Table 12-4. Results of FOCUS example calculation (concentrations in µg/L) for D2 ditch scenario (temperature correction: -1 °C)

FOCUS	Original FOCUS results				Adapted to Norwegian conditions				Difference in Percent			
Substance	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**
A	8.169	3.035	1.559	0.710	8.670	3.314	1.736	0.773	6.13	9.19	11.35	8.91
B	6.500	1.537	1.124	0.879	6.996	1.757	1.286	1.026	7.63	14.31	14.41	16.75
C	0.642	0.245	0.085	0.364	0.642	0.260	0.090	0.381	0.00	6.05	6.59	4.78
D	16.620	8.767	6.125	2.518	16.730	8.867	6.220	2.573	0.66	1.14	1.55	2.18
E	15.590	7.612	6.244	6.555	15.720	7.733	6.368	6.751	0.83	1.59	1.99	2.99
F	2.268	1.057	0.757	3.192	2.407	1.129	0.809	3.495	6.13	6.81	6.91	9.49
G	18.890	10.850	8.243	4.295	18.940	10.900	8.297	4.356	0.26	0.46	0.66	1.42
H	18.380	10.120	8.837	12.630	18.450	10.180	8.901	12.840	0.38	0.59	0.72	1.66
I	5.752	3.327	2.547	23.960	5.851	3.396	2.606	24.860	1.72	2.07	2.32	3.76

Table 12-5. Results of FOCUS example calculation (concentrations in µg/L) for D2 stream scenario (temperature correction: -1 °C)

FOCUS	Original FOCUS results				Adapted to Norwegian conditions				Difference in Percent			
Substance	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**
A	5.385	1.926	1.040	0.418	5.709	2.076	1.142	0.453	6.02	7.79	9.81	8.45
B	4.123	1.021	0.705	0.565	4.434	1.151	0.796	0.650	7.54	12.73	12.96	15.09
C	0.571	0.218	0.075	0.324	0.571	0.231	0.080	0.339	0.00	6.01	6.47	4.75
D	10.820	4.794	3.470	1.481	10.890	4.842	3.518	1.512	0.65	1.00	1.38	2.09
E	9.806	4.400	3.625	3.783	9.888	4.464	3.692	3.893	0.84	1.45	1.85	2.91
F	1.415	0.567	0.392	1.671	1.501	0.606	0.419	1.826	6.08	6.75	6.95	9.28
G	12.270	5.960	4.691	2.562	12.300	5.991	4.725	2.601	0.24	0.52	0.72	1.52
H	11.550	5.814	5.101	7.395	11.590	5.851	5.139	7.524	0.35	0.64	0.74	1.74
I	3.608	1.876	1.419	13.510	3.670	1.916	1.453	14.020	1.72	2.13	2.40	3.77

Table 12-6. Results of FOCUS example calculation (concentrations in μg/L) for D3 ditch scenario (temperature correction: -1 °C)

FOCUS	Original FOCUS results				Adapted to Norwegian conditions				Difference in Percent			
Substance	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**
A	0.657	0.091	0.046	0.048	0.666	0.102	0.056	0.053	1.51	11.52	21.50	8.49
B	0.632	0.067	0.022	0.087	0.632	0.068	0.023	0.087	0.00	1.00	0.98	0.91
C	0.632	0.066	0.022	0.210	0.632	0.067	0.022	0.213	0.00	1.01	1.04	1.19
D	3.620	3.074	3.030	2.154	3.826	3.282	3.239	2.343	5.69	6.77	6.90	8.77
E	0.640	0.082	0.032	0.109	0.643	0.086	0.036	0.116	0.55	4.36	10.92	6.35
F	0.632	0.074	0.025	0.238	0.632	0.074	0.025	0.238	0.00	0.11	0.12	0.13
G	9.226	8.703	8.673	8.323	9.339	8.816	8.786	8.478	1.22	1.30	1.30	1.86
H	3.195	2.645	2.637	8.953	3.384	2.836	2.833	9.692	5.92	7.22	7.43	8.25
I	0.632	0.075	0.025	0.241	0.632	0.075	0.025	0.241	0.00	0.01	0.04	0.00

Table 12-7. Results of FOCUS example calculation (concentrations in μg/L) for D4 pond scenario (temperature correction: -1 °C)

FOCUS	Original FOCUS results				Adapted to Norwegian conditions				Difference in Percent			
Substance	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**
A	0.022	0.008	0.003	0.002	0.022	0.009	0.003	0.002	0.00	7.02	9.36	4.62
B	0.022	0.008	0.003	0.004	0.022	0.009	0.003	0.005	0.00	6.99	9.37	4.57
C	0.022	0.008	0.003	0.012	0.022	0.008	0.003	0.013	0.00	6.91	9.28	5.23
D	2.538	2.522	2.418	1.471	2.798	2.780	2.677	1.674	10.24	10.23	10.71	13.80
E	0.512	0.507	0.493	0.611	0.564	0.559	0.542	0.696	10.12	10.23	9.98	13.86
F	0.055	0.051	0.049	0.181	0.061	0.057	0.054	0.210	9.22	9.88	11.72	16.13
G	13.270	13.260	13.180	11.310	13.590	13.580	13.510	11.670	2.41	2.41	2.50	3.18
H	5.278	5.270	5.211	12.500	5.558	5.549	5.489	13.290	5.31	5.29	5.33	6.32
I	0.756	0.752	0.731	4.097	0.795	0.791	0.770	4.343	5.17	5.19	5.21	6.00

