Sirkulær bruk av vannressurser - SirkVann

Sluttrapport fra NIBIO På-tvers prosjekt

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4.4 Spatial planning of water retention measures

Integrated analysis of the effectiveness of WRMs can therefore be considered an important aspect of a national or regional environmental management strategy. This chapter elaborates on how terrain analysis, based on readily available geodata, can provide a starting point for finding optimal locations for effective measures and how this could be a basis for an efficient WRMs strategy. The premise for all methods presented here is that the required data are readily available in Norway's national geodata repositories, and therefore applicable at any spatial scale without additional data acquisition.

Buffer zones

Buffer zones are a method to uncouple a hillslope from a waterway. The increased surface roughness that results from the perennial or permanent vegetation reduces the velocity of the overland flow coming from the hillslope. This reduces the sediment transport capacity and increases the infiltrating fraction of the surface runoff.

Buffer zones are situated alongside riverbanks and creeks, and as such, they are easily mapped for small or large areas. In Norway, the geodata source that represents surface waters best is FKB-vann (Kartverket, 2015). This map contains two layers: one containing line and one containing polygons. The first represents small watercourses and creeks, the latter more sizeable rivers and lakes (see Fig. 4.1).

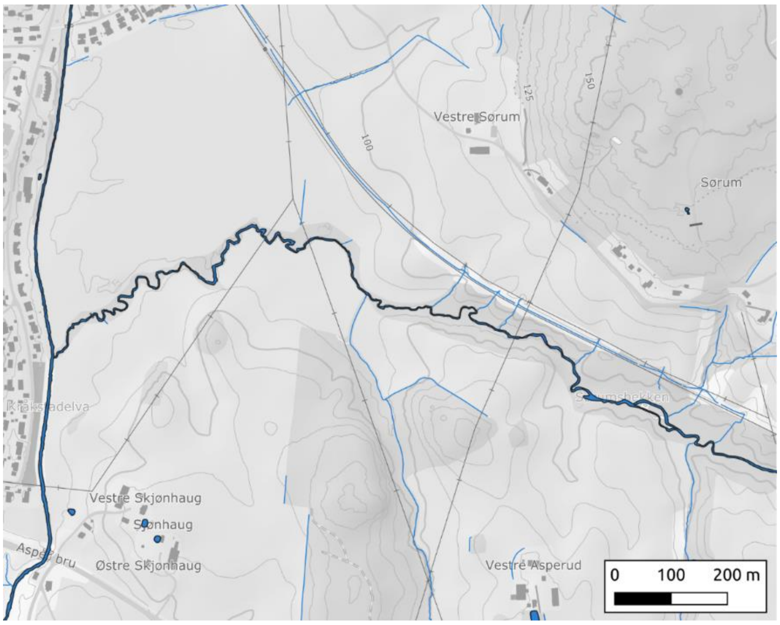

Fig. 4.1. FKB-Vann; base map for drawing buffer zones.

Care should be taken to only include streams (first order and higher) that have continuous discharge throughout the year. FKB-Vann does not differentiate based on discharge, so local or expert knowledge is required to confirm the appropriateness of the selected streams.

Once the line and polygon elements are checked against aerial imagery or another source of verification, a polygon is created by drawing a buffer with a certain width at either side (see Fig. 4.2).

