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Climate change and *terroir*: The challenge of adapting geographical indications

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The concept of *terroir* is often included in legal descriptions of Geographical Indicators (GIs). GIs are intellectual property that recognizes a food, beverage, or artisan product as holding distinct properties based on geographic origin. GIs are used to indicate these distinctions while deterring the sale of products carrying similar labels without having the GI determined qualities. Climate change and its effects on aspects of *terroir* such as rainfall, water availability, soil quality, and temperature is already having an effect on some production aspects crucial to what brings distinctiveness to GI products based on *terroir*. These factors raise questions as to how conceptions of *terroir* and the formalized rules underpinning the distinctiveness of GIs are evolving in the face of climatological changes. This paper discusses how climate change may influence how *terroir* is encoded in legally recognized GIs and how this will influence international regulation, recognition, and trade flows in GI-protected food and beverages. It discusses the relationship between GIs, credence attributes and the legal recognition of *terroir*. It then explores three options for products with GIs based on *terroir* that are experiencing climate change: product quality change, definitional change, or re-interpreting the boundaries of *terroir* relevant to the GI distinction.

KEYWORDS
climate change, geographical indications, intellectual property, *terroir*

1 | CLIMATE CHANGE AND *TERROIR*: THE CHALLENGE OF ADAPTING GEOGRAPHICAL INDICATIONS

A Geographical Indication (GI) is legally tied to a specific, closely defined, geographic location. GIs are also often seen as a means by which traditional methods and commensurate lifestyles can be preserved (Broude, 2005). The attributes of each product are often tied to specific agronomic or other production practices, which form the legal justification for the GI. Hence, the central hypothesis of this paper is that climate change can affect local agronomic conditions in ways which necessitate adaptation of farming methods or a change in location that may contravene the legal basis of GIs based on *terroir*. This paper explores the likely effects of climate change on agricultural producers who enjoy the benefits provided by a GI and how both farmers and/or the GI institution may or may not adapt to climate change. It also assesses the need for further research into the likely effects on the communities and cultures GIs are designed, in part, to sustain.

The concept of *terroir* is central to the potential difficulties climate change can precipitate for those endowed with the legal rights to a GI. *Terroir* pertains to location specific interactions among soil, moisture, sunlight, and other natural factors that impart particular qualities to a product. Although originally developed for French wine,[1] using *terroir* to legally protect food and beverages from fraudulent claims is now applied to other specialty agricultural products such as coffee, tea, tequila, honey, olive oil, fruits, and cheese (Vaudour, Costantini, Jones, & Mocali, 2015). Climate change raises interesting questions as to how conceptions of *terroir* and the formalized rules and practices behind GI-protected food and beverages can evolve in the face of climatological shifts. Climate change is predicted to alter precipitation patterns, ambient temperatures, weed veracity, disease outbreaks, pest infestations, and erosion rates (Backlund et al., 2008; Burton & Lim, 2005; Kulshreshtha, 2011; Mooney & Arthur, 1990; Parry, Rosenzweig, Iglesiasc, Livermored, & Fischer, 2004). There is a considerable body of research examining the effects of climate change on agriculture, and the meaning of *terroir* in GIs, but there appears to be little analysis of the implications of climate change for food and beverage sectors carrying a GI label primarily based on *terroir*. The anticipated effects of climate change on agricultural production can be expected in some cases to alter the underlying basis of *terroir*. Drawing on academic literature from the fields of environmental science, rural sociology, food science, agricultural economics, social anthropology, trade policy as well as law, the paper discusses how climate change may influence how the concept of *terroir* is encoded in legally recognized Geographical Indications and how this will influence international regulation, recognition, and trade flows in GI-protected food and beverages. It begins by discussing the legal definition of a GI, then discusses the relationship between GIs, credence attributes in food and beverages and the legal recognition of *terroir*. The paper then defines a typology of GIs based on how *terroir* and human capital are recognized as intrinsic components of the GI-protected product. The discussion then turns to examining the effects climate change is having on agriculture in general, and then explores three possible options for products with GIs based on *terroir* that are experiencing climate change: product quality change, definitional change, or re-interpreting the boundaries of *terroir* relevant to the GI distinction. It focuses on three case studies to illustrate how some GI-protected food and beverages are responding to climate change: European wine, Assam tea, and Olives\Olive oil.

