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EXPLORATORY ANALYSIS OF POTENTIAL EFFECTS OF CLIMATIC CHANGE IN THE "VALES DA UVA GOETHE"

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Introduction

The fast and intense scientific, technological, economic and social progress witnessed by society since the eighteenth century, beginning with the First Industrial Revolution, brought profound changes in daily life and lifestyle, but that triggered to a process of ecosystem degradation and resource depletion without precedence in human history. The sheer scale of human intervention in ecosystem dynamics is promoting a series of changes in the natural system (IPCC, 2007a, 2014; MARENGO *et al.*, 2011; WORLD BANK, 2012; PBMC – Brazilian Panel for Climatic Change, *Painel Brasileiro de Mudanças Climáticas*, 2013; The US National Academy of Sciences and the Royal Society, 2014).

The magnitude attained by environmental problems by the turn of the 21st century (ANDI, 2007; Marengo *et al.*, 2011; PBMC, 2013) reveal that this will be the greatest challenge faced by society in our day. In several regions, the degradation of the natural environment has already jeopardized the quality of life and wellbeing (SEIFFERT, 2007; MARENGO *et al.*, 2011). An increasing amount of regions suffers from a degraded hydric environment, a rapidly changing local microclimate, loss of soil fertility, and the desertification of extensive agricultural areas, among other adverse effects (MARENGO, 2007a; MARENGO *et al.*, 2011).

Comune asserts that (1994, p. 45-46), "*se no passado à economia condicionou a utilização do meio ambiente, sem se preocupar com a degradação e exaustão de seus recursos, atualmente parece ser o meio ambiente que deve condicionar a economia*"[i]. This means that society finds itself in a completely different context than what was experienced in the

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twentieth century. Therefore, traditional analytic toolkits must be reviewed, because the potential impact of this new context on socioeconomic dynamics evaluated, particularly in agriculture, will be highly sensitive to changes in ecosystem dynamic.

Corroborating Thomas and Callan's (2010, pp. 1-2) claim that "*como sociedade, já reconhecemos que a atividade econômica e o ambiente natural estão inexoravelmente, conectados e que essa profunda relação está no núcleo da gestão e da economia ambientais*"[ii]. In this regard, the recent reports released by the Intergovernmental Panel on Climate Change (IPCC, 2007a; 2014), World Bank (WORLD BANK, 2012), United Nations (UN, 2008; UNDP, 2007), The US National Academy of Sciences and the Royal Society (2014), European Community (Europa, 2013), the Brazilian National Institute for Space Research (INPE) and *Rede Clima* (Earth System Science Center – CCST, *Centro de Ciência do Sistema Terrestre*, 2014) are unanimous in calling attention to this close relationship, and to the intensification of climatic change caused by an increased concentration of greenhouse gases in the atmosphere, largely due to human activity, and due to the absence or ineffectiveness of global emission reduction agreements and policies (MARENGO *et al.*, 2011).

There are strong indications that greenhouse gas emissions are currently affecting global climatic dynamics (IPCC, 2007a; 2014; MARENGO *et al.*, 2011; WORLD BANK, 2012; PBMC, 2013). Fossil fuels extracted from the natural system and burned or used in economic processes, invariably resulting in the release of carbon dioxide (CO2) in the atmosphere. In this manner, as a result of the matter and energy exchanges involved in these processes, environments are affected by the concentration of CO2 and other greenhouse gases in the atmosphere, such as methane, CH4, Nitrous Oxide, N2O, a by--product in the production of Nitric Acid, HN3, all of which may be altering the average temperature of Earth (IPCC, 2007a; 2014; STOTT, 2013). Over the last two centuries, the volume of CO2 in the atmosphere has increased significantly (IPPC, 2007a; 2014), recently reaching a record of 400 ppm (parts per million) (STOTT, 2013)[iii].

In an attempt to assess the potential impacts of the increase in the global average temperature, the IPPC (2007b) has been working with six scenarios to assess trends both in global average temperature and sea level variation. As Moraes (2010) highlighted, in spite of the uncertainty involved in the construction of any scenario, however conservative, results indicate a minimum projected increase in temperatures of 0.6 °C, and in sea level of 18 inches (IPCC, 2007b). Besides, the increase in global average temperature of 4 °C is the central trend expected in case of continued high emissions (IPCC, 2007b).

Projections by the Brazilian National Institute for Space Research (INPE, *Instituto Nacional de Pesquisa Espaciais*) on the potential effects of climate change expect an increase from 4 °C to 6 °C (pessimistic scenario), or from 1 °C and 3 °C (optimistic scenario) in Brazil's average temperatures by 2100 (MARENGO, 2007b; BRASIL, 2013; PBMC, 2013). Impacts from the temperature rise may advance arid and semiarid areas and desertification, loss of biodiversity, decreased agricultural productivity, changes in rainfall regime, and among other effects (IPCC, 2007a; 2007b; MARENGO, 2007a; 2007b; MARENGO et al, 2011; PBMC, 2013). INPE projects a reduction in rainfall in the North region and an increase in droughts in the semiarid Northeast in Brazil (MARENGO, 2007b; BRASIL, 2013; PBMC, 2013).

Regardless of the uncertainties involved in IPCC's projections and scenarios for the global average temperature, or even in the source of the changes[iv], whether climatic change is anthropogenic in origin, society has witnessed several changes in the natural ecosystems dynamic, and even in average temperatures (ANDI 2007), especially at local and regional scales.

In Monteiro understanding (2011, p. 1), "*a mudança do clima prevista para as próximas décadas como resultado do aquecimento global coloca em risco a produção agrícola no Brasil*"[v]. In this new context, what is the possible impact of the planet's temperature variations on agriculture? According Monteiro (2011), an increase in global average temperatures may reduce the favorable area for soybean, coffee, corn, rice and other crops; the IPCC expects clear impacts on wheat, rice and maize yields (IPCC 2014); estimating a loss to Brazil reach $ 7.5 billion by 2020 (MONTEIRO, 2011). In another study, Moraes (2010) estimates that the potential loss to Brazilian agriculture may reach 0.29% of the GDP (Gross Domestic Product) in Brazil in the A2/2020 scenario, or around 1.09% of the GDP, in the B2/2070 scenario[vi].