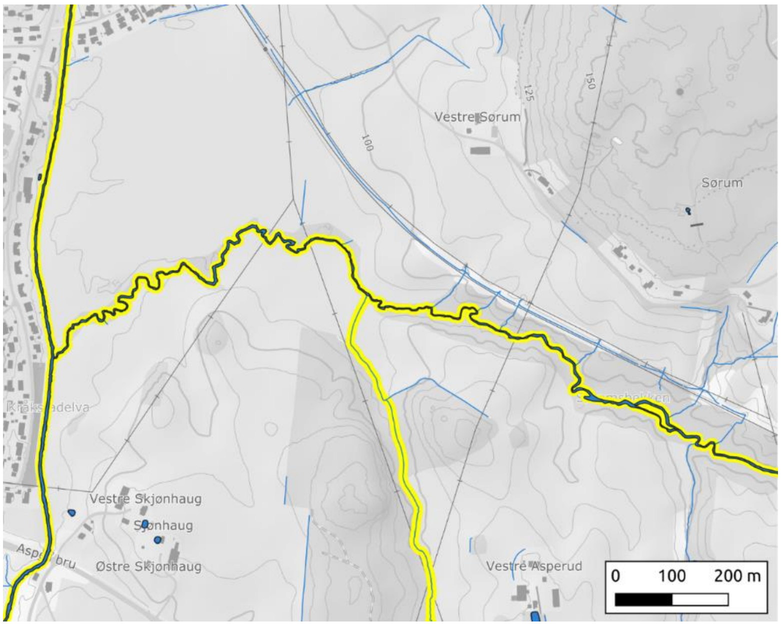

Fig. 4.2. 6m wide buffer zones along FKB-Vann water bodies.

Buffer efficiency is a function of its dimensions and location. Buffer areas with a large and/or steep contributing area are more likely to carry sediments than a small and/or flat area. Prioritisation of buffer zones should therefore be accompanied by an analysis of the hydrological or sediment connectivity at the interface between hillslope and stream network.

Grassed waterways

Grassed waterways are located in talweg, linear areas of concentrated overland flow. On agricultural soils in Norway, these areas are prone to ephemeral[1] gully erosion. An ephemeral erosion risk map was developed by NIBIO and published in 2020 as part of the national erosion risk map (NIBIO, 2022). The optimal placement of grassed waterways is therefore easily obtained by drawing a 6 m wide buffer with the existing gully erosion risk lines as the centre lines (Fig. 3.3).

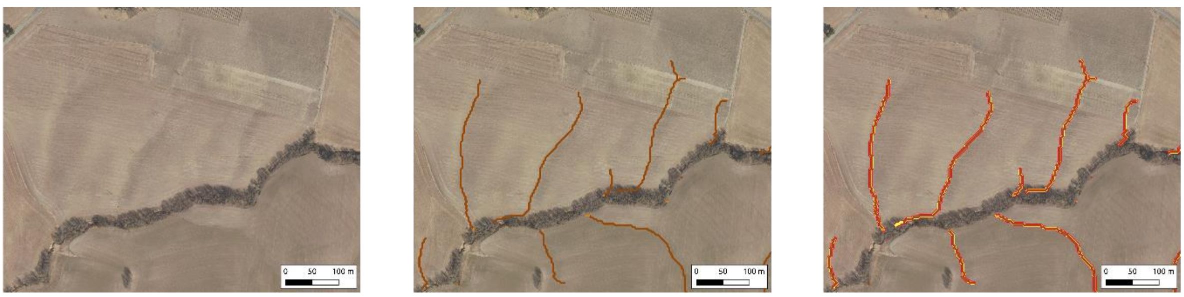

Fig. 4.3. ***Placement of grassed waterways: terrain > gully erosion risk > grassed waterways (6 m width).***

Inundation zones

Water levels in streams and rivers vary throughout the year. Inundation of low areas occurs when the profile of the waterway cannot contain storm water due to its dimensions or reduced conductivity because of obstructions, such as vegetation, ice, or soil compaction. In undulating landscapes, streams are often situated in flat areas. Any rise in the water level above the bank height can therefore result in the inundation of substantial sections of the adjacent agricultural soils. Maintenance of a resilient soil structure is important in these areas to reduce sediment losses during such storm runoff events.

While soil conservation measures are not directly aimed at water retention, their effect on peak flow reduction is a matter of hydrological principle. Many countries in Northern Europe have adapted their river storm flow management according to this principle, vacating flat areas adjacent to large rivers and removing barriers to flow. An example is the Room for the River projects (*https://www.hollandlandofwater.com/ruimte-voor-de-rivier/*), conducted in the Netherlands between 2000 and 2020. These projects show that inundation should not only be perceived as a threat to water quality, but that it also can play a key role in water retention during peak flow events.