2 | LEGAL RECOGNITION OF CREDENCE ATTRIBUTES THROUGH GIs

To fully understand the relationship between how GIs are recognized, how *terroir* is incorporated into those GIs and what potential effects climate change may have on the integrity of the GI label, it is crucial to specify what a GI is, and how it is recognized in the legal system. It is also important to understand the basis for the creation of GIs in the first place. It has been a long running and central theme of agricultural development that farmers need to find a means to escape from commodity production whereby: (i) profits are competed away due to the entry of additional competitors (e.g., other farmers) and (ii) technological changes mean that existing lifestyles and communities are threatened (e.g.,

by the competitive pressure to adapt and the scale bias embodied in many technological advances). One means to escape the commodity trap is through product differentiation (Gordon, Hannesson, & Kerr, 1999; Wolf, 1944). Product differentiation may be accomplished through individual farms being able to produce a unique product for a market niche or groups of farmers banding together in a cooperative or other group marketing structure (Brink et al., 1997; Fulton, Jones, & Schrader, 1998; Hobbs, 2001). One of the most effective means to achieve such product differentiation is to gain a geographical indication for the products of a group of farmers (Herrmann, 2009).

2.1 | The need for legal protection for claims related to *terroir*

GIs received legal recognition in the multilateral trading space with the signing of the World Trade Organization (WTO) Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) that came into effect in 1994. GIs are defined in this agreement as something that: "identify a good as originated in the territory of a Member, where a given quality, reputation or other characteristic of the good is essentially attributable to its geographical origin" (TRIPS, 1994, Article 22.1).

The World Intellectual Property Organization (2016, p.1) defines a Geographical Indication as:

> *a sign used on products that have a specific geographical origin and possess qualities or a reputation that are due to that origin. In order to function as a GI, a sign must identify a product as originating in a given place. In addition, the qualities, characteristics or reputation of the production should be essentially due to the place of origin. Since the qualities depend on the geographical place of production, there is a clear link between the product and its original place of production.*

GIs are considered to be property rights, and member countries have to provide legal tools to protect these rights. To receive the legal protection provided by the receipt of a GI designation requires that a case be made for the product seeking designation. The case must demonstrate that the product has attributes that differentiate it from similar products. Part of the reason why a legal definition is required is that the characteristics differentiating the product from others are *credence* attributes (Giovannucci, Josling, Kerr, O'Connor, & Yeung, 2009).

Credence attributes are qualities that cannot be determined even after the product has been inspected and consumed (Hobbs, 1996).[2] Arguably, if the special attributes that differentiated the product could be easily discerned by purchasers via inspection (a search attribute) or even consumption (an experience attribute) then a geographical indication would not be necessary. This is because purchasers would be able to determine the provenance of a good and be able to reject those that are not authentic. For example, the legal protection of Port is required because it is not possible for consumers to determine if the fortified red wine they are consuming was actually sourced in the Douro valley in Portugal. Without the legal protection of a GI counterfeit products could be passed off as Port through the use of false labeling. Having one's product recognized as the exclusive collective intellectual property of farmers (or artisans) in a particular geographic area provides the protection that stems from the power of the state through its law-making capacity. This means that the differential associated with the product becomes legally sanctioned exclusivity—competitors are prevented from entering the market in effect giving the holders of the GI a monopoly.[3] Thus, profit erosion by new competitors is eliminated. The monopoly may also provide sufficient price premiums to accommodate the higher costs associated with traditional production methods, meaning that lifestyles and communities can be maintained.

Of course, the practice of labeling products in one legal jurisdiction, which holds a GI designation in another legal jurisdiction, is a current legal practice taking place in many countries. This is because the GI granted by a foreign jurisdiction is not recognized. For example, a fortified red wine is labeled as Port because it is considered a generic term—in other words the GI for Port granted by the European Union (EU) is not recognized in the particular political jurisdiction. Such practices abound—sparkling white wine labeled as Champagne, white cheese labeled as Feta, ham labeled a Parma, etc.

What justifies a GI are credence attributes. It is not normally sufficient to simply specify that the product comes from a particular geographic area to receive a GI; either *terroir* or particular post-harvest production skills must be specified.[4] For example, in the case of Port, the vineyards in the Douro valley where the wine input for Port must be grown cannot be irrigated. As a result, consumers must be informed that the product incorporates the attribute—primarily through labeling. In the case of GIs, credence attributes must be legally defined for them to receive legal protection. Many, but not all, GIs are based on the credence attribute of *terroir*.

2.2 | The modern concept of *terroir*

Terroir provides the criteria for identifying a product's credence attributes. The literal translation of *terroir* is *terrain*, *soil*, *land*, *ground*, or *earth*. It is better understood as a concept based on the idea that a product's qualities *come with the territory*. *Terroir* is defined as something that can only be drawn from one location, and no one else outside of that location can claim (via labeling) to make the same product. In its Guide on Geographical Indications, the Food and Agricultural Organization defines *terroir* as

> *(1) a delimited geographic space. (2) where a human community, (3) has constructed over a course of history a collective intellectual or tacit production know-how, (4) based on a system of interactions between physical and biological milieu, and a set of human factors, (5) in which the socio-technical trajectories put into play, (6) reveal an originality, (7) confer a typically, (8) and can engender a reputation, (9) for a product that originates in that terroir (Giovannucci et al., 2009, p. xv).*

GIs based on *terroir* have their origin as far back as the seventeenth century when it was used to define and protect Chianti wine (Tomasi, Gaiotti, & Jones, 2013). The concept of *terroir* was central to the protection of the Champagne label in the nineteenth century (Marre, 2004). Historically, GIs were based primarily on *terroir* but in the present context, and particularly as a result of the evolution of agricultural/rural development policy in the EU (Josling, 2006), GIs are increasingly granted based on attributes related to human capital inputs rather than *terroir* (Viju, Yeung, & Kerr, 2013).