Table 12-8. Results of FOCUS example calculation (concentrations in µg/L) for D4 stream scenario (temperature correction: -1 °C)

FOCUS	**Original FOCUS results**				**Adapted to Norwegian conditions**				**Difference in Percent**			
Substance	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**
A	0.548	0.021	0.007	0.024	0.548	0.022	0.007	0.024	0.00	0.51	0.52	0.46
B	0.548	0.021	0.007	0.049	0.548	0.022	0.007	0.049	0.00	0.51	0.52	0.53
C	0.548	0.021	0.007	0.091	0.548	0.021	0.007	0.091	0.00	0.52	0.52	0.68
D	2.155	1.989	1.842	0.998	2.328	2.153	1.994	1.095	8.03	8.25	8.25	9.75
E	0.680	0.540	0.382	0.397	0.727	0.580	0.414	0.431	7.03	7.40	8.46	8.41
F	0.548	0.059	0.031	0.120	0.548	0.065	0.035	0.130	0.00	9.22	12.04	8.78
G	6.644	6.371	6.076	4.898	6.731	6.456	6.164	4.997	1.31	1.33	1.45	2.02
H	2.936	2.771	2.705	4.816	3.035	2.895	2.813	5.070	3.37	4.47	3.99	5.27
I	0.992	0.555	0.471	1.539	1.029	0.581	0.495	1.619	3.70	4.76	5.12	5.20

Table 12-9. Results of FOCUS example calculation (concentrations in µg/L) for D5 pond scenario (temperature correction: -6 °C)

FOCUS	**Original FOCUS results**				**Adapted to Norwegian conditions**				**Difference in Percent**			
Substance	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**
A	0.038	0.034	0.023	0.010	0.215	0.196	0.142	0.064	461.28	474.44	519.92	522.50
B	0.022	0.018	0.012	0.010	0.056	0.053	0.041	0.044	157.20	190.95	245.29	332.02
C	0.022	0.011	0.004	0.015	0.022	0.014	0.007	0.020	0.00	29.47	59.93	31.55
D	2.885	2.818	2.556	1.293	4.136	4.083	3.847	2.149	43.36	44.89	50.51	66.20
E	0.734	0.715	0.644	0.827	0.991	0.974	0.908	1.282	35.06	36.28	40.87	55.00
F	0.034	0.031	0.026	0.097	0.053	0.049	0.043	0.172	52.55	57.81	66.58	77.22
G	12.420	12.400	12.290	10.640	15.080	15.060	14.940	13.500	21.42	21.45	21.56	26.88
H	4.022	4.009	3.936	9.481	5.542	5.529	5.449	14.220	37.79	37.91	38.44	49.98
I	0.452	0.445	0.423	2.955	0.649	0.640	0.613	4.723	43.56	43.88	44.84	59.83

Table 12-10. Results of FOCUS example calculation (concentrations in µg/L) for D5 stream scenario (temperature correction: -6 °C)

FOCUS	Original FOCUS results				Adapted to Norwegian conditions				Difference in Percent			
Substance	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**
A	0.591	0.066	0.041	0.029	0.591	0.209	0.153	0.072	0.00	218.79	268.55	145.69
B	0.591	0.077	0.035	0.062	0.591	0.182	0.086	0.099	0.00	137.48	144.76	60.45
C	0.591	0.031	0.010	0.124	0.591	0.032	0.011	0.127	0.00	2.27	2.33	2.91
D	2.046	1.787	1.334	0.746	2.588	2.330	1.834	1.066	26.49	30.39	37.48	42.86
E	1.255	0.624	0.318	0.444	1.413	0.723	0.388	0.583	12.59	15.85	21.77	31.26
F	0.591	0.032	0.011	0.132	0.591	0.032	0.011	0.133	0.00	0.22	0.18	0.99
G	5.643	5.161	4.863	3.666	6.313	5.759	5.523	4.303	11.87	11.59	13.57	17.38
H	2.648	1.780	1.493	2.827	3.139	2.295	2.007	3.969	18.54	28.93	34.43	40.40
I	0.643	0.239	0.159	0.786	0.804	0.336	0.216	1.138	24.98	40.33	35.76	44.88

Table 12-11. Results of FOCUS example calculation (concentrations in µg/L) for D6 ditch scenario (temperature correction: -8 °C)