Specifically addressing the wine industry, Monteiro *et al.* (2012) shows how climatic conditions directly influence the development, yield, and quality of vineyard crops. In the case of temperate viticulture, Monteiro (2011) expounds that an increase in average temperatures may result in milder winters, interrupted by temperatures warm enough to trigger growth, affecting the winter dormancy, causing a loss of uniform budburst, difficulties in crop management, and contributing to the spread of disease. In this scenario, the projected changes in climatic dynamics are very likely to affect the wine industry, as they have already affected agriculture as a whole (PBMC, 2013).

In this context, the main goal of this work is to develop an exploratory analysis of the potential impact of changes in global and regional climatic dynamics on the wine industry in the region defined by the "*Indicação de Procedência Vales da Uva Goethe*" (Geographical Indication) 'IPVUG', in the south tip of *Santa Catarina*, a state of southern temperate Brazil.

A survey was issued with a semi-structured questionnaire to eighteen grape producers in the *Vales da Uva Goethe* who are members of the local association, ProGoethe (*Associação dos Produtores da Uva e do Vinho Goethe da Região de Urussanga*), with the purpose of identifying any changes in the productive dynamics that may have not been captured by the official statistics. It should be noted that this gathering of information had the objective of appraising the producers' perceptions regarding any changes in production, without the researchers' mentioning climate change or its possible effects on the region or agriculture in general. This work also appraises scientific literature, and local climatic data from the local weather station, to verify possible alterations in the local climatic dynamic, in the region defined as the "*Vales da Uva Goethe*".

The work is organized into two sections, aside from this introduction and the final remarks. The first section presents the materials and methods used in the development of the exploratory study; characterizes the studied region; and describes methodological aspects in general. The second section presents and analyzes the information gathered from IPVUG producers.

Materials and methods

Viticiniculture in Brazil

In Brazil, the production of grapes and wine began in the 16th century. However, the production only began in earnest in the late 19th century with the arrival of German and Italian immigrants to the state of *Rio Grande do Sul* (GUERRA *et al.*, 2009), but the industrial and commercial production really was consolidated from the 1960s (PROTAS; CAMARGO; MELO, 2002).

Vieira, Watanabe and Bruch (2012) explain that the wine industry developed in nine regions across Brazil: *Rio Grande do Sul* (four regions, the mountain ranges '*Serra do Sudeste*' '*Serra Gaúcha*', '*Campos de Cima da Serra*', and the 'Central and North' region of *Rio Grande do Sul*); *Santa Catarina* (three regions, '*Vale do Rio do Peixe*', '*Planalto Serrano*' *and* '*Planalto Norte e Carbonífera*'); *São Paulo*; *Minas Gerais*; *Paraná*; and the Lower *São Francisco* River, (*Pernambuco* and *Bahia*). This shows that the wine industry was developed across a wide area of the country, ranging from latitudes 31º S in *Rio Grande do Sul*, to 5º S in *Rio Grande do Norte* and *Ceará*, and covering a great part of Brazilian states (CAMARGO; TONIETTO; HOFFMANN, 2011).

This large production area, according to Guerra *et al.* (2009), results from the manifold types of climate and soil found in Brazil. The variety of elements enables growing produce with varied characteristics, both in productivity and in quality (MONTEIRO *et al.*, 2012). Traditionally, the temperate south of the country is home to the most important wine production region, the '*Serra Gaúcha*' of *Rio Grande do Sul*, covering 8,000 km^2 (VIEIRA; ALBERT; BAGOLINN, 2007). However, the neighboring, also temperate state of *Santa Catarina* began to gain prominence with the production of small grape farmers, mostly Italian immigrants (PANDOLFO, 2010). Since the 1980s this region's wine industry has begun to professionalize.

Methodological aspects

The analysis of the potential effects of climate change on economic and social dynamics must be realized based on a multidisciplinary approach. In this regard, an interesting multidisciplinary approach for analyzing the environmental issue is suggested by Ecological Economics[vii]. This new paradigm integrates into a theoretical-analytical approaching several scientific fields, including economics, ecology, thermodynamics, ethics, and other natural and social sciences. Its goal is to provide an *integrated, holistic, dynamic, and 'biophysical' approach to the interrelationship between the natural system and the socio-economic subsystem, in an attempt to provide structural contributions for the solution of environmental and social problems*. (COSTANZA, 1994; RÖPKE, 2004). This approach has been called *transdisciplinary*, seeking integration and transversal synthesis in a single theoretical approach of several areas of scientific knowledge, to promote the cross-fertilization of ideas; the objective is not to create a new discipline, but to develop a plural form of addressing environmental issues (COSTANZA, 1994). Inasmuch as the transdisciplinary approach is different from the multidisciplinary perspective, it involves a full integration of methods, theories and results, delimiting no clear boundaries between the fields of knowledge involved in solving a problem (CAVALCANTI, 2010).

This approach recognizes the importance of "unscientific" knowledge. For the present scenario, this work seeks to adopt as far as possible this theoretical-methodological proposal. It should be noted that, in this approach, the choice of analytical instruments or theories as a methodological subsidy for the analysis, that must not be performed before to the identification and analysis of the problem, but have to be determined according to the problem under analysis. Thus, the analytical method proposed in this study is non-traditional, does not focus on the conventional approach, but includes gathering information from non-experts (outside academia) who are firsthand observers, such as small producers of *Goethe* grapes and *Goethe* wines in the target region.

Based on these assumptions, in this study we sought information and perceptions from many sources: conducting a semi-structured questionnaire and interviews, but also analyzing raw weather data and agricultural statistics. The instrument was applied to farmers, to analyze their perception of any climatic change and its influence on wine production, in the region defined for this study.

Field research was conducted interviewing eighteen grape and wine producers in the region defined by the "*Vales da Uva Goethe*" geographical indication, located in the south of Santa Catarina, Brazil, between February and March, 2013. The interviews had two objectives: i) identifying any changes in the productive dynamics not captured by the official statistics; ii) gathering information from producers regarding any variability in production, productivity or product quality, however without mentioning the topic of "climate change" or suggesting that any noted variability could relate to the latter. This strategy was adopted to avoid leading or influencing interviewee response.

To validate the information and impressions gathered from producers, these were complemented to external objective raw data on the climatic dynamics of the target area. These data were collected at the local weather station, provided by the Company for Agricultural Research and Rural Extension of *Santa Catarina* and the Center for Environmental Resource and Hydrometeorology Information of *Santa Catarina* - EPAGRI/CIRAM, which divulges information on the monthly rainfall, absolute monthly maximum, minimum and average temperatures, average monthly insolation, and monthly average relative air humidity. The climatic data were collected by the EPAGRI meteorological station in the town of *Urussanga*/SC (27°31'55" S, 49°18'53" E, altitude 48 meters) (Map 1). These data allowed verifying any variability in weather conditions, over time, in the region.