As Berard et al. (2005, p. 2) state, *terroir* is a spatial and ecological concept that "links actors, their histories, their social organizations, their activities, and most importantly, their agricultural practices." These human capital-based GIs are largely used as a way to protect, promote and preserve artisan skills in the production of food and non-food products.[5] Trubek (2008) claims that traditions and cultural practices contributing to the development and flavors of food and beverages based on *terroir* are central to the concept. *Terroir*, however, cannot be claimed solely based on traditions and cultural practices comprising human capital.

As an example of the requirements for a product to receive a GI designation, the EU *Guide to Applicants* (Regulation (EC) No 1151/2012) is illustrative:

> *The product must be specific: it cannot be a generic product, with no characteristics distinguishing it from others…The description must give technical, scientific data to describe the specific product. Include the product's specific physical, microbiological, chemical, and organoleptic[6] data…In the Specification, describe the geographical area by referring as far as possible to physical boundaries (e.g. rivers, roads) or administrative boundaries. It must be clear to a farmer and to an inspector whether each individual field is within or outside the area…It should demonstrate in what way the product's characteristics are due to the geographical area and what the natural, human and other elements are which give its specificity to the product…Identify and describe the characteristics of the defined geographical area relevant to the link. These may include the pedo-climatic features; topography, climate, soil, rainfall, exposure, altitude, etc.*

Thus, the legal definition used to grant a GI is premised on specific descriptions that become the basis upon which the legal protection is provided. While the specific example presented pertains to the EU's *sui generis* system for GIs, other countries have similar requirements in their *sui generis* systems (Giovannucci et al., 2009). In essence, the granting of a GI locks the farmers or artisans into a particular, specified, production system. The system receives the legal protection of the state. If the objective is to protect a traditional *way of life* or *method of production*, it can be instrumental in achieving that objective by both increasing income through the granting of a monopoly and preventing others from passing off their goods as those meeting the specification of the GI.[7]

Once granted, the reputation of the GI can be burnished through advertising and other forms of marketing. GIs are monitored and controlled by regional institutions. This is to prevent fraudulent activity, but also to maintain the standards set out in the details of the geographical distinction. When a geographic region like Bordeaux carries cachet, exclusive control produces economic benefits for local producers whether or not specific, unique qualities are found in the product or not (Hughes, 2006).

Farmers may alter their production processes to maximize their returns within the specifications set out for the GI. In the process of protecting a traditional *method of production* newer cost-saving technologies available to competitors producing near-substitutes[8] may have to be eschewed because they do not fit within those specified for the GI. As a result, the relative competitiveness of those producing to GI standards will decline over time. Hence, those enjoying the GI will increasingly have their livelihood intertwined and dependent upon the viability of the GI. This can be an enviable position to be in,[9] and one that those seeking a GI designation aspire to and envision (Bérard & Marchenay, 2006; Giovannucci et al., 2009). It is, however, dependent on the continued viability of the GI. Given the specifications of a particular *terroir*, climate change can be a disruptive force that threatens the ongoing viability of a GI.

As long as markets and consumer tastes remain relatively stable, the holders of a GI may be able to sustain both their livelihood and their lifestyle, including aspects of community. A major disruption, such as climate change, however, may threaten both. This is because obtaining a GI carries with it certain obligations that form the legal basis upon which the GI was granted. These may include specific production practices and well-specified geographic boundaries, neither of which can be easily changed because they are an intrinsic part of the legal definition.[10]

2.3 | PDOs and links with "*terroir*"

Of the geographical and human characteristics set out in the legal understanding of a GI, those particularly vulnerable to climate change are those solely based on *terroir*. Under the banner of a GI in the EU context, there are sub-categories of Protected Geographical Indication (PGI) and Protected Designations of Origin (PDO). A PGI is "where the product must be produced, processed OR prepared, and which has specific qualities attributable to that geographical area" (Giovannucci et al., 2009, p. xiv). PGIs refer to names of areas with some link to product quality and with at least one stage of production, processing, or preparation occurring in the area of question.