FOCUS	Original FOCUS results				Adapted to Norwegian conditions				Difference in Percent			
Substance	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**
A	0.831	0.312	0.239	0.093	1.482	0.633	0.441	0.213	78.25	102.82	84.91	130.35
B	1.345	0.518	0.302	0.342	2.377	1.005	0.556	0.651	76.73	94.02	84.39	90.47
C	0.639	0.257	0.092	0.391	0.639	0.350	0.134	0.532	0.00	36.40	45.50	35.91
D	2.742	1.590	1.135	0.576	3.148	2.034	1.539	0.901	14.81	27.92	35.59	56.48
E	4.120	1.976	1.160	1.388	4.466	2.230	1.370	1.632	8.40	12.85	18.10	17.58
F	1.873	0.460	0.206	0.915	2.349	0.562	0.323	1.192	25.41	22.07	57.14	30.26
G	5.572	4.968	4.338	3.343	6.856	6.345	5.677	4.577	23.04	27.72	30.87	36.91
H	5.610	3.369	2.437	4.042	6.146	3.967	3.009	5.424	9.55	17.75	23.47	34.19
I	3.431	1.378	0.773	2.598	4.009	1.752	0.980	3.315	16.85	27.14	26.72	27.60

Table 12-12. Results of FOCUS example calculation (concentrations in µg/L) for R1 pond scenario (temperature correction: -2 °C)

FOCUS	Original FOCUS results				Adapted to Norwegian conditions				Difference in Percent			
Substance	PECsw max	TWA 7d	TWA 21d	PECsed max	PECsw max	TWA 7d	TWA 21d	PECsed max	PECsw max	TWA 7d	TWA 21d	PECsed max
A	0.034	0.020	0.013	0.006	0.036	0.023	0.015	0.007	6.98	14.93	15.15	16.03
B	0.036	0.022	0.014	0.013	0.038	0.025	0.016	0.015	6.99	14.90	15.31	16.00
C	0.036	0.022	0.011	0.036	0.041	0.027	0.014	0.044	12.94	20.16	27.51	23.55
D	0.055	0.051	0.043	0.020	0.055	0.052	0.045	0.022	1.17	2.08	3.79	5.60
E	0.058	0.053	0.045	0.048	0.059	0.054	0.047	0.052	1.10	1.99	3.69	6.57
F	0.085	0.076	0.065	0.247	0.087	0.079	0.068	0.271	2.48	3.31	4.83	9.77
G	0.059	0.057	0.053	0.030	0.059	0.057	0.053	0.030	0.17	0.25	0.43	0.88
H	0.062	0.060	0.055	0.080	0.062	0.060	0.056	0.081	0.15	0.24	0.42	1.47
I	0.099	0.093	0.086	0.458	0.099	0.094	0.086	0.466	0.28	0.38	0.54	1.75

Table 12-13. Results of FOCUS example calculation (concentrations in µg/L) for R1 stream scenario (temperature correction: -2 °C)

FOCUS	Original FOCUS results				Adapted to Norwegian conditions				Difference in Percent			
Substance	PECsw max	TWA 7d	TWA 21d	PECsed max	PECsw max	TWA 7d	TWA 21d	PECsed max	PECsw max	TWA 7d	TWA 21d	PECsed max
A	2.856	0.173	0.061	0.178	2.957	0.179	0.063	0.185	3.54	3.64	3.44	3.76
B	3.075	0.187	0.066	0.409	3.192	0.194	0.068	0.425	3.80	3.91	3.71	4.06
C	0.753	0.048	0.019	0.228	0.783	0.053	0.019	0.238	4.05	10.74	3.42	4.48
D	3.532	0.215	0.075	0.223	3.545	0.216	0.075	0.224	0.37	0.37	0.37	0.40
E	3.868	0.236	0.082	0.521	3.881	0.237	0.082	0.523	0.34	0.34	0.33	0.36
F	0.959	0.090	0.030	0.317	0.963	0.091	0.030	0.321	0.42	1.03	1.03	1.45
G	3.608	0.220	0.077	0.228	3.611	0.220	0.077	0.228	0.08	0.09	0.09	0.09
H	3.957	0.242	0.084	0.534	3.960	0.242	0.084	0.534	0.08	0.08	0.07	0.09
I	0.982	0.096	0.032	0.345	0.983	0.096	0.032	0.345	0.03	0.08	0.09	0.12

Table 12-14. Results of FOCUS example calculation (concentrations in µg/L) for R2 stream scenario (temperature correction: -3 °C)

FOCUS	Original FOCUS results				Adapted to Norwegian conditions				Difference in Percent			
Substance	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**
A	5.467	0.383	0.153	0.384	6.595	0.462	0.182	0.466	20.63	20.74	18.54	21.26
B	0.704	0.049	0.023	0.106	0.865	0.061	0.029	0.131	22.90	23.02	27.09	23.61
C	0.482	0.009	0.006	0.071	0.482	0.012	0.007	0.089	0.00	23.96	18.68	24.93
D	1.216	0.085	0.032	0.087	1.240	0.087	0.033	0.089	1.97	1.91	1.85	1.95
E	1.696	0.119	0.064	0.262	1.731	0.122	0.066	0.268	2.06	2.09	2.52	2.14
F	0.482	0.034	0.015	0.332	0.482	0.036	0.016	0.362	0.00	7.59	2.78	8.82
G	1.318	0.093	0.035	0.095	1.320	0.093	0.035	0.095	0.15	0.17	0.17	0.18
H	1.851	0.130	0.072	0.287	1.855	0.131	0.072	0.288	0.22	0.23	0.25	0.21
I	0.482	0.046	0.024	0.473	0.482	0.048	0.025	0.477	0.00	2.97	2.87	0.87