The Norwegian Water Resources and Energy Directorate (NVE) have undertaken mapping of inundation prone areas.

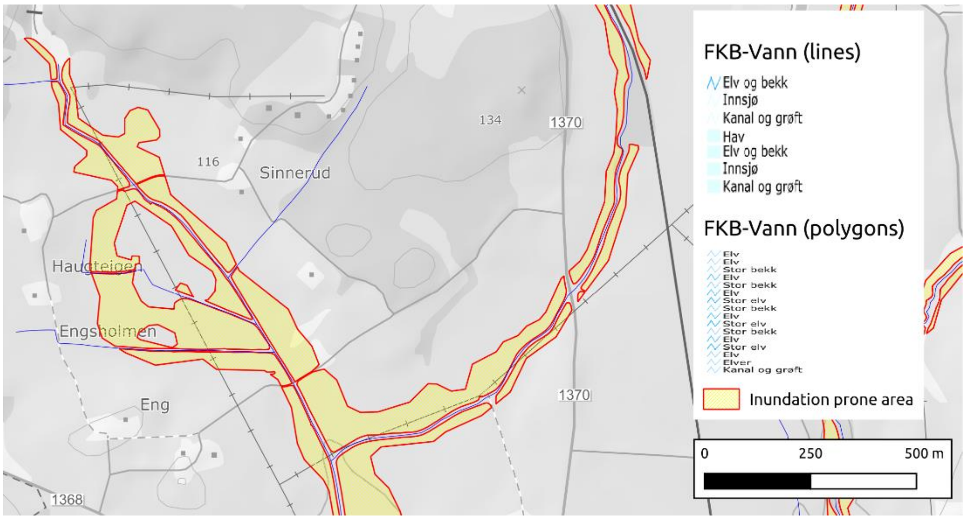

Fig. 4.4. Part of NVE's map over flood prone areas.

NVE publishes a series of nature related risks, among which an inundation risk map (NVE, 2021). The method behind the map is based on an assumed water level rise. If the sum of this storm level and the terrain level in the stream is then higher than the elevation of the adjacent areas, the area is classified as prone to inundation.

Constructed wetlands

The main function of constructed wetlands within an integrated water management strategy is the improvement of runoff from agricultural soils by removing sediment and nutrients. The optimal placement of constructed wetlands is prescribed by this function, and its hydraulics. Wetlands are efficient in locations in the watershed where overland flow contains significant amounts of sediment and/or nutrients. It filters out sediments primarily by reducing the velocity of the overland flow by flow divergence and retention and increased surface roughness (i.e., vegetation). These conditions can be mapped quantitatively at any spatial scale because of the availability of the required geodata.

Constructed wetlands are aimed at the reduction of sediment delivery from agricultural soils. The first condition for optimal placement therefore is the percentage of agricultural land use in the contributing area of the wetland. The hydraulic function of constructed wetlands requires the presence of a longitudinal flat area with a natural depression, or at least characterized by terrain that can be excavated and/or levelled.

Fig. 4.5. First ranking of locations for constructed wetlands, combining contributing area and location slope.