2.4 | The legal specifications of *terroir*

A PDO necessitates that the "product must be produced AND processed in the defined geographic area, using recognized know-how" (Giovannucci et al., 2009, p. xiv). Qualities and properties are exclusively determined by natural and human factors. PDO regulatory boards are made up of farmers, cooperatives, industries, marketing companies, and public administrators. They are responsible for establishing the reference standards and regulations for the PDO, certifying, and giving the seal of approval to any products wishing to use the official label. In the wine industry for example, under the PDO label, winemakers, winegrowers, and experts through an association or organization define what constitutes a particular zone that is permitted to produce wines under common producing rules considered to be traditional. The designated zones are usually based on pre-existing administrative boundaries or patterns of hydrological networks, roads, or railways. The PGI is not as stringent as those applied to a PDO, although

there are special conditions granted to some products carrying the PDO label (recognized as designations of origin in the country prior to 2004), such as Roquefort cheese. Roquefort has a limited geographical area of processing (caves in Roquefort can only be used to mature Roquefort cheese), but the milk can come from outside the processing area (Kireeva, 2011). In order to qualify for a PDO, the raw materials used in production must come from the defined geographical area. There are no such rules for PGIs. PDOs and PGIs have been recognized in some jurisdictions outside the EU by, for example, recognition being agreed in EU preferential trade agreements. They are now viewed as an important policy tool that can give producers opportunities to move from commodity production to producing for a differentiated niche market. They can add value to local production systems and help producers obtain market recognition including, in many cases, premium prices (Babjoub, Ajal, Fernandez-Gutierrez, & Cassasco-Pancorbo, 2016). Despite the substantial differences between PDOs and PGIs, *terroir* is sometimes used to refer to a PDO and can be confused with a PGI (Barham, 2003). In some cases however, one or more *terroir* units may be present in the designated area of the PDO and be included in the definition of the PDO (Vaudour et al., 2015).

2.5 | GIs effected by climate change

As it concerns assessing the effects of climate change on GI, four relevant types of GIs can be identified: (i) exclusively *terroir*-based GI, which do not rely on any particular geographically tied human capital for processing (e.g., olive oil where *terroir* defines the agronomic conditions under which the olive trees are cultivated but the olives are pressed using modern pressing technology); (ii) those based on a combination of *terroir* and geographically specific human capital (e.g., artisan cheeses where the milk production is *terroir*-based and is combined with artisan processing methods); (iii) cases where agricultural inputs are not *terroir*-based but the human capital is associated with a particular geographic area (e.g., cured meat where the animals can be raised outside the geographic area but the meat processing is based on human capital that is tied to a specific geographical location—e.g., Parma ham); and (iv) those in which the product is not based directly on agricultural inputs (e.g., Kotpad Handloom fabric). Climate change is unlikely to have a negative impact for GIs in categories (iii) and (iv). This is because the primary input is either not an agricultural product, as in the case of category (iv), or can be brought into the geographic area for processing, such as category (iii). Hence, if agricultural production is forced to shift to a different geographical area, it still can be transported to the center of artisan production within the specified geographic area. Categories (i) and (ii) could, however, face significant challenges in maintaining their *terroir*-based GI as the effects of climate change advance. The next section focuses on GIs that fall into categories (i) and (ii), both of which are dependent on the ability of the *terroir* to continue to provide the credence attributes associated with the product.

3 | CLIMATE CHANGE AND GIs BASED ON *TERROIR*

Climate change is expected to lead to a more vigorous hydrological cycle, including more total rainfall and more frequent high intensity rainfall events (IPCC, 2013). Climate change models predict that rainfall amounts and intensities are expected to continue to increase during the twenty-first century. These rainfall changes along with expected changes in temperature, solar radiation, and atmospheric CO_2 concentrations will likely have significant impacts on soil erosion rates (Nearing, Pruski, & O'Neal, 2004). Even in cases where annual rainfall is projected to decrease, system feedbacks related to decreased biomass production could lead to greater susceptibility to soil erosion (Vaudour et al., 2015).

If climate change makes a GI solely based on *terroir* no longer viable in its existing form because rainfall is too plentiful for, for example, optimal olive production, or if temperature rises sufficiently to reduce the productivity of vineyards, then to secure the continued viability of the valuable GI asset, the holders of the GI must find ways to adapt. The need to adapt will arise when the productivity of the geographic area declines sufficiently that livelihoods are threatened. The problem, however, is that not all farmers within the geographically designated region will be affected equally. Some will find that it is imperative to adapt while others will be able and likely desire, to continue as before.

Given that most GIs are the intellectual property of a group of farmers, the differential effects on individual farm operations will bring into play group dynamics and lead to stress within the organization that holds the GI. Thus, there is both a need for the GI specifications to adapt to changing climate and for the organization that holds the GI to accommodate adaptation to climate change.