Table 12-15. Results of FOCUS example calculation (concentrations in µg/L) for R3 stream scenario (temperature correction: -5 °C)

FOCUS	Original FOCUS results				Adapted to Norwegian conditions				Difference in Percent			
Substance	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**
A	5.656	0.541	0.185	0.425	6.164	0.590	0.202	0.466	8.98	9.14	8.90	9.43
B	4.170	0.598	0.204	0.992	4.564	0.657	0.224	1.089	9.45	9.92	9.74	9.73
C	0.943	0.239	0.091	8.520	1.037	0.266	0.102	9.559	9.93	11.48	13.15	12.19
D	7.177	0.689	0.235	0.545	7.237	0.695	0.237	0.550	0.84	0.86	0.85	0.88
E	5.351	0.776	0.264	1.289	5.400	0.783	0.267	1.304	0.92	0.95	0.95	1.16
F	1.225	0.322	0.128	11.650	1.237	0.326	0.129	11.790	0.98	1.12	1.33	1.20
G	7.348	0.705	0.240	0.559	7.355	0.706	0.241	0.559	0.10	0.10	0.08	0.09
H	5.485	0.797	0.271	1.330	5.492	0.797	0.271	1.331	0.13	0.06	0.07	0.08
I	1.258	0.332	0.132	12.030	1.259	0.332	0.132	12.040	0.08	0.12	0.08	0.08

Table 12-16. Results of FOCUS example calculation (concentrations in µg/L) for R4 stream scenario (temperature correction: -7 °C)

FOCUS	**Original FOCUS results**				**Adapted to Norwegian conditions**				**Difference in Percent**			
Substance	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**	**PECsw max**	**TWA 7d**	**TWA 21d**	**PECsed max**
A	0.419	0.012	0.004	0.016	0.419	0.012	0.004	0.017	0.00	1.31	1.35	1.41
B	0.419	0.018	0.006	0.033	0.419	0.032	0.011	0.053	0.00	77.35	77.33	62.62
C	0.419	0.039	0.013	0.129	0.565	0.071	0.024	0.241	34.77	82.83	82.88	87.33
D	0.419	0.013	0.004	0.017	0.419	0.013	0.004	0.017	0.00	0.16	0.14	0.18
E	0.660	0.061	0.020	0.103	0.698	0.064	0.021	0.109	5.90	5.91	5.89	6.04
F	1.104	0.139	0.046	0.486	1.172	0.148	0.049	0.518	6.16	6.25	6.23	6.54
G	0.419	0.013	0.004	0.017	0.419	0.013	0.004	0.017	0.00	0.00	0.02	0.00
H	0.745	0.068	0.023	0.116	0.749	0.069	0.023	0.117	0.55	0.57	0.57	0.60
I	1.253	0.158	0.053	0.556	1.261	0.159	0.053	0.559	0.64	0.63	0.63	0.65

13 Appendix III

13.1 WRB soil units and distribution in Norway

The top 3 soil dominating soil types in Norway is Albeluvisols, Stagnosols and Cambisols (table 13-1). In a new version of WRB (2014) Albeluvisol has been included in Stagnosol which now covers 62 % of the agricultural land of Østlandet and 25 % in Trøndelag (Lågbu, 2018)

Table 13-1. Selected WRB units in Norwegian agricultural land compared with Europe and globally (Solbakken et al., 2006)

WRB group	% of agricultural area	% of land area	% of land area
	Norway*	Europe**	World***
Albeluvisol	21.6	14	2
Stagnosol	22.4	No information	No information
Cambisol	21.5	12	12
Leveled soil	9.4	No information	No information
Arenosol	5.5	1	7
Gleysol	5.1	5	6
Umbrisol	2.1	3	1
Podzol	2.3	14	4
Histosol	2.6	5	3
Fluvisol	1.1	5	3
Leptosol	0.5	9	13

*Source: NIJOS
**Source: European commission, 2008. "Soil Atlas of Europe"
*** Source: FAO, 2001. "Lecture notes on the major soils of the world"

Area distribution of the soil types differs largely between the different regions, which is related to different origin, geology and soil generating processes. Splitting the country into six main regions, the differences are more visible: Eastern Norway south (Østlandet), Eastern Norway north (Innlandet), Rogaland (Sørlandet og Rogaland), Trøndelag, North of Norway (Nord-Norge) (figure 2-3).

