# **Systems analysis as tool for developing sustainable solutions in agricultural production**

Society is facing several major challenges including climate change, increasing food demand as well as decreasing arable land area. Agriculture plays the central role in the provision of food and feed. Changing the current largely fossil-based economy to a renewable resource-based economy, agriculture needs to also satisfy increasing demands for the production of materials and energy. This will require large amounts of agricultural biomass, i.e. crops and residues, in addition to food and feed production. Our current knowledge needs to be broadened to combine these production goals in efficient production systems and to unlock the full agricultural potential. An increased production and recovery of biomass from agriculture needs to be implemented in an environmentally and economically sustainable way that is also socially acceptable. To assess if a production system is sustainable, systems analysis is used to e.g. identify major environmental impacts or cost-intensive steps. For that purpose, material and energy used in each step of the production process and resulting emissions and impacts are estimated using mathematical models. These results are then used to describe and compare the sustainability of alternative production system. Systems studies can be used to find sustainable solutions by answering the following questions:

**Where does the biomass come from?** Sweden´s potential to produce biomass in agriculture is large. It includes both residues such as crop residues and excess ley crops, but also crops such as intermediate crops and ley crops from intensification. The goal of using these biomass resources is to minimize the impact on the current food and feed production. The potential amount of available biomass can be estimated in systems analyses based on statistical data on cultivation area, yields, residue fractions and efficiency of biomass recovery from the fields.

**How is the biomass used best?** Beside crop parts that are used for food and feed purposes, existing biomass residues do already have a use today, e.g. as green manure or bedding material. Sustainable use of these resources needs to consider current uses and prioritize between current and alternative uses. A specific biomass resource can be used in different ways, producing different end-products using a multitude of technical solutions. Techno-economic assessments investigating these technical solutions can help to compare alternative production options and evaluate if the options are economically feasible.

**What is the impact of change?** Life-cycle assessment or LCA is a systems analysis method that helps studying the impacts of production systems on e.g. climate, biodiversity and socio-economic aspects which can be estimated and compared to the impact of the current production system. This way, pros and cons of alternative production systems can be assessed in theory. However, in order to assure realistic outcomes with high reliability, these assessments will have to be complemented with field experiments in order to acquire relevant data. Systems analysis also helps to learn about existing production systems, for instance, how quality aspects important in the processing steps can be improved by adjusting the production of the crops.

**Are there any examples?** There are promising concepts of production systems that help to develop the agricultural sector as provider of biomass for the bioeconomy, as provider of ecosystem services and as a sector with low emissions. To improve the current production system to become sustainable requires that we overcome economic challenges. But such a change also offers opportunities to develop Swedish agriculture into an innovation platform for bio-based, renewable and sustainable products. Here, systems analyses can support agricultural product and value chain development, e.g. production of biomass-based materials, chemicals, energy or fertilizer products.