De Økonomiske Råd

The Environmental Economic Conference 2022

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Cost-effective implementation of the WFD in Denmark

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Abstract : The Water Framework Directive (WFD) has set a deadline for 2027 to reach at least good ecological status (GES) in coastal and marine waters in the EU. In Denmark, cost-effectiveness analyses have been commissioned by the Ministry of Environment to identify the most cost-effective measures to reach GES.

For this purpose, we have used an integrated economic-environmental model system, *TargetEconN*, and have applied the model in the 108 coastal catchments in Denmark. Integrating economics, agronomics and hydrology within one modelling framework provides the possibility to assess targeted policies including the differences in environmental effects and economic costs among locations and farms, thus providing essential information for implementation. The model takes a social planner approach, and the results can provide valuable insight for policy development

The model is set up to minimize the costs of achieving nitrogen (N) load reduction targets in each of the 108 catchments. The model has been extended to include phosphorus (P), providing the options for modelling trade-offs and synergies between the regulation of both nutrients. In this presentation we focus only on N targets. The model has also been extended to include a marine mitigation measure, mussel production which can be used to reduce the N in the coastal areas and fjords by recycling the nutrients during harvest of the mussels.

TargetEconN combines a diverse sets of information on agronomy, hydrology and economics,. The detailed modelling at catchment level combines these data layers on crop types (average on field level in a rotation of 5 years), gross margin data for the crops in a 5 years rotation, fertilization levels, soil types, retention, nitrogen leaching effects from measures as well as detailed modelling of the potential for implementing measures at field scale. The model account for the costs of abatement measures as the combination of lost economic returns from the crop production at field level and the costs of the implementation of measures.

The results for the WFD targets indicate that permanent set aside and forestation are the most cost-effective measures at a large share of the catchments, and also that requirements for targeted catch-crops, as set out in the governmental plans, will be less cost-effective and therefore not part of the optimal solution to the same degree as in the governmental plans. When the governmental plans are set as requirements for the solutions, i.e. a certain share of catch crops is required, the costs increase by about 50 percent.

The choice of permanent set aside and forestation provides significant, positive spill-over effects on climate mitigation (measured as CO_2 equivalents) as well as P losses from agricultural fields. These side-effects are not part of the optimization, but the results indicate that there might be significant gains from coordinating these policy domains.

Including marine measures in the portfolio of measures also has an influence on the spatial distribution of the implementation of land-based measures and reduce the share of set aside in the catchments that have a potential for mussel cultivation. Including mussels also has an impact on the overall costs of meeting good ecological status in the catchments that have a potential. We therefore conclude that including mussel farming in policy initiatives to meet WFD targets has a potential, and that the distributional effects on land-based measures should be a central part of the policy discussions.

We conclude that spatially explicit integrated modelling, as the model developed for this paper, can offer useful insights to the unescapable trade-offs in effective policy design to meet the WFD. As part of the commissioned work for the Ministry on WFD the model solutions from TargetEconN is compared to the solutions from another model, SMART, and the comparison has been used for sensitivity analysis of the results and provide an upper and lower bound for the costs estimated for the WFD target achievement.