Eastern Norway south (Østlandet)-area 1

In this region, Albeluvisol is the dominating soil type inside the moraine ridge in Østfold and Vestfold (table 13-2) with origin of marine clay and deposits. Albeluvisols need drainage and the soil is often periodically water saturated. Albeluvisol is the prevalent soiltype in the boreal zone and in the coldest part of the temperate zone. Recent research shows that these soil types are prone to leaching of pesticides when subjected to freezing and thawing (Holten et al., 2019). As one of the most dominant soil types in Norway, this soil was selected as one of the Nordic Reference Soils (Greve et al., 1998). Because of the frequent occurrence of Albeluvisols in the main agricultural areas, this soil type is a part of the national scenarios in Norway for prediction of groundwater concentration at Rustad and Heia by MACRO (Eklo et al., 2008). Surface run-off scenarios of Syverud and Bjørnebekk including the same soil type, was selected as representative in the Norwegian scenarios modelling with WISPE (Bolli et al., 2013).

A typical soil profile of Albeluvisol used in the Norwegian Surface run-off Scenario contain 2.5-2.6 % organic carbon in the Ap-layer and 0.1-0.5% in the other soil layers. pH differs from 6-7 and the topsoil is characterized as silty clay loam. This soil often exhibits cracking and contain macro pores, facilitating transport of some pesticides. Because of high content of silt and clay the soil is vulnerable for erosion and surface run-off.

Table 13-2. Selected WRB units of the mapped areas in Eastern Norway south (Østlandet) -area 1 (1.1.2014)

WRB-group	Area (km2)	% of agricultural area
Albeluvisol	813,0	31,6
Stagnosol	696,2	27,0
Leveled artificial profile	348,1	13,5
Cambisol	292,2	11,3
Arenosol	119,2	4,6
Gleysol	108,1	4,2
Podzol	58,1	2,3
Umbrisol	38,0	1,5
Histosol	32,6	1,3
Fluvisol	30,1	1,2
Regosol	13,0	0,5
Phaeozem	12,8	0,5
Anthrosol	8,5	0,3
Leptosol	7,0	0,3

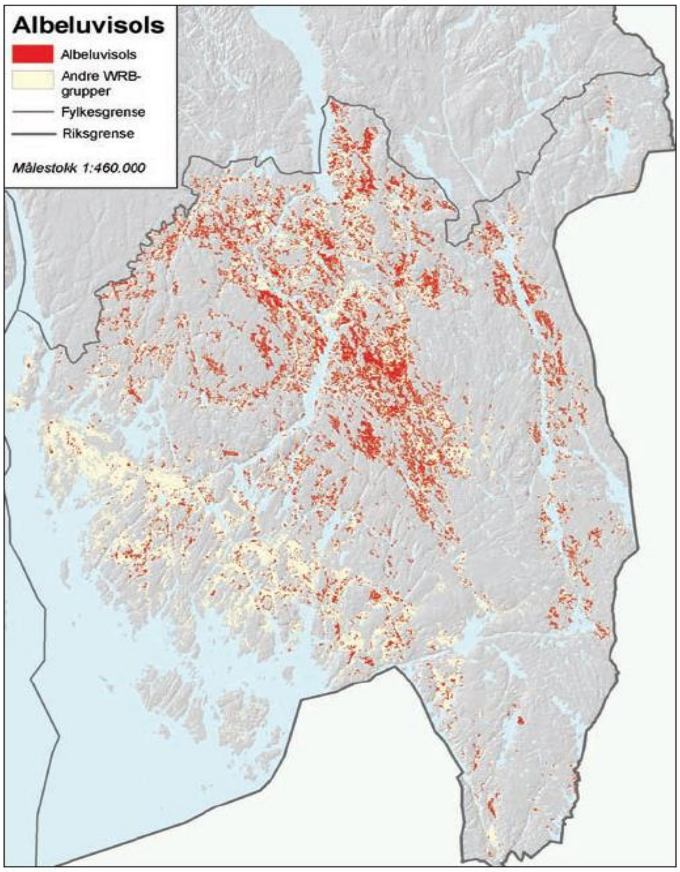

Figure 13-1. Distribution of Albeluvisols in former Østfold county (Nyborg etal., 2008)