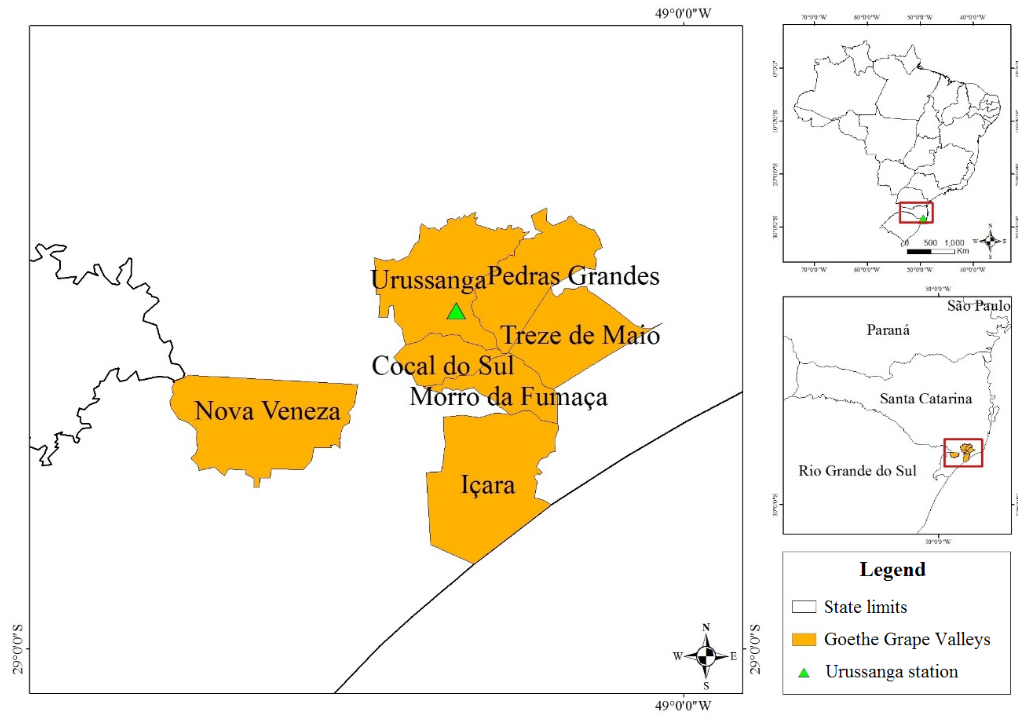
The study area: Geographical Indication of 'Vales da Uva Goethe" (IPVUG) of Santa Catarina

The history of vitivinicultural production in the IPVUG region is indistinguishable from that of Italian immigration in the late 19th Century, as the first vines were planted. The *Goethe* Grape, a hybrid of North America origin, became a typical regional grape due to optimum adaptation to the local climate and soil (REBOLLAR *et al.*, 2008).

Wine and grape production had a troubled history in the region, marked by a dispute between the vitiviniculture and mining industries, because the latter offering better salaries than did the fields. After the decline of the 'golden age' of mining, and midst a search for new economic activities, the Italian immigrants, pursuing their tradition and know-how and using the *Goethe* grape, developed a differentiated wine, with its own identity.

Starting with a marketing strategy to attain public recognition of the value of a typically regional product rooted in the culture and tradition of its people, winemakers constituted the *Associação dos Produtores da Uva e do Vinho Goethe* (ProGoethe) of the *Urussanga* Region in 2006, with the objective of valuing this typical product, which had nearly vanished over time. The producer association was focused on recognizing the Geographical Indication for the "*Vales da Uva Goethe*". This should cover the area of the municipalities of *Urussanga, Pedras Grandes, Cocal do Sul, Morro da Fumaça, Orleans, Nova Veneza, Içara* and *Treze de Maio* (Map 1)[viii] (VELLOSO, 2008).

Map 1 - Location of the Vales da Uva Goethe, *Santa Catarina*, Brazil



Source: Prepared by the authors, based on IBGE (2013a).

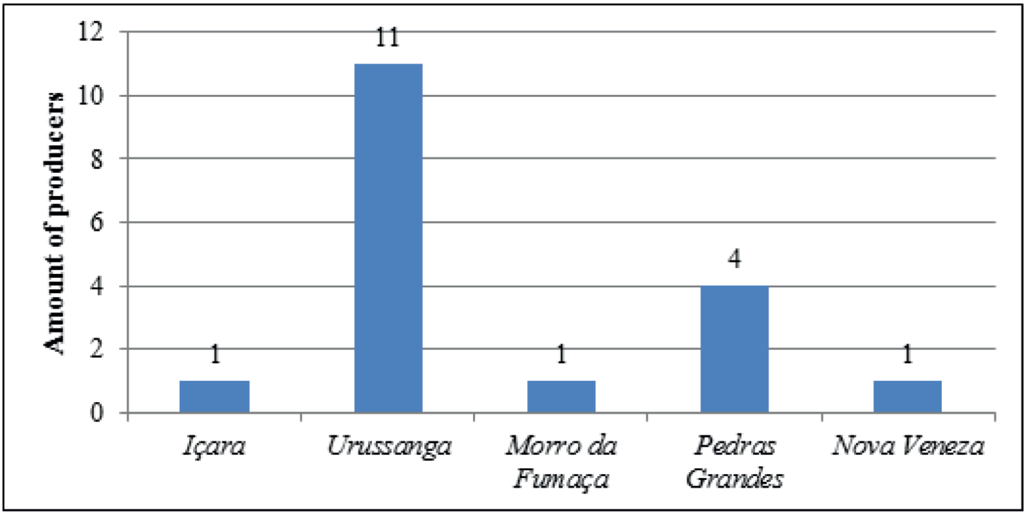
With this objective, producers sought support from SEBRAE (Brazilian Micro and Small Business Support Service), the Federal University of *Santa Catarina* (UFSC), the Ministry of Agriculture (MAPA), and the Company for Agricultural Research and Rural Extension of *Santa Catarina* (EPAGRI) (VIEIRA, WATANABE AND BRUCH, 2012).