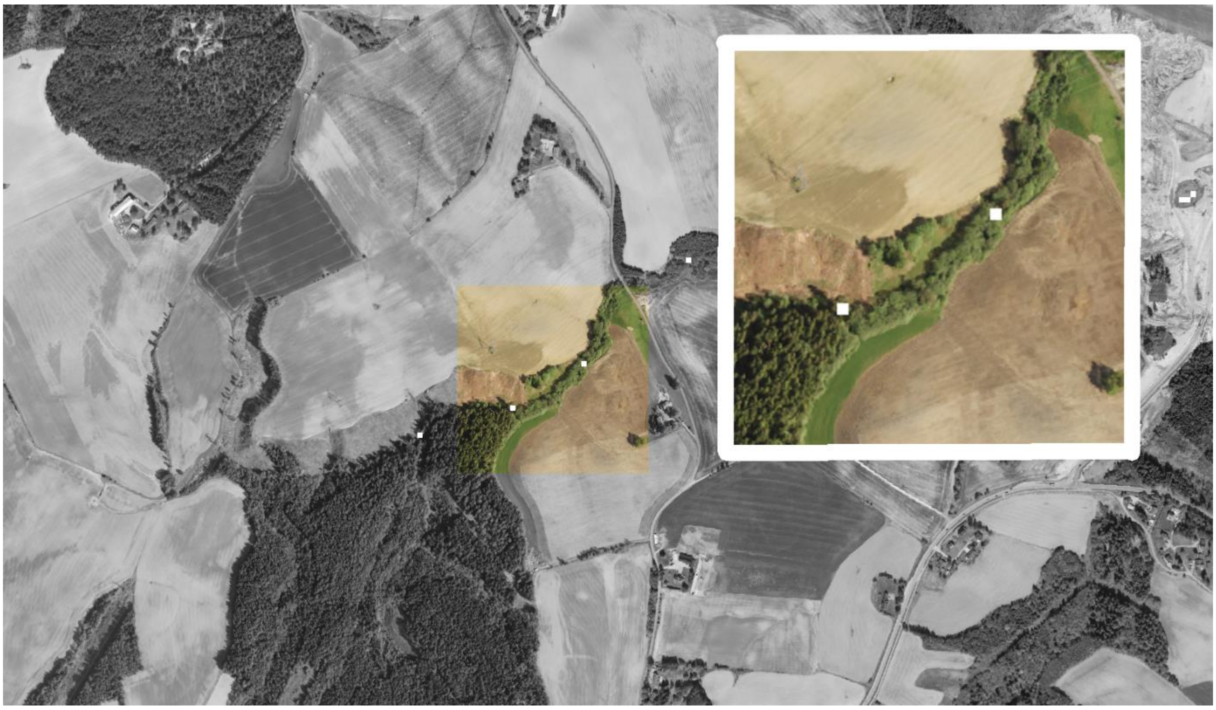

Fig. 4.6. Reducing the number of locations of Fig. 4.5 (50 m or more along the profile, slope inclinations of 1% or less).

Earlier research by NIBIO showed that the optimal location of a constructed wetland has a contributing area between 0.5 and 3.0 km². Once the number of locations is reduced, additional suitability indicators that can be included in an optimisation exercise are nature value, the presence of quick clays (prone to land sliding), and hydrological connectivity.

The availability of a national Norwegian elevation model with a high spatial resolution (a 1x1 meter raster grid), provides the opportunity to assess the presence of naturally occurring depressions in the landscape (Fig. 4.7). These depressions, or sinks, are a natural starting point for the detailed design of the basins that make up a constructed wetland.