3.1 | Institutional adaptability

Institutional adaptation to change is an issue that has affected a range of groupings of farmers including traditional agricultural co-operatives (Fairbairn, 2004; LeVay, 1983), new generation agricultural cooperatives (Fulton et al., 1998), and organic producer organizations (Clark, 2015; Khaledi, Weseen, Sawyer, Ferguson, & Gray, 2010). Yeung and Kerr (2011) outline some of the difficulties faced by the farmer groups holding GIs when confronted with pressures to change that are unrelated to climate change. Adaptation in institutions with group-based decision-making can be a major challenge. There are potential strategies, however, that could help GI rights-holder groups adapt to climate change: lower production quality standards, modifying production practices, and probably the least desirable, changing the boundaries of the geographical distinction (or some combination of the three). There is also the *status quo* option (do nothing), but for most *terroir*-based GI products that are (or will likely be) affected by climate change, this may be an untenable option.

Some argue that the *terroir*-based GIs that may be affected by climate change can simply alter human capital inputs and production processes to adjust. Under the PGI specifications for an artisanal cheese, for example, milk may be brought into a particular region to produce a GI-protected cheese that does not violate the standards and guidelines of production. What if, however, changing production processes alters the organoleptic qualities of the product, thus undermining the foundation of the *terroir*-based GI?

3.2 | Case studies

Climate change will present a number of challenges for some GIs based in whole, or in part, on *terroir*. These challenges will encompass legal issues, economic impacts and group dynamics. As each bundle of attributes that comprise a *terroir* is unique, it is impossible to generalize the form which adaptation will take. Each case will be different. Individual cases can provide insights into both the challenges presented by climate change and the adaptive response elicited. Three *terroir*-based GIs are considered in what follows.

3.2.1 | European wine

If yields are declining as a result of climate change, then lowering the minimum standard for a product to be included in the GI's standards may be proposed. For example, if olive yields are declining, top grade olives that qualify to be included as a GI product may be insufficient to meet demand and some farmers may propose lowering the minimum standard for inclusion of olives in the GI. Research on the potential effects of climate change on wine has primarily focused on Europe, as the EU is the world's largest wine economy with approximately 70% of global production, and 60% of global consumption. It is also the major proponent of using legal GI designations as the means to protect and expand agricultural industries (Josling, 2006). Maintaining consistency across the EU requires overarching single market wide wine quality classifications and production laws. The first iteration of categorical distinctions carried on labels was QWPRS (Quality Wine Produced in a Specific Region) and *Table Wine*. In 2011, these categories were replaced with PDO and PGI. Appellations granted by national governments that attained PDO status have, in some cases, provided *terroir*-defined wines in the EU with legal protection from fraudulently labeled wines since 1935 (Vaudour, 2003).

The effects of climate change on viticulture are likely to vary across the EU. Early studies predict that growing seasons will lengthen and precipitation will increase in the Northern part of Europe, and decrease in the South (Lough,

Wigley, & Palutikof, 1983). Based on spatial modeling, these changes may result in more favorable conditions in Bordeaux and Champagne. In terms of varietals, analysis of Sangiovese and Cabernet Sauvignon in Italy show that higher temperatures may result in shorter growing seasons leading to higher variability in grape yields (Bindi, Fibbi, Gozzini, Orlandini, & Miglietta, 1996). Jones, White, Cooper, and Storchmann (2005) report that pest and disease pressure arising from milder winters and changes to sea levels may influence viticultural microclimates. Increase of atmospheric CO_2 may result in changes to grape quality and the texture of oak wood used for wine barrels. The potential effect of climate change on wine growing areas in the EU has been outlined by Mozelle and Thach (2014), p. 85:

> *In Europe, the impact of global warming on wine growing regions would be large. The loss of the Gulf Stream would chill Bordeaux and parts of Spain, forcing a replanting toward cooler climate grapes. . . However, other regions would become warmer. Alsace, for example, has been experiencing a shortening of the growing season and a shift of harvest from October to September in the last three decades. . .Burgundy may soon come to "resemble Bordeaux. . .So troubling is this possibility, even the term, "climate," as an expression of Burgundian identity, is facing pressure toward redefinition. . .Even the region's planting of Pinot noir may wane as the finicky grape begins to lose viability. . . Spain's interior may experience such change in rising temperatures and water availability, that it "may be difficult to survive" at all. . .Tuscany's Chianti region is finding grapes ripening far too early forcing a shift in varieties. . .Vast portions of Europe on the Mediterranean coastline, especially Italy, Greece, and France, may become completely inhospitable to grape production by 2050. . .Southern England, by contrast, is resembling Champagne and has had several vintages of note.*

Examining these types of changes through the GI lens suggests that there may be pressure to alter the legal geographical delimitations of a number of *terroirs*. If the areas on the Mediterranean coastline become inhospitable to grape production, can they remain in the definitions of whatever *terroir* defines the particular GI? It would suggest not, and to allow such areas to remain as part of the GI could lead to low quality grapes being included as inputs to the GI wine product with the potential to lower the reputation of the GI. As the effects of climate change are likely to be felt slowly over time, those owning land in the valuable GI area are likely to resist having the geographic extent of the GI area legally redefined to exclude their land—which would precipitate a rapid decline in its value. On the other hand, those producers in the GI region not affected so severely by climate change will want to change the geographic boundary to protect the wine's quality and the value of the GI. Hence, there is likely to be considerable stress within the institution holding the GI. Another option, however, may be to source raw materials from outside of the designated geographic region.