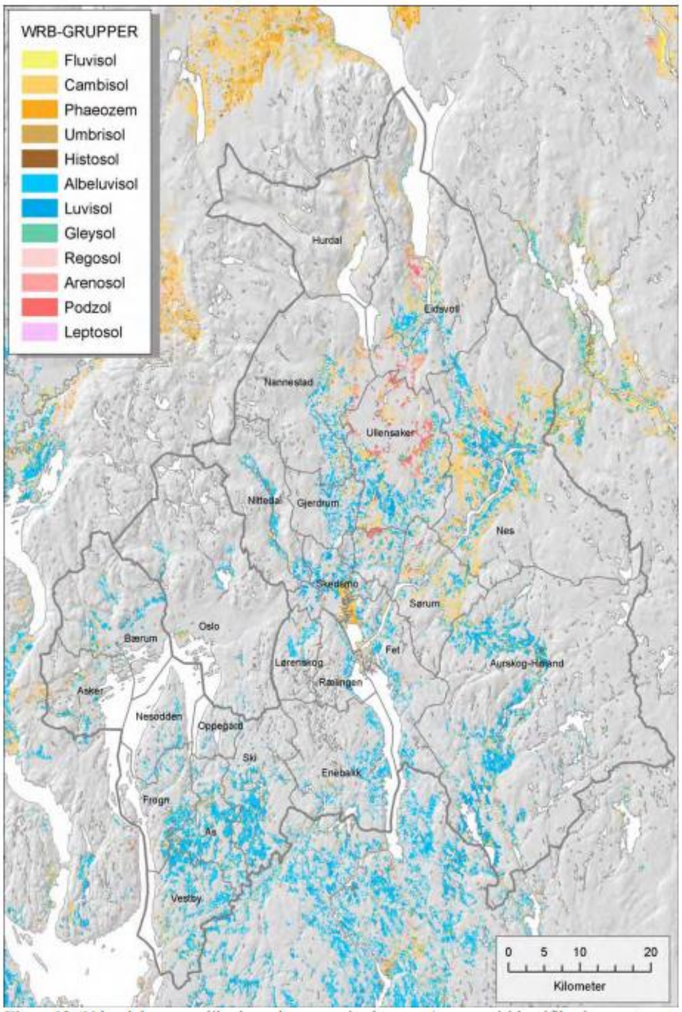

Figure 13-2. Distribution of WRB groups in former Akershus county (Klakegg, 2005)

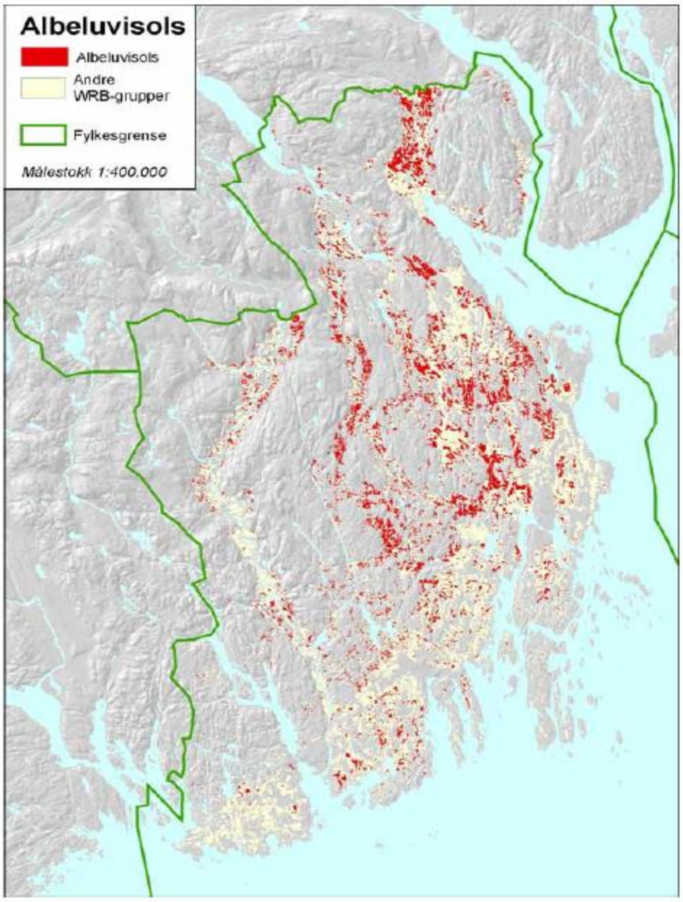

Figure 13-3. Distribution of Albeluvisols in former Vestfold county (Solbakken et al., 2006)

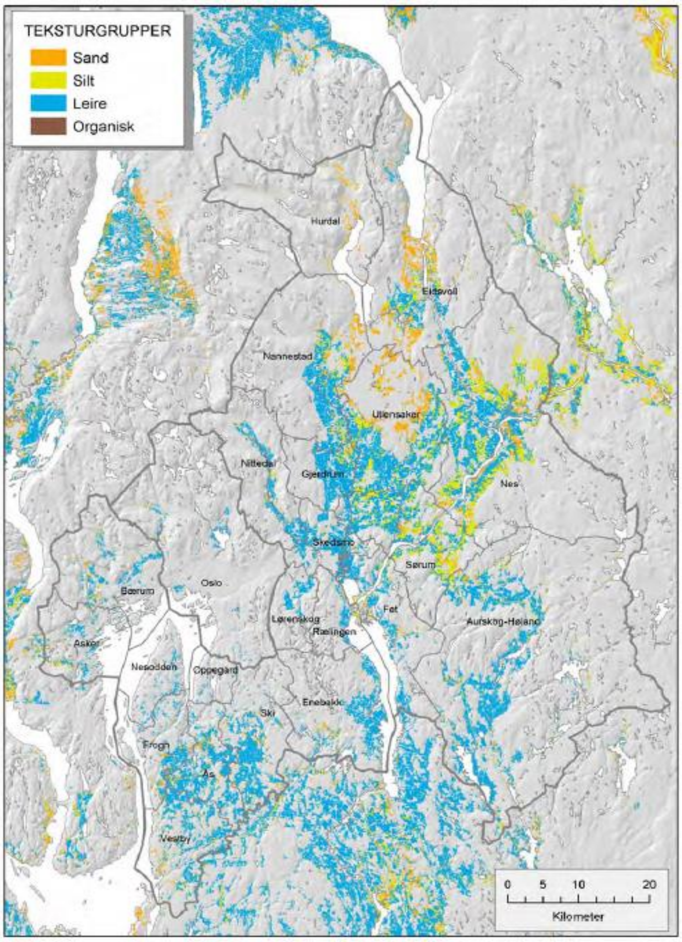

Figure 13-4. Texture in the plow layer in Akerhus county (Klakegg, 2005) (blue= > 10% clay)