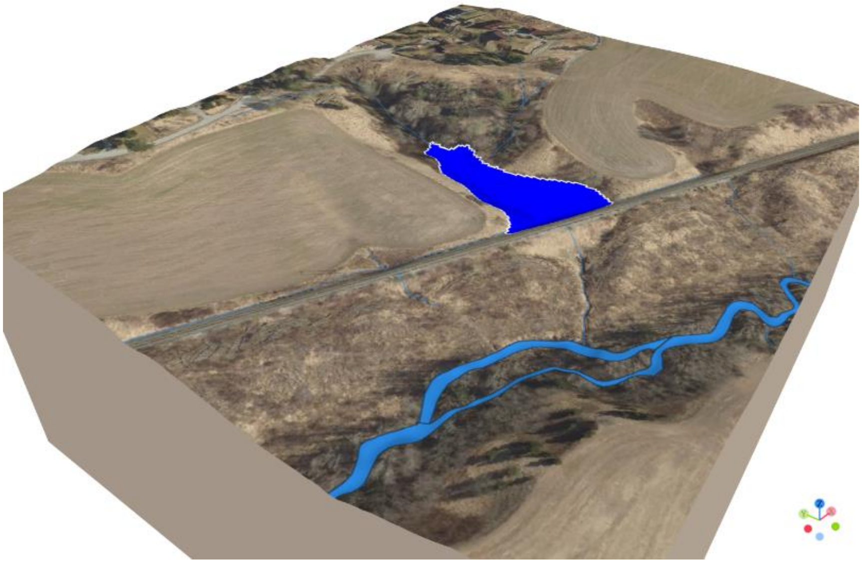

Fig. 4.7. ***Detailed mapping of depressions in the terrain (dark blue indicates a potential retention or wetland location).***

Even when aggressive filters are used to reduce the number of potential wetland locations, the selection will still contain an unrealistically high number of points in the landscape. Locations can be ranked according to any parameter that carries relevance for the goal of constructed wetlands, the reduction of sediment fluxes from agricultural land to the freshwater system. An example of a relevant parameter is the percentage of agricultural land use in the contributing area of the wetland.

Fig. 4.8. ***Section of an interactive map displaying two potential locations for constructed wetlands. In this example, the suitability parameters (text box in the centre) are hydrological connectivity and the percentage of agricultural land use in the contributing area.***

Operational selection can only be conducted with landowners. A map that contains all potential locations (Fig. 4.8) can be a useful starting point for discussions and strategy development.

Retention dams

While constructed wetlands aim at the retention of sediments, retention dams are planned for peak flow reduction and flood prevention. The primary qualification for locations in the landscape is the possibility to store significant volumes of water, and to release it naturally with a lower discharge rate. Retention dams can be constructed to protect infrastructure, built up areas and agricultural areas. NIBIO has undertaken mapping exercises for large areas in South-eastern Norway; Haldenvassdraget, Øyeren, Morsa and Glomma-Sør (Stolte and Barneveld, 2020).

The initial mapping of locations starts with identifying sizeable sinks in the landscape. The availability of the 1 m Digital Elevation Model for Norway allows for the mapping of small and narrow sinks, which might not be detectable with lower resolution elevation data (see Fig. 4.9a).

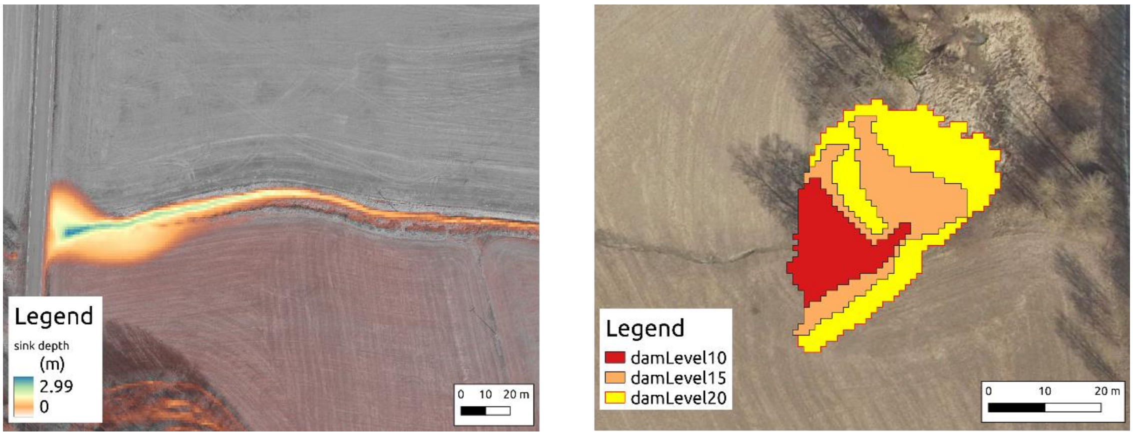

Fig. 4.9. a. ***Sink depth mapping to identify retention dam potential areas for retention. b: Three scenarios for a location: dam heights of 1.0, 1.5 and 2.0 m.***