There are reports that the *terroir* conditions associated with Champagne are moving north, possibly extending into southern England, and that some French Champagne houses are considering acquiring land in England to secure a future supply of grapes with appropriate characteristics (Kime, 2014). Would French holders of GI rights to Champagne allow the geographic area to be defined to include parts of England for this iconic French product? As Blakeney (2014, p. 52) notes:

> *it can be envisaged that the grape producing areas of southern England may in time become closer to the growing conditions for Champagne than the vineyards of Epernay. In this situation, the wine producers of the Champagne province may look to England for their raw material. Some growers in areas where grape yields are declining significantly would be in favour, they need a new source of grapes that have the right terroir while those less affected by climate change would worry about the reputation effect of reducing the association of Champagne as being French.*

Such an adaptation would likely be difficult. Presumably, climate change will disproportionately affect grape growers and winemakers in EU member states such as France that emphasize geographic location in their marketing

rather than the grape varieties.[11] Close identification with a legally defined GI inhibits the potential range of adaptations. Neither varietal nor regional substitutions can be easily achieved in these countries and, in some cases, are prohibited. This suggests that the notion of *terroir*-based wines, where a grape variety is expressed in terms of certain land and weather characteristics, may be too inflexible to allow for adaptations to a changing climate. Thus, according to Ashenfelter and Storchmann (2016), unless the appellation rules in the EU are loosened and planting rights are abolished, its wine producers are likely to be one of the losers from climate change.

Adaptation is likely to prove difficult for the groups that are the collective holders of GIs, which are legally defined by *terroir*. Within the groups, as suggested above, there are likely to be losers as well as winners from any potential change to the legal justification for the GI. Hence, achieving agreement on the form of adaptation, if any, is likely to be difficult. If agreement could be achieved among the rights holders and application made to alter the legal definition of the GI, other parties may wish to intervene in the change. If production practices that change or lower input standards (e.g., grape quality) are included in the proposed new definition of *terroir*, the GI regulators may question whether the *terroir* actually imparts the special qualities required for a GI designation to be granted. As GIs endow the group of producers with a monopoly—implying consumers pay a higher price—consumers may also call into question whether flexible definitions of *terroir* constitute a rationale for the legal protection of intellectual property.

3.2.2 | Assam tea

Assam tea is another example of a GI product primarily based on *terroir*. Assam Orthodox Tea, as it is officially known, is registered as a Geographical Indication in India. Assam is an Indian state and the single largest tea growing area in the world. It produces 55% of the tea produced in India and accounts for 31% of global tea production. The quality of the tea produced is dependent upon the climatic conditions in Assam, which arise from low altitude and ample rainfall. Assam Orthodox teas are defined as "teas grown and manufactured out of the basis *Camellia Sinenses var. Assamica* and other variants in tea estates located in the Brahmapurtra or Assam valley in North East India" (Indian Tea Association, 2016). Climate change, however, has already begun to influence the conditions of production. Assam is already pushing the upper boundary of the optimum range for tea growing.

Growers in the Assam region claim that rising temperatures are changing the distinct flavors attributed to the GI-protected tea. Assam produced 564,000 tons of tea in 2007, but this fell to 460,000 tons in 2010. While the decline in productivity resulted in a 10% price increase for teas from Assam (Hussain, 2010), this was not able to offset the nearly 20% decline in output resulting in lower revenues for producers. Rainfall patterns are also changing. According to the chief scientist at the Tea Research Association, over the past century the average temperature in Assam has increased by 1.3°C and rainfall has declined by 20 cm a year. Rainfall has also become less predictable over the last 30 years. Worries about rainfall and temperature are prompting some producers to increase vegetation cover to create more bodies of water on vacant land within plantations (Cousins, 2015). The general effectiveness of such measures is, however, unknown.