Actually, the IPVUG has these members are: *Vinícola de Noni* (winery), *Vinhos Quarezemin* (winery), *Vinhos Trevisol* (winery), *Vinícola Irmãos Felipe* (winery), *Vinícola Mazon* (winery), *Vitivinícola Urussanga* (Casa del Nonno) (winery), *Vinho Artesanal Raul Savio* (winery), *Vinho Artesanal Rafael Sorato* (winery), *Vinho Artesanal Márcio Scremin* (winery), *Vinho Artesanal Cancelier* (winery), *Rodolfo Della Bruna* (grape grower), *Denner Quarezemin* (grape grower), *Deivson Baldin* (grape grower) (PROGOETHE, 2014).

The region delimited by the IPVUG is characterized in the Köppen classification as the Humid Subtropical Climate, marked by well-distributed rainfall and warm summers (Cfa). The average monthly temperature ranges from 12°C to 15.1°C in the cool months, and a monthly average of 23.4°C to 25.9°C in the warm months. The region receives an average annual rainfall of 1,220 mm to 1,660 mm[ix].

The interviews were held with wine maker and grape grower members of the Pro-Goethe association (Charts 1 and 2). The concentration of producers' in some municipalities reflects the spatial convergence of producers around the town of *Urussanga*. The second ranking producing region is *Pedras Grandes*. Finally, the municipalities of *Morro da Fumaça, Nova Veneza* and *Içara* shelter a single wine producer or grape grower each.

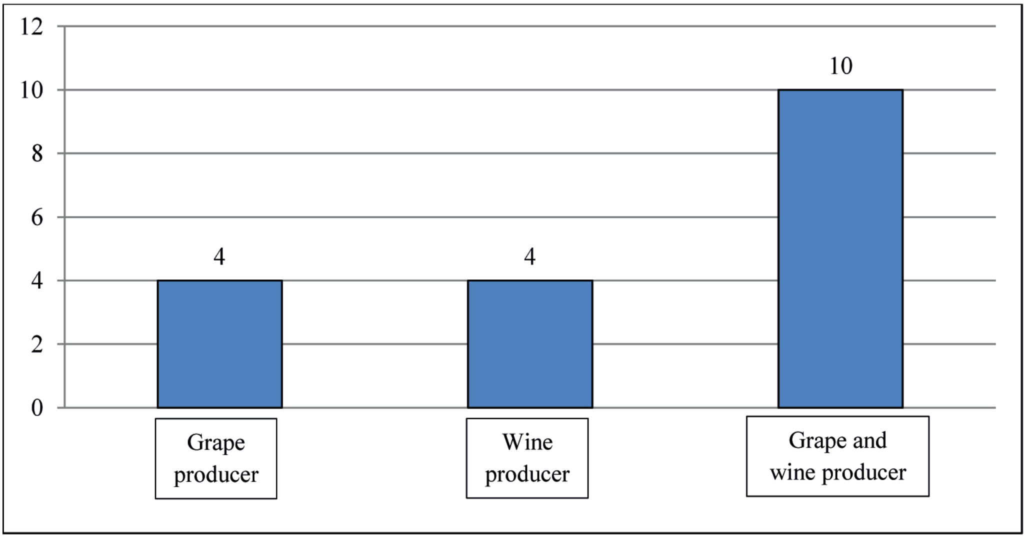
Chart 1: IPVUG municipalities, per amount of winemakers or viticulturists



Source: prepared by the authors from data collected during interviews

The eighteen respondents related as their primarily occupation the production of grapes, wine, and both grapes and wine (Chart 2). Among these, four are grape growers, four produce only wine and buy grapes from third parties, and ten produce both grapes and wine. Current wine production reported by the respondents reaches around 808,000 liters/year. The winemakers with the largest production are *Irmãos Felipe, Trevisol* and *Del Nono*.

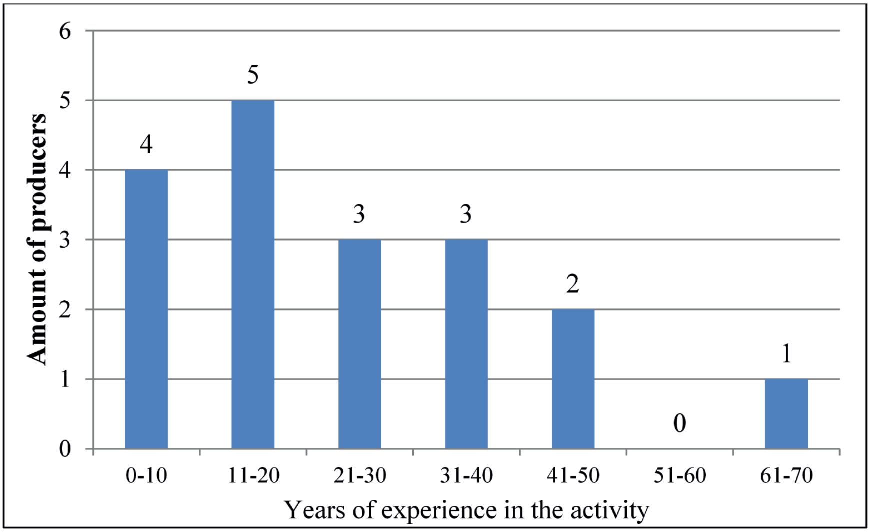
Chart 2: Main Interviewee Activity



Source: prepared by the authors from data collected during interviews

Beginning in the 1970s and 80s, these entrepreneurs started to invest in making quality wine from *Goethe* grapes, striving to rescue the cultural traditions surrounding the grape, winemaking, and other nearly forgotten traditions (MAESTRELLI, 2011). In this sense, producer experience in the activity, as shown in Chart 3, may contribute to the comprehensiveness of the collected information.

Chart 3: IPVUG winemaker and viticulturist experience, in years



Source: prepared by the authors from data collected during interviews.