Eastern Norway north- (Innlandet) – area 2

This area consists of Hedmark and Oppland (figure 2-3) and represents the northern and inner part of the Eastern Norway. Cambisol is the dominant group (table 13-3) and is one of the most prevalent WRB groups worldwide and dominating in the boreal and temperate zones, especially in areas affected by the glaciation.

Table 13-3. WRB unit distribution in the Eastern Norway north –area 2.

WRB-group	Area (km^2)	% of agricultural area
Cambisol	602,5	53,6
Phaeozem	134,2	12,0
Stagnosol	129,7	11,6
Arenosol	56,4	5,0
Histosol	35,7	3,2
Regosol	32,5	2,9
Albeluvisol	22,1	2,0
Gleysol	21,7	1,9
Podzol	20,9	1,9
Fluvisol	19,7	1,8
Levelled	18,8	1,7
Anthrosol	16,0	1,4
Umbrisol	7,0	0,6
Leptosol	6,2	0,6

Sørlandet and Rogaland – area 3

Table 13-4. WRB unit distribution in Sørlandet and Rogaland –area 3.

WRB-group	Area (km^2)	% of agricultural area
Umbrisol	77,4	30,2
Podzol	37,1	14,5
Histosol	33,8	13,2
Stagnosol	31,6	12,4
Gleysol	30,9	12,1
Levelled	12,5	4,9
Arenosol	12,5	4,9
Cambisol	7,5	2,9
Regosol	6,2	2,4
Leptosol	2,4	1,0
Anthrosol	1,8	0,7
Fluvisol	1,3	0,5
Albeluvisol	0,9	0,3
Phaeozem	< 0,1	< 0,1

In Norway most of the Umbrisols appear in the south-west of Norway (table 13-4). Globally, Umbrisols are rare but appear close to the west-coast of Portugal and Spain, in wet areas with inflow of fresh water. Umbrisols have low pH and low content of nutrients due to the origin of organic matter, which degrades slowly and organic content in the plow layer is often more than 10 % (Solbakken et al., 2006). Umbrisols fit well for crop production but need liming and fertilizer (Sperstad and Nyborg, 2008).

Trøndelag – area 5

Stagnosols are the prevalent soil in area 5 (table 13-5). Characteristics of this soil type is periodically water saturation after heavy rain and snow melt. Drainage system is necessary to facilitate crop production. High content of silt and slow/limited infiltration will increase the risk of erosion and surface run-off. Buried layers with low hydraulic conductivity down into the profile retarding the water movement. With efficient drainage system this soil represents an important soil for crop production (Sperstad and Nyborg, 2008). In the northern hemisphere, this soil type appears in the boreal belt right up to the tundra areas. Information on the global distribution of this soil type is limited (Solbakken et al., 2006).

Table 13-5. WRB unit distribution in the Trøndelag –area 5.

WRB-group	Area (km^2)	% of agricultural area
Stagnosol	239,7	28,5
Cambisol	143,6	17,1
Gleysol	74,9	8,9
Albeluvisol	73,5	8,7
Levelled	69,6	8,3
Arenosol	58,5	7,0
Regosol	39,4	4,7
Histosol	39,1	4,6
Anthrosol	39,0	4,6
Umbrisol	33,0	3,9
Phaeozem	10,4	1,2
Leptosol	9,9	1,2
Fluvisol	6,9	0,8
Podzol	4,5	0,5

North Norway – area 6

Table 13-6. WRB unit distribution in the North Norway –area 6.

WRB-gruppe	Area (km^2)	%
Histosol	35,9	32,4
Podzol	19,5	17,6
Gleysol	9,8	8,8
Stagnosol	9,8	8,8
Cambisol	8,8	8,0
Umbrisol	8,1	7,3
Phaeozem	6,0	5,4
Arenosol	5,3	4,8
Regosol	3,4	3,0
Fluvisol	1,6	1,4
Leptosol	1,5	1,3
Planert og påkjørt jord	1,1	1,0
Albeluvisol	0,2	0,1
Anthrosol	< 0,1	< 0,1

The mapped area in this region comprises Lofoten, Ofoten, parts of Tromsø and some scattered areas in Nordland, Troms and Finnmark. Total mapped area is 111 km^2 (table 13-6). The most prevalent soil is Histosol, which on a national scale represent less than 2 % of the agricultural area. Globally, this soil type cover less than 3 % of the land area and most of the areas are in the subarctic region. Characteristic for Histosol is the organic layer of >40 cm, sometimes buried under a thin layer of mineral soil. Histosol is formed when contribution of organic matter is larger than the microorganisms in soil are able to degrade.