Once the large sinks are identified from the DEM analysis, their suitability can be ranked according to the preferences set by the objective of the dams. In the example by Stolte and Barneveld (2020) retention dams were projected to protect agricultural land. A further selection of the locations was created by finding sinks in forested areas, upstream from agricultural land. Dams with small contributing areas are not efficient and can be filtered out from the selection. The extent of the area that could be flooded can be mapped tentatively by selecting the downstream area of the lowest point of the potential dam. This in turn can be included in a ranking exercise that further reduces the number of locations.

Results can then be presented in on- or offline maps (e.g., Fig. 4.10) for further discussion with land users, municipality or county administrators and other stakeholders.

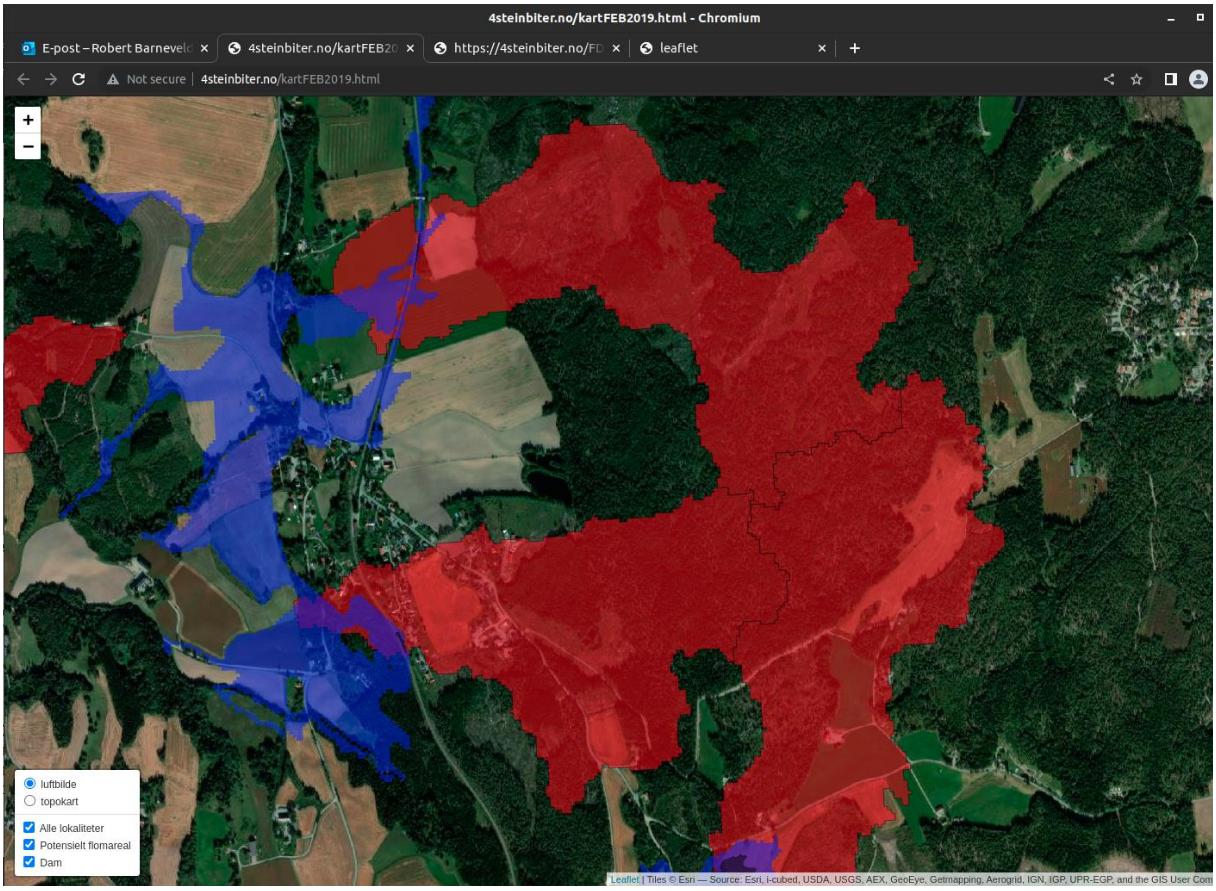

Fig. 4.10: ***Example of an online representation of a selection of potential locations for retention dams. The red areas are contributing areas, the blue areas are at risk of being flooded by storm waters from these catchments.***

Optimization

None of the measures described in this chapter are unique to Norway or Scandinavia. Evidence of their effectiveness is well documented in many cases. If implemented correctly, all the measures are likely to increase catchments' water retention capacity and can be recommended without hesitation. For the assessment of the efficiency and effectiveness of measures, quantification is required. This need is even greater in cases where compound effects of measures are to be assessed. Optimizing the spatial layout of a set of WRMs in the setting of a watershed is a matter of studying interactions characterised by complexity in time and space. The efficiency of measures becomes mutually dependent between these measures. Measures situated upstream from, for example, a constructed wetland reduce the efficiency of the wetland; if fewer sediments come in, its cost/benefit ratio will increase. The complexity of these interactions can only be assessed by process simulation.

NIBIO is cooperating with 19 other research institutes in an ongoing EU-funded (2020 - 2025) research project that develops a tool for exactly this purpose. The OPTAIN (OPtimal strategies to reTAIN and re-use water and nutrients in small agricultural catchments) project is aimed at the development of methods to harmonise optimal use and re-use of water resources in a multi-stakeholder environment under changing climatic conditions. One of NIBIO's contributions is the development of a case study that incorporates different mathematical models for the assessment of water retention strategies for a small, agricultural catchment.