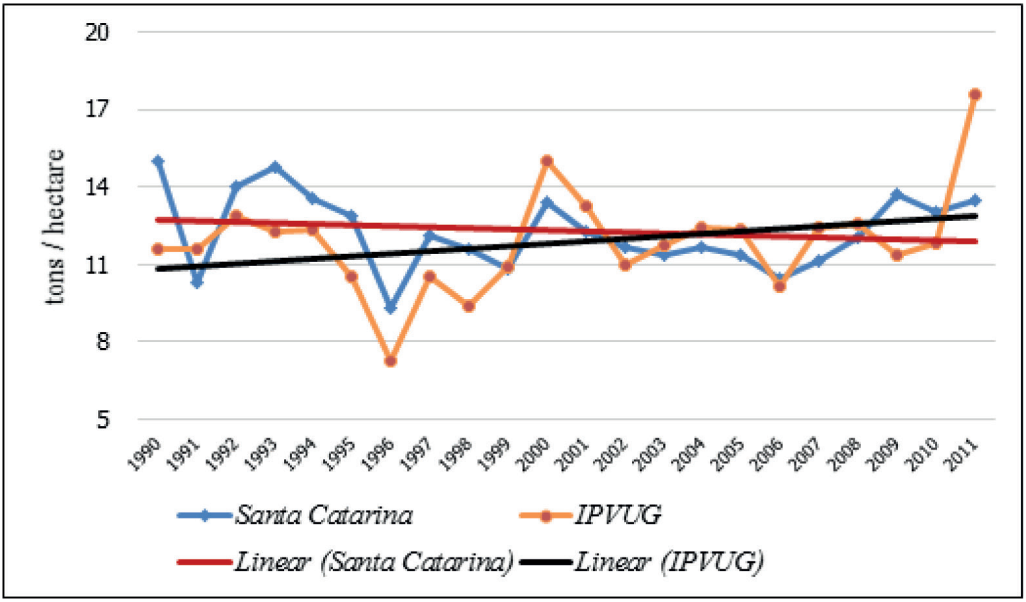
The subsequent section follows our results, discussing and analyzing the information gathered from producers and the literature and climatic data of the region.

Results and discussion

This section has the purpose of presenting the results of the survey made with IPVUG grape growers and wine producers to identify changes in productive dynamics not captured by official statistics. Another purpose of the survey is to appraise the producers' perception of any variations in the productivity and quality of the grape grown in the region, in an attempt to assess whether there is any spontaneous indication by the producers that this variation may be associated with climate change.

For this purpose, our field research has sought to appraise information on the producers' perceptions, and how these changed since the beginning of production in the region – when the producer began activities – regarding any changes in productivity or product quality. In all, ten producers reported noticing changes in productivity, which is in fact also reflected in the Municipal Agricultural Survey (PAM, *Pesquisa Agrícola Municipal*) released by the Brazilian Institute of Geography and Statistics (IBGE, 2013b). The Municipal Agricultural Survey reveals that the region does in fact present high variability in grape yield, both in the IPVUG region and in the state of *Santa Catarina* as a whole (Chart 4).

Chart 4 - Comparative evolution of grapevine mean Yield per Hectare, in IPVUG and the state of *Santa Catarina*, 1990 – 2011



Source: Prepared by the authors based on IBGE (2013b).

An interesting aspect is that the variability observed in the IPVUG region is much higher than that observed in *Santa Catarina* as a whole. While the IPVUG region registered standard deviation of 1.99 in the mean yield between 1990 and 2011, whereas in *Santa Catarina*, the standard deviation was of 1.5: in 1990, productivity in Santa Catarina was of 15 tons per hectare; in 2011, 13.5 tons per hectare, i.e., a decrease of 11%. It should be noted that some periods recorded an even larger plunge - for example, in 1996 the yield drop reached 61% of the 1990 levels. However, the IPVUG region's productivity in 1990 was of 11.6 tons per hectare, and in 2011 reached 17.5 tons per hectare, an increase of 34% compared to 1990.

Among the producers who noticed a change in productivity, seven reported that there was an increase in yield, three that there was a decrease. The perceptions of both increases and reductions in yield, it was found, are both consistent with the Municipal Agricultural Survey as there was in fact reveal great variability in the average grapevine yield in the region, far higher than that of the state as a whole. This poses the question: what could explain the greater localized variability in the grape yield, in the IPVUG region?

The surveyed producers listed several factors to explain the variations, drops and upsurges in their crop yields, among which the most representative are: climatic influence, vineyard management and maintenance, improvement in grape quality, techniques to anticipate possible climatic actions, the use of enhanced pruning technique as suggested by EPAGRI, and the vineyard's stage of development. One interesting aspect is that the influence of climatic variability in productivity was "perceived", or spontaneously pointed out, by four producers. Three, of these producers, were also those who reported a decrease in yield. Therefore, the concept of climatic change as a hazard has indeed entered the interviewees' culture, being the most common spontaneously recalled cause in case of yield drop.

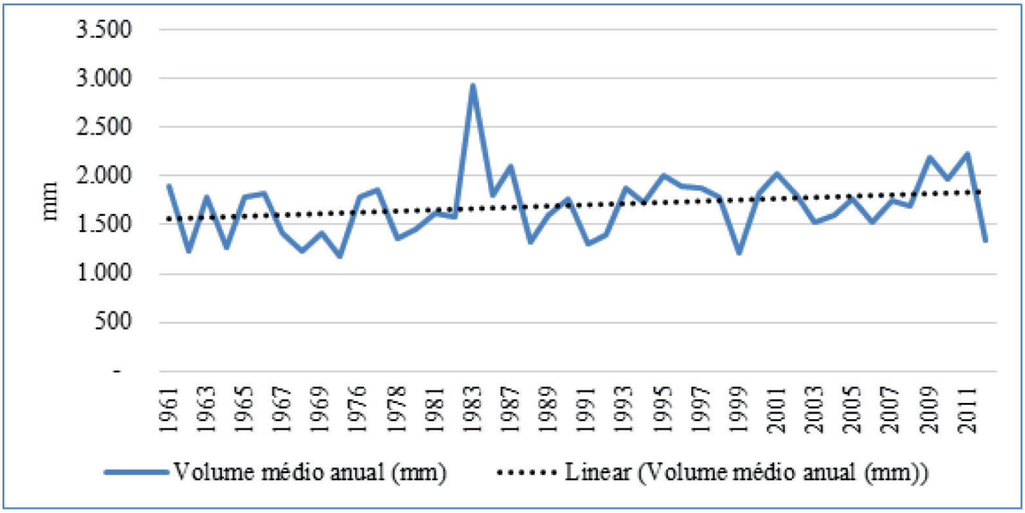
Regarding grape quality, according to field results, when growers and winemakers were asked about their perception regarding the beginning of grape growing in the region, and whether they had noticed any changes in grape quality, from the 18 interviewees, 15 producers replied to this question: 8 reported that there was indeed a change in grape quality, while the other 7 reported that there was not.