As a result of these changes in climate, the quality of the product may decline. As Hussain (2010) notes:

> *the flavor of Assam tea is changing. The strong flavor profile attributed to Assam has been noticed to be declining. As one tea planter in Jorhat, Assam's main tea growing district stated, 'Assam tea's strong flavor is its hallmark', in essence, what gives it the value attributed to the GI distinction.*

Lowering the quality of the product could lead to factious issues for the group that is legally vested in the GI. Most agricultural production is defined by distributions of quality. It is the basis for the considerable degree of sorting and grading that takes place in agriculture (Considine, Kerr, Smith, & Ulmer, 1986; Erdman, 1950; Farris, 1960). Many products with GI designations have minimum quality standards, for example, olive oils with GIs can only be pressed from olives harvested directly off of the tree, not from the ground (see Hinojosa-Rodriguez, Parra-Lopez, Carmona-Torres, & Sayadi, 2014). This means that production that does not meet the minimum standards is not allowed to

display the GI. This sub-standard product is sold in alternative markets, processed into other products or discarded. If climate change reduces average quality, this means that more product will fail to meet the minimum standard to be included in the GI. The income of some producers of GI products will decline. To maintain incomes (at least in the short run) one alternative is to lower the minimum standard, meaning more product qualifies to receive the premium associated with the GI. Altering quantity standards to enhance farmers' returns through grade manipulation has a long history in agriculture (Mehren, 1955).

While this path of adaptation may be desired by some producers of the GI whose incomes are declining, others will worry about the long term effects on the GIs' reputation if consumers are less satisfied with the quality of the product. Given the credence nature of many *terroir*-based attributes, lowering quality may be a risk some may be willing to take, but others will be concerned about the degree to which the attributes are truly credence in nature. In any case, permission will have to be sought to alter the official GI description, thus allowing the information on the strategy of lowering quality to become a matter of public record. It will likely be difficult to reach a *consensus* on such a change among the membership of those that collectively hold the legal rights to the GI.

To return yield or quality to pre-climate change levels, some farmers may suggest that new production practices be allowed (e.g., the use of irrigation or pesticides where they were not allowed under the conditions that the GI was granted). Each of these adaptations to climate change has its specific challenges, and in particular within the institutional structure of the group holding the legal rights to the GI. This route of adaptation is to alter the production methods incorporated in the GI's definition to offset the decline in productivity associated with climate change.

Assam Orthodox Tea appears to be experiencing declining revenues due to climate change. Redefining the legal specifications of the GI by lowering minimum quality or experimenting with technological solutions may be the type of short-term solutions that appeal to some tea producers but these may lead to discernable declines in the appeal of Assam sourced tea for consumers. In the long run this will reduce the collective returns from the GI. Consumers may not be able to identify the provenance of the tea due to its credence nature but may well be able to discern a decline in quality as *terroir* changes in Assam.

3.2.3 | Olives and olive oil

Farmers in the olive oil industry have engaged aggressively in production differentiation through geographical indications. In 2010, there were over 100 origin-labeled extra Virgin Olive Oils (VOOs) around the world, with those in the EU having either PGI or PDO designations. Groups of farmers in Italy, Greece and Spain are the heaviest users of GIs. The market value for European-origin VOOs was 215 million Euros per year from 2006 to 2008. Several studies have been conducted demonstrating the differences among VOOs originating in different geographic regions related to, for example, olive tree variety, soil, climate, and cultivation practices as well as processes for extraction, storage conditions, etc. The differentiation in these factors causes physicochemical differences in sensorial attributes and the chemical composition of VOOs (Babjoub et al., 2016). VOOs certified under a PDO are required to fulfill a specific set of conditions including the tree varieties planted, the physical, chemical, and organoleptic characteristics of the oil as well as the cultivation practices. How the olives are collected, sorted, and transported may also be specified. Those who use the GI are required to follow the strict practices set out in the legal description of the PDO.

Climate is particularly important to the VOO industry that uses GIs and climate change is creating considerable concern for holders of the rights to the GIs. Studies of temperature indicate that it has been increasing over time. This can be significant for a VOO PDO because increased temperatures influence the timing of flowering of woody species such as olive trees. Early flowering may lead to lower fruit production while later flowering may increase olive production. Early flowering can also lead to situations where reproductive organs are at greater risk to any sharp drops in temperature that may occur in late winter (International Olive Council, 2010).

In response to the need to address some aspects of climate change, olive growers in Andralusia, southern Spain are employing soil conservation practices. They are changing some practices used in the groves, including cessation of olive-desuckering debris burning, the shredding of olive-pruning debris for use as inert soil cover and the use of cover

crops managed through mowing. These changes in practices contribute to sustainable olive growing. By adopting these practices, growers can reduce soil erosion (Rodriguez-Entrena & Arriaza, 2013). In Hinojosa-Rodriguez et al.'s (2014) study of PDOs in Spain, they found that not only do PDOs result in better quality product, but they also have positive effects on improving environmentally sustainable agricultural practices in olive groves. Although this may not combat all aspects of climate change, a shift in these practices is contributing to soil health without drastically changing pertinent processes related to the GI attributed to VOOs from this region.