Parametrising such models carries two major challenges; calibration of the baseline scenario (with or without implemented measures) and assigning effectiveness quantifiers to measures. The first is a common activity in hydrological modelling and can be based on a variety of measurements and observations. This is not the case for the latter. Even if measurements are reported in in-house reports, scientific publications or handbooks, the actual effectiveness of measures is a function of terrain, topology, weather and agronomy and other circumstances.

In OPTAIN, expertise from 14 case studies is developed on shared modelling platforms, with the aim of identifying and developing quantitative methods to incorporate the effectiveness of water retention measures into hydrological models.

If these methods are found to be sufficiently representative of the changes to the physical environment that they represent, models can be used to compare WRM strategies and to develop a cost-efficient ensemble of measures for a certain catchment.

Norsk institutt for bioøkonomi (NIBIO) ble opprettet 1. juli 2015 som en fusjon av Bioforsk, Norsk institutt for landbruksøkonomisk forskning (NILF) og Norsk institutt for skog og landskap.

Bioøkonomi baserer seg på utnyttelse og forvaltning av biologiske ressurser fra jord og hav, fremfor en fossil økonomi som er basert på kull, olje og gass. NIBIO skal være nasjonalt ledende for utvikling av kunnskap om bioøkonomi.

Gjennom forskning og kunnskapsproduksjon skal instituttet bidra til matsikkerhet, bærekraftig ressursforvaltning, innovasjon og verdiskaping innenfor verdikjedene for mat, skog og andre biobaserte næringer. Instituttet skal levere forskning, forvaltningsstøtte og kunnskap til anvendelse i nasjonal beredskap, forvaltning, næringsliv og samfunnet for øvrig.

NIBIO er eid av Landbruks- og matdepartementet som et forvaltningsorgan med særskilte fullmakter og eget styre. Hovedkontoret er på Ås. Instituttet har flere regionale enheter.

Forsidefoto: Rødvannet på Hurum er et eldre regulert vann for kraftproduksjon, prosessvann, landbruksvanning og friluftsliv. Foto: T. Mæhlum

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