Validating this impression with external data, regarding grape quality, however, by analyzing information from other regions or on the state of Santa Catarina, is somewhat more complicated, due to the a lack of a standard, or even of basic records on crop quality in regional and local scales. However, it is noteworthy that among those 8 producers who answered "yes" when asked whether grape quality had improved, seven responded positively, that it had. Interestingly, among the listed factors for this improvement was "favorable weather", even though it was not possible to identify whether this was due to a better distribution of rainfall, of average temperature variability, or other factors.

Finally, another point is worthy of note, regarding quantitative and qualitative changes in production and the local climatic dynamics: producers reported several other factors to explain the improvement in grape quality, aside from the favorable climate, namely: good vineyard maintenance, technical guidance, EPAGRI's services, investments in technology, the presence of a local weather station, and vineyard development and maturity level.

In an attempt to investigate other possible causes of the high variability in grape yield and quality, the research analyzed the local climatic data. From average monthly rainfall, the estimate was made that the total maximum yearly rainfall reached 2,936 mm (average 245 mm/month) in 1983, and the minimum was 1,217 mm (average 101 mm/month) in 1999 (EPAGRI/CIRAM, 2013). The historical series of mean annual rainfall indicates an upward trend (Chart 5), reflected in increased monthly averages. This information is aligned with the projections presented by Marengo *et al.* (2009), indicating an increase in total rainfall in the south region of Brazil.

Graph 5 - Average annual rainfall (mm) recorded at the *Urussanga* weather station, 1961-2012



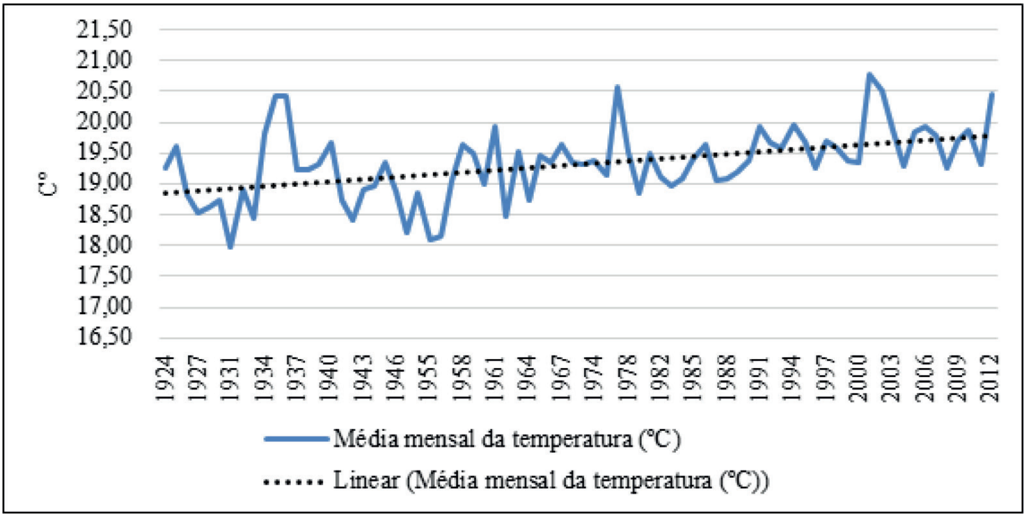
Source: Prepared by the authors based on data provided by Epagri/Ciram (2013).

Considering that the *Goethe* grape is harvested in January, February and March, the increase in average rainfall in December, January and February can affect the ripening of the grapes, as pointed out in an interview by Stevan Arcari (2013), enologist and winemaking consultant at the EPAGRI station in *Urussanga*/SC. According to the wine expert, this is because only at the end of the ripening period do grapes reach the requisite phenolic and sweetness levels, balancing sweetness with acidity and tannin levels, thus allowing the desired balance between these elements to be reached. EPAGRI/CIRAM data (2013) revealed an increasing trend in rainfall over this period. In addition, an increase in the average rainfall in September, October and November will aggravate the difficulty in maintaining vineyard health and bring a need for greater use of agrochemicals or risk a yield loss. EPAGRI/CIRAM data (2013) also indicated an increasing trend in rainfall over this period (September to November).

An upward trend can also be observed in average monthly temperatures - to a much steeper degree than rainfall – in both on-year (Chart 6) and monthly levels (EPAGRI/

CIRAM, 2013). It should be noted that a sharp increase in mean temperature may affect grape crops, but its main impact is in the selection of crop variety, once at times changes are demanded in the grown varieties in some regions, as pointed out by Jones (2007). A graver aspect related to an increase in average temperature is the higher probability of blights, pests and diseases (NEMANI *et al.*, 2001).

Chart 6 - Average monthly temperature in degrees Celsius, recorded at the *Urussanga* station, 1924-2012



Source: Prepared by the authors based on data provided by Epagri/Ciram (2013).

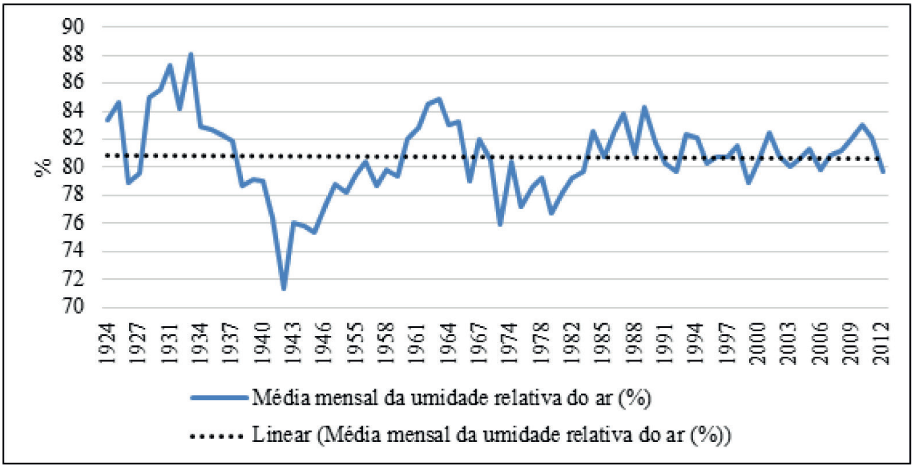
The historic series of monthly temperatures shows that the largest changes occurred in the average minimum (low) temperatures, which increased from 5.75 °C in 1924, to 8.3 °C in 2012, an annual increase of 0.00504 °C. The increase in the monthly low temperatures - more than the overall average, or mean, may negatively influence grape crop quality in that low-temperature periods are desirable in grape cultivation for wine production in connection with the 'winter dormancy' period of the vine. The monthly average maximum (high) temperatures witnessed smaller variation, increasing from 33.53 °C in 1924 to 34.7 °C in 2012. Strong increases in the monthly average high temperatures will also adversely affect the production of wine grapes. Grace *et al.* (2009) holds that exposure of wine grape vines to high temperatures are likely to inhibit or even fully block a series of key physiological and biochemical processes, affecting produce quality. This reduction of spread and in the variation between the average minimum (low) and maximum (high) temperatures are aligned to similar observations published in several studies (NEMANI *et al.*, 2001; ALEXANDER *et al.*, 2006; BLAIN et al, 2009;. KAYANO; SANSIGOLO, 2009).

