Fork-to-farm agent-based simulation tool augmenting BIOdiversity in the agri-food VALUE chain – BioValue, H2020

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BioValue will investigate the complex relationships between climate change and biodiversity within the European agricultural context, recognizing that these interconnected dynamics will present significant challenges for both biodiversity conservation and agricultural productivity. As climate extremes, such as heatwaves, droughts, and altered precipitation patterns, become more frequent and severe, BioValue will focus on developing adaptive strategies grounded in high-resolution climate model data. These data-driven models will provide critical insights into the risks posed by climate change to agricultural systems and biodiversity, thus supporting proactive and localized adaptation measures. Given the current unavailability of EURO-CORDEX CMIP6 simulations, BioValue will select alternative high-resolution models and adapt them specifically for agricultural applications within Europe. BioValue will thus leverage advanced Earth System Models (EC-Earth3, CNRM-CM6-1-HR, and MPI-ESM1-2-HR), using the SSP5-8.5 high-emission scenario to simulate and assess worst-case climate outcomes for Europe in the mid-21st century. This scenario will highlight the urgency of preparing agricultural systems for substantial warming and climate variability, especially as traditional agricultural practices face intensified pressures.

To produce precise climate projections on a regional scale, BioValue will employ two robust statistical post-processing techniques: downscaling via the Perfect Prognosis (PP) approach and bias correction through Quantile Delta Mapping (QDM). The PP approach will facilitate the transition from large-scale climate models to localized climate insights by harmonizing large-scale climate predictors with region-specific variables, yielding geographically and temporally refined climate projections tailored to BioValue pilot sites. QDM will complement this by aligning model outputs more closely with observed climate data, reducing biases while preserving projected climate trends essential for accurate climate assessments. These techniques will allow for downscaling to spatial resolutions as fine as approximately 1 km, thus producing highly localized data essential for assessing climate impacts and supporting BioValue's mission to provide European agriculture with actionable climate information.

The project's primary outputs will include the development of climate atlases for each BioValue pilot site, offering site-specific projections on daily, monthly, and seasonal scales. These atlases will incorporate both current and projected climate scenarios for selected crops, making them a valuable resource for regional adaptation planning. Alongside the atlases, BioValue will create a comprehensive table of agriculture-relevant indicators designed to quantify and evaluate climate risks at the regional level. This table will include essential metrics such as drought indices, heat stress markers, and indicators of compound events, all of which will be crucial for monitoring climate risks across BioValue's pilot sites. Key indicators such as the Standardized Precipitation Index (SPI), Heat Magnitude Day (HMD), and Combined Stress Index (CSI) will offer indispensable tools for assessing the conditions that can impact crop growth and productivity on a regional basis. Together, the atlases and the indicator tables will provide a scientifically rigorous foundation for policymakers and stakeholders to engage in data-driven adaptation planning that addresses both the immediate and long-term threats posed by climate variability and change.

In addition, BioValue will investigate the projected impacts of compound climate events on European agriculture, with a particular focus on patterns such as dry winters followed by

intensely hot summers. These compound events are well-documented stressors for crops, as they create cumulative challenges that heighten the likelihood of crop failures and reduced yields. By analyzing these climate sequences, BioValue will provide valuable insights into the specific pressures that European agriculture may encounter, especially in regions susceptible to significant climate variability. This research will be essential for guiding the adaptation of agricultural practices and developing mitigation strategies that help secure crop viability and maintain food security amidst the rising unpredictability of the climate.

Through this comprehensive, multi-faceted approach, BioValue will equip European agricultural systems with climate-informed tools needed to foster resilience in the face of evolving climate and biodiversity challenges. The combination of refined model outputs, site-specific climate atlases, and targeted climate risk indicators will enable more strategic and responsive planning, ensuring that the agricultural sector is better prepared to adapt and thrive in the decades to come.