Chapter 63
Modeling Environmental Impacts on Viticultural Ecosystems:
A First Case Study in a Regulated Wine Producing Area

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ABSTRACT

This paper focuses on simulating environmental impacts on grapevine behavioral dynamics and vineyard management strategies. The methodology presented uses technology from geomatics object oriented databases and spatio-temporal data models. Our approach has two principle objectives, first, to simulate grapevine phenology and grape ripening under spatial and temporal environmental conditions and constraints and secondly, to simulate viticultural practices and adaptation strategies under various constraints (environmental, economical, socio-technical). The approach is based on a responsive agent-based structure where environmental conditions and constraints are considered as a set of forcing data (biophysical, socio-economic and regulatory data) that influences the modelled activities. The experiment was conducted in the regulated wine producing appellation Grand Cru "Quarts de Chaume", situated in the middle Loire Valley, France. All of the methodology, from the implementation of the knowledge database to the analysis of the first simulation, is presented in this paper.

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INTRODUCTION

Global climate change affects regional climates and hold implications for wine growing regions worldwide (Jones, 2007 & 2015; Van Leeuwen & Darriet, 2016). In Europe, the implications of climate change at regional scales have been particularly assessed during the last decade, with several studies showing the relationship between recent warming and changes in grapevine behaviour (Jones & Davis, 2000; Duchêne & Schneider, 2005; Bock et al., 2011; Tomasi et al., 2011; Neethling et al., 2012; Koufos et al., 2014).

The prospect of 21st century climate change consequently is one of the major challenges facing the wine industry (Keller, 2010). They vary from short-term impacts on wine quality and style, to long-term issues such as varietal suitability and the economic sustainability of traditional wine growing regions (Schultz and Jones 2010; Quénol 2014b). To address the potential effects of climate change, namely responding to both environmental and socio-economic risks, winegrowers must reconsider their viticultural practices and strategies (Battaglini et al. 2009, Fraga et al. 2012; Ollat et al., 2016; Ashenfelter & Storchmann, 2016; Mosedale et al., 2016). Within this perspective, many studies have addressed the issue of future climate change impacts and potential adaptation options, based on modelling technologies (Webb et al., 2007; Malheiro et al., 2010; Santos et al., 2012; Fraga et al., 2013, Hannah et al., 2013, Briche et al., 2014). These studies place an important dependence on regional climate change projections and socio-economic scenarios, which are then used to analyse climate change impacts on vine growth, through the use of bioclimatic models (Dessai & Hulme, 2004). These models can be simple representations of grapevine behaviour or more complex models, incorporating several variables. Yet very few studies are devoted to modelling the complex interaction between abiotic (i.e. environmental aspects), biotic (i.e. vine behaviour) and anthropogenic factors (i.e. viticultural activities) at local scales.

Indeed, grapevine growth and health, grape yield and quality are strongly related to local environmental conditions and constraints (Jackson & Lombard, 1993; Tesic et al., 2002; Van Leeuwen et al., 2004; Carey et al., 2008, Bonada & Sadras, 2015). To that end, spatial and temporal climate variations play a major role on the seasonal rhythm of vine phenology and grape ripeness at harvest (Huglin & Schneider, 1998). From here, these environmental variations together with grapevine behaviour and winegrowers' end-product objectives will greatly influence vineyard management practices and decision making at plot- to farm-level (Coulon et al., 2012; Neethling et al., 2016). Although winegrowers are constantly adapting to internal and external factors, there is a necessity to develop tools, which will allow them to better define actual and future agro-climatic potentials and therefore ensure quality and unique wine production. Within this context, it seems appropriate to develop a modelling approach, able to simulate the impact of environmental conditions and constraints on vine behaviour and the dynamics of viticultural activities.

First of all, our approach is to implement a model that can simulate agronomic action practiced by winegrowers in well-known agro-climatic contexts (for different reference years). By extension, our goals are to provide prospective simulations can simulate the conditions of adaptations of existing routes in the context of climate change. Without being a decision support system our approach aims to provide projections of spatial and temporal adaptation of vineyards to climate change scenarios. Through an experiment conducted in the wine appellation Grand Cru "Quarts de Chaume", situated in the middle Loire Valley wine growing region, France, all of the methodology, from the implementation of the knowledge database to the analysis of the first simulation, is presented in this paper. And finally, research approach and perspectives are discussed.