In this context, the observations made by Stevan Arcari (2013) are worthy of note, pointing out that an increase in the mean winter temperatures may jeopardize budding, considering that it is the low temperatures that determine the grape's winter dormancy period; the onset of warmer temperatures breaks dormancy. The warm irregular winters break dormancy, causing irregular early budding. The early buds are, in turn, aborted by the subsequent late-winter frost. EPAGRI/CIRAM data (2013) also revealed a slightly increasing trend in mean temperatures in the winter months of June, July and August. However, if an equivalent increase in mean temperatures occurs in the summer months - Stevan Arcari (2013) observed – this could be far more prejudicial, as grape ripening could be accelerated, preventing adequate phenolic maturity, which requires a correct maturation period to achieve the right balance between sweetness, acidity and tannins. Marcio Sonego, researcher at EPAGRI'S Station at *Urussanga*, SC (2013) remarked:

> As videiras florescem no mês de setembro, quando há aumento na precipitação em relação ao inverno. Em setembro chove em média 12 dias do mês, contra apenas 9 dias em junho. Além disso, setembro tem se mostrado como mês de pouco brilho solar comparado aos outros meses do ano. Se a floração da videira acontece em uma semana chuvosa, ou mesmo em um mês todo chuvoso, isto acarretará na lavagem do pólen, menor fertilização do cacho e menor número de frutos. Esta condição poderá ser compensada pelo aumento do peso das bagas de uva, caso o clima seja mais seco durante a maturação[x].

Similarly, EPAGRI/CIRAM data (2013) indicated a trend in increasing temperatures in the summer months of December, January and February – with a very strong increase in the first two months - which could be particularly critical for grape maturation. However, this increase in average temperatures did not significantly affect relative humidity levels, which between 1924 and 2012 remained almost constant at 80%, even of showing a slight downward trend (Chart 7), with negative and positive peaks.

Graph 7 - Average monthly relative humidity (%), recorded at the *Urussanga* station, 1924-2012



Source: Prepared by the authors, based on data provided by Epagri/Ciram (2013).

It is worthy of notice that Carvalho *et al.* (2011) warns that an increase in ambient moisture could easily contribute to the 'ripe rot' disease, the rotting of the ripened grape caused by the *Glomerella cingulate* (Stonemam) Spauld & Schrenk[xi]. Thus, a drop in relative air humidity could reduce the probability of this disease striking grape crops. However, as data also indicate an increase in average monthly temperature and rainfall, this combination could adversely affect the growing grapes, because it increases the likelihood of diseases associated with the increased presence of fungi, even pests. According to Cavalcanti *et al.* (2013, p. 9), "*O declínio e a morte de plantas de videira, associados a fungos, representam um problema para a viticultura mundial, devido à gravidade dos prejuízos*"[xii]. The authors highlights that this situation is worsened "by the absence of specific control measures".

Sonego (2013) believes the increase in temperature has risen far more in minimum (low) night temperatures than in maximum (high) temperatures. Note that this coincides with forecasts made in the IPCC 2007 reports, which predicted an increase in nighttime minimum temperatures above that of maximum temperatures. Thus, there will be fewer available 'cold hours', responsible for vine dormancy, which can indeed affect its fruiting potential. In addition, the researcher sustains that the Goethe grape is quite vigorous, and its budding may rather unaffected by a slight increase in temperatures.

Still, the researcher would note that the Goethe grape maturation and harvest season occurs from the last half of January to the first half of February, the period usually of highest rainfall in *Urussanga*, SC. In this case, if a summer is too rainy, the grape producer will lose in both quantity and quality. Moreover, this has become quite common in the region. The last two years, 2012 and 2013, had dry, rain-free harvest periods, which greatly improved the grapes' degree Brix, or sweetness level, enabling a good harvest. The researcher would also note that the Goethe grape is also very sensitive to excess moisture in the soil. When it rains too much, and the soil becomes soggy, grapes absorb excessive water, inflate, and their peels burst, losing much of the harvest. Excess moisture in the soil will also cause an excess of water in the fruit to reduce the grape's sugar content (degree Brix) forcing winemakers to correct the must's sugar level by adding sugar, a process that is legally allowed when the sugar is added during the fermentation and the adding up to three degrees' alcohol to the wine, that is called chaptalização (SONEGO; 2013).

Final Remarks

The exploratory analysis of the potential effects of climatic change on viniculture in the "*Indicação de Procedência Vales da Uva Goethe*" (Geographical Indication) indicates that several of the changes expected to occur in climatic conditions may already be underway, in the region. This possibility was suggested by some of the interviewed producers and, even more strongly, by long-term data recorded at the local weather station. Given that only a few producers actually suggested that the variations in grape crop quantity and quality, observed in recent years, might be related to the effects of climate variation, a causal relationship could not be verified. Nevertheless, among those few who reported a yield drop, climatic change was by far the most often cited cause; therefore, the concept of climatic change as a hazard, even if only as a catchphrase, has indeed been assimilated into their culture. However, the gathered information indicates a clear need for further studies, to verify how changes in the region's climatic dynamics can affect grape and wine production

It should also be noted that the data in Municipal Agricultural Survey made by IBGE showed great variability in harvest yield in the region. It is also verified that the historic series of annual average rainfall indicates an upward trend, which was also reflected in the monthly averages, and which may affect the yield and quality of wine grape crops. An upward trend can also be observed in monthly mean temperatures - much sharper than in rainfall - and one higher still in average minimum (low) temperatures, which increased from 5.75°C in 1924, to 8.30°C in 2012.

