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Meteorological risks as drivers of innovation for agroecosystem management

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Devastating weather-related events recorded in recent years have captured the interest of the general public in Belgium. The MERINOVA project research hypothesis is that meteorological risks act as drivers of environmental innovation in agro-ecosystem management which is being tested using a "chain of risk" approach. The major objectives are to (1) assess the probability of extreme meteorological events by means of probability density functions; (2) analyse the extreme events impact of on agro-ecosystems using process-based bio-physical modelling methods; (3) identify the most vulnerable agro-ecosystems using fuzzy multi-criteria and spatial analysis; (4) uncover innovative risk management and adaptation options using actor-network theory and economic modelling; and, (5) communicate to research, policy and practitioner communities using web-based techniques.

Generalized Extreme Value (GEV) theory was used to model annual rainfall maxima based on location-, scale- and shape-parameters that determine the centre of the distribution, the deviation of the location-parameter and the upper tail decay, respectively. Likewise the distributions of consecutive rainy days, rainfall deficits and extreme 24-hour rainfall were modelled. Spatial interpolation of GEV-derived return levels resulted in maps of extreme precipitation, precipitation deficits and wet periods. The degree of temporal overlap between extreme weather conditions and sensitive periods in the agro-ecosystem was determined using a bio-physically based modelling framework that couples phenological models, a soil water balance, crop growth and environmental models. 20-year return values were derived for frost, heat stress, drought, waterlogging and field access during different sensitive stages for different arable crops. Extreme yield values were detected from detrended long term arable yields and relationships were found with soil moisture conditions, heat stress or other meteorological variables during the season. A methodology for identifying agro-ecosystem vulnerability was developed using spatially explicit information and was tested for arable crop production in Belgium. The different components of vulnerability for a region include spatial information on meteorology, soil available water content, soil erosion, the degree of waterlogging, crop share and the diversity of potato varieties. The level of vulnerability and resilience of an agro-ecosystem is also determined by risk management. The types of agricultural risk and their relative importance differ across sectors and farm types. Risk types are further distinguished according to production, market, institutional, financial and liability risks. Strategies are often combined in the risk management strategy of a farmer and include reduction and prevention, mitigation, coping and impact reduction. Based on an extensive literature review, a portfolio of potential strategies was identified at farm, market and policy level. Research hypotheses were tested using an on-line questionnaire on knowledge of agricultural risk, measuring the general risk aversion of the farmer and risk management strategies.

The "chain of risk" approach adopted as a research methodology allows for investigating the hypothesis that meteorological risks act as drivers for agricultural innovation. Risks related to extreme weather events in Belgium are mainly caused by heat, frost, excess rainfall, drought and storms, and their impact is predominantly felt by arable, horticultural and extensive dairy farmers. Quantification of the risk is evaluated in terms of probability of occurrence, magnitude, frequency and extent of impact on several agro-ecosystems services. The spatial extent of vulnerability is developed by integrating different layers of geo-information, while risk management is analysed using questionnaires and economic modelling methods. Future work will concentrate on the further development and testing of the currently developed modelling methodologies.

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