Organic material is important for the sorption of many pesticides. Soils with a high content of organic matter covers a large proportion of the area on the west coast (Rogaland, table 13-7). These areas have high annual precipitation.

Table 13-7. Content of organic matter in different regions in Norway (* 50 % of the area represent Lofoten)

Region	Organic soils (> 20 % OM)	Humic rich soils (6 -20 % OM)	Others (< 6 % OM)
Eastern Norway south	1,5	4,9	93,6
Eastern Norway north	3,4	3,7	92,8
Rogaland	17,5	61,0	21,6
Trøndelag	6,0	9,1	84,9
North Norway*	40,3	14,6	45,1

14 Appendix IV

14.1 Description of the soil profiles of the four Norwegian scenarios

Table 14-1. Soil characterisation of the field site Syverud

Layer	Depth cm	Sand	Silt %	Clay	Tot C %	Tot N %	pH H_2O
Ap1	0-10	26	47	27	3.1	0.29	5.45
Ap2	10-22	25	48	27	2.9	0.28	5.47
Eg	22-48	25	57	18	0.4	0.05	5.59
Btg	50-70	17	53	30	0.3	0.05	6.00
Cg	70+	13	48	39			6.67

Table 14-2. Soil characterisation of the field site Bjørnebekk

Layer	Depth cm	Sand	Silt %	Clay	Tot C %	Tot N %	pH H_2O
Ap	0-10	9	64	26	1.5	0.2	5.95
A/B	10-13	14	64	23	0.6	0.1	5.98
Cg1	13-50	1	57	42	0.3	0.1	7.08
Cg2	50+	1	54	45			7.64

Table 14-3. Soil characterisation of the field site Rustad

Layer	Depth	Sand	Silt	Clay	Tot C	Tot N	pH		Soil density
	cm		%		%	%	H_2O	$CaCl_2$	g cm^{-3}
Ap	0-26	12.7	60.1	27.4	1.9	0.15	6.6	5.8	1.32
Eg/Bt	26-34	9.5	57.3	33.2	0.4	0.05	5.7	4.9	1.75
Bt	34-71	6.3	55.3	38.5	0.3	0.05	6.6	5.6	1.62
BCg	71+	8.8	53.2	38.1	0.3	0.05	7.1	6.1	1.75

Table 14-4. Soil characterisation of the field site Heia

Layer	Depth	Sand	Silt	Clay	Tot C	Tot N	pH		Soil density
	cm		%		%	%	H_2O	$CaCl_2$	g cm^{-3}
Ap	0-30	64.9	29.9	5.2	2.2	0.05	6.4	5.6	1.39
Eg/Bt	30-40	55.7	40.3	4.0	0.3	0.05	6.1	5.4	1.69
Bt	40-60	46.3	40.5	11.1	0.1	0.05	6.1	5.5	1.68
BCg	60+	51.4	38.4	10.2	0.1	0.05	6.4	5.9	1.73

15 Appendix V

15.1 Climate data for selected regions in Norway

Precipitation

Table 15-1. Precipitation data, normal period (1961-1990) and more recent data (1991-2014), for selected sites within important agricultural regions in Norway.

Site	Period	Mean summed precipitation (mm)			
		Annual	Mar-May	Jun-Sep	Oct-Feb
North Norway (area 6-Holt)	Normal 1961-1990	1000	175	310	515
	1991-2014	953	192	291	470
Trøndelag (area 5-Kvithamar)	Normal 1961-1990	900	158	363	379
	1991-2014	970	197	352	421
Sørlandet and Rogaland (area 3-Særheim)	Normal 1961-1990	1280	210	455	615
	1991-2014	1405	230	456	719
East, northern (area 2 - Apelsvoll)	Normal 1961-1990	600	105	275	220
	1991-2014	699	125	287	287
East, southern (area 1-Landvik)	Normal 1961-1990	1230	225	412	593
	1991-2014	1359	229	429	701

Temperature

Table 15-2. Temperature data, normal period (1961-1990) and more recent data (1991-2014), for selected sites within important agricultural regions in Norway.

Site	Period	Mean daily temperature (°C)			
		Annual	Mar-May	Jun-Sep	Oct-Feb
North Norway (area 6-Holt)	Normal 1961-1990	3.1	1.2	9.8	-1.2
	1991-2014	3.8	2	10.3	-0.1
Trøndelag (area 5-Kvithamar)	Normal 1961-1990	5.0	4.3	12.3	-0.3
	1991-2014	5.9	5	13.2	0.8
Sørlandet and Rogaland (area 3-Særheim)	Normal 1961-1990	7.1	5.7	13.0	3.2
	1991-2014	8.1	6.5	13.7	4.0
East, northern (area 2 - Apelsvoll)	Normal 1961-1990	3.6	2.9	12.8	-3.3
	1991-2014	5.3	4.3	13.6	-1.9
East, southern (area 1-Landvik)	Normal 1961-1990	6.9	5.5	14.5	1.9
	1991-2014	7.7	6.6	15.1	2.4