It is verified that there has clearly been an effective change in the climate of the region and which in the short term may represent an advantage to the local wine grape culture, but which in the long run may bring disadvantage in the form of greater likelihood of diseases and pests associated to higher mean temperatures and excessive rainfall. In addition, there may be a sharp increase in yield variation, in face of the rising minimum (low) temperatures, jeopardizing adequate seasonality, breaking winter dormancy and bringing chaotic budding.

Finally, it is worthy of note that Brazil's wine industry has already shown interesting and practical solutions to address climatic adversities and innovation by obtaining good results in tropical and subtropical viniculture whereas the world focuses on temperate viticulture. In addition, in Brazil are cultivated both the traditional Vitis vinifera, but also varieties of *Vitis labrusca* and several new hybrids of first, second and third generation which have proven resistant, well adapted, and differentiated, and may provide adequate solutions and alternatives for traditional viticulture (CAMARGO; TONIETTO; HOFFMANN, 2011).

In this sense, these results indicate a need for further studies on the effects of climate change on Brazilian viniculture, with the purpose of raise additional elements to support the development of new crop management practices, regional policies, amongst other actions as necessary to support and maintain the activity.

Notes

i In a free translation: "if, hitherto, the economy has been accustomed to freely using and exploiting the environment, unhindered by concern for degradation or resource depletion, currently it seems that it is the environment that should condition the economy"

ii In a free translation: "as a society, we already recognize that economic activity and the natural environment are inextricably connected, and that this deep relationship is at the core of proper stewardship of the environment and management of environmentally intensive economic activities"

iii Regarding climate change theories, see Hamilton (2012). Regarding the debate in Brazil, see Moraes and Ferreira Filho (2013).

iv See Marengo *et al.*, 2011.

v In a free translation: "the climate change expected for the coming decades as a result of global warming will endangers agricultural production in Brazil".

vi The A2/2020 scenario simulates the effects of climatic change by 2020 disregarding social and economic changes. The B2/2070 scenario simulates the effects of climate change by 2070, however, considering social and economic changes (MORAES, 2010).

vii Ecological economics is the result of the "silent" concern by a group of scientists, highlighting the work of Nicholas Georgescu-Roegen, The Entropy Law and the Economic Process (published 1971), about the approach that should be taken to the interrelationship between anthropocentric economic activity and the limited natural system (GEORGESCU-ROEGEN, 1975; [1971] 1999).

viii The Geographical Indication (GI) was certified in 2012 by the National Institute for Industrial Property (INPI), as published in the Industrial Property Magazine # 2145, on 14 February 2012. GI certification strives to ensure consistency in the demand for a product and, if possible, add value, seek an improvement in local producer income, and promote local development (VELLOSO, 2008; VIEIRA, WATANABE and BRUCH, 2012).

ix Climatic information extracted from the Climatological Atlas of the state of Santa Catarina (PANDOLFO *et al.*, 2002).

x In a free translation: "The vines bloom in September, in spring, when there is an increase in rainfall in relation to the drier winter. In September, it rains on average 12 days of the month, compared to only 9 days in June. In addition, September has proven to be a month of scant sunshine compared to the other months of the year. If the vine happens to flower on a rainy week, let alone on a rainy month, this will result in pollen 'washing', causing lower cluster fertilization and fewer fruit. This condition may eventually be offset by the development of larger grapes, provided the weather is reasonably dry during maturation".

xi The disease occurs most intensely in hot, humid areas (Carvalho *et al.*, 2011).

xii In a free translation: "the decline and death of vines associated to fungi represents a grave problem for world viticulture, due to the severity of the damage".

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EXPLORATORY ANALYSIS OF POTENTIAL EFFECTS OF CLIMATIC CHANGE IN THE "VALES DA UVA GOETHE"

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KELLY LISSANDRA BRUCH

Abstract: The future of agriculture has been conditioned by uncertainties about the effects of climate change. Thus, the main goal of this work is to develop an exploratory analysis of the potential impacts of climate change in dynamics in the vitiviniculture in the region bounded by the Indication of Origin of *Vales da Uva Goethe*. The analysis was developed based on direct consultation at producers and production and climate data. The results indicate that only share of producers has related changes in the quantity and quality of the grapes to the effects of climate change. However, there was an actual change in climate. The average monthly minimum temperatures increased from 5.75°C to 8.30°C 1924-2012, which can increase the probability of occurrence of disease and pests associated with high average temperatures.

Key-words: Climate change; *Vales da Uva Goethe*; Vitiviniculture.
Classificação JEL: Q50, Q54, Q57, Q59

Resumo: O futuro da agricultura está condicionado as incertezas envolvidas em relação aos efeitos das mudanças climáticas. Deste modo, o objetivo principal deste trabalho é desenvolver uma análise exploratória a respeito dos potenciais impactos decorrentes da mudança na dinâmica climática na vitivinicultura na região delimitada pela Indicação de Procedência dos *Vales da Uva Goethe*. A análise foi desenvolvida com base em consulta direta aos produtores e dados climáticos e da produção da região. Os resultados indicam que apenas parcela dos produtores relaciona as variações na quantidade e na qualidade das uvas aos efeitos das mudanças climáticas. Todavia, constatou-se uma efetiva alteração no clima. As temperaturas médias mínimas mensais aumentaram de 5,75° C para 8,30° C entre 1924 a 2012, o que pode elevar a probabilidade de ocorrência de doenças e pragas associadas às altas temperaturas médias.

Palavras-chave: Mudanças climáticas; *Vales da Uva Goethe*, Vitivinicultura.

Resumen: El futuro de la agricultura está condicionado las incertidumbres sobre los efectos del cambio climático. Por lo tanto, el objetivo principal de este trabajo es desarrollar un análisis exploratorio de los impactos potenciales del cambio climático en la dinámica de la viticultura en la región limitada por la Indicación del Origen de *Vales da Uva Goethe*. El análisis se desarrolló con base en la consulta directa con los productores y de los datos de la producción y climáticos. Los resultados indican que sólo una parte de los productores en relación con los cambios en la cantidad y calidad de la uva a los efectos del cambio climático. Sin embargo, hubo un cambio real en el clima. Las temperaturas mínimas promedio mensual aumentó de 5,75°C para 8,30°C entre 1924-2012, lo que puede aumentar la probabilidad de ocurrencia de enfermedades y plagas asociado con altas temperaturas medias.

Palabras clave: Cambio climático; *Vales da Uva Goethe*, Viticultura.