Unless the effects of climate change are spread evenly across all producers, such changes in productive practices are likely to prove controversial. The first controversial aspect is likely to be similar to that described above for the second type of adaptation. Changing the production process may alter quality or the perception of quality or add cost and time to production. Farmers whose incomes are negatively affected to a greater degree by climate change are likely to be willing to risk a change in quality. Others, who are less affected, will be opposed to accepting this risk. Again, to change the production practices embedded in the GI (such as a move to irrigation) would require a formal petition to alter the specifications of the GI, making the change a matter of public record. If the reputation of the GI is, in part, based on the use of traditional production methods, then there may be adverse effects on the value of the GI.[12]

The olive oil industry is taking measures to address the challenges that climate change is creating, but the worry is that even on-farm changes to production practices may not be enough to combat temperature rises and changes in rainfall. Particular olive oil producing regions whose GI is *terroir*-based, Sicilian olive oil for example, may not be able to adequately address climate change with the result that the amount of olive oil produced may be reduced. Reduced yields and/or increases in costs may reduce the viability of using traditional methods, thus nullifying the benefit of having a GI designation.

If a climatological shift occurs where the particular agronomic conditions defining *terroir* takes place, changing the geographic boundaries of the designated geographic area may be proposed. This seems to be the last option a GI based on *terroir* would choose because it ultimately undermines the entire concept of *terroir* and the basis of the GI. Still, it is important to consider, as in some cases, this may be the only option for particular geographical regions subject to the negative effects of climate change. One example of a GI protected product that altered geographic parameters related to the product is tequila. Although the factors behind the change in boundaries were economically motivated and not directly related to climate change, the tequila example is illustrative of how a GI protected product may be forced to respond in order to protect the GI label and the value behind the label (see Bowen & Zapata, 2009).

Virgin Olive Oil GIs are based primarily on *terroir* and are, for the most part, located in areas where climate change is expected to have major and negative effects. While there may be some adaptation of production practices that fall within the existing legal scope of GIs, yields and quality are likely to decline in future. The result will be pressure to lower quality (through the relaxation of specifications for olives) or distinctiveness (through planting hardier varieties of trees). Such potential changes are likely to prove contentious among the groups of producers holding rights to the GI and invoke a negative reaction from consumers. Hence, adapting to climate change across the wide swath of southern Europe represents a considerable challenge.

4 | CONCLUSION

In many parts of the world, climate change will provide an incentive for agricultural producers to adapt their production and post-harvest systems to evolving agronomic conditions (Kulshreshtha, 2011). Some farmers will successfully adapt their operations in response to climate change—as they have successfully adapted to myriad technological changes over the era of scientific agriculture (Kerr, 2014)—but others will not be willing or able to adapt. Limiting the negative impacts of climate change for agricultural producers is one of the major public policy challenges faced by the sector. Some groups of producers, however, may face additional constraints on their strategies to adapt to climate change—those that have been legally endowed with the rights to a geographical indication based on *terroir*.

While many GIs are premised on artisan-based intellectual property and, hence, unlikely to be affected by changes in climate, others are based on *terroir*, which is defined by specific geographic qualities such as soil, rainfall, sunlight, plant type, etc. that are, in part, a function of climatic conditions. As the properties imparted by *terroir* to agricultural products are credence attributes, legal protection requires detailed specification of *terroir*. Receiving a GI designation provides protection from similar products not produced according to the legal definition of *terroir* but also endows the group of farmers with a monopoly over the sale of their product (Yeung & Kerr, 2011). This monopoly provides the basis for ongoing profitability[13] using traditional methods to sustain particular lifestyles. If climate change reduces productivity or quality, then production based on legally defined *terroir* may not provide sufficient benefits for farm businesses or lifestyles to be maintained. As a result, pressure for altering the legal specification of *terroir* may arise.[14]

Adaptation options are likely to include a move away from traditional production practices, reductions in the specifications of quality, and altering the geographic scope of the GI designation. Given that the rationale for granting the GI is based on the unique properties of the underlying *terroir*, those granting the designation may question the new justification and, given that consumers associate the GI with certain attributes, there may be resistance to altering the existing legal specification. Further, as not all farmers in the group holding the legal rights to the GI will be negatively impacted to the same degree by climate change, adaptation strategies may prove contentious among the group of rights holders. Hence, adaptation may be considerably constrained and the value of being endowed with a GI reduced. Given that in a number of jurisdictions the granting of GIs is seen as an important plank of agricultural policy, the issue of how adaptation can be managed needs to be addressed. How GIs can be adapted will be part of the larger issue of the effect of climate change on agriculture.

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ENDNOTES

[1] The system of Appellations d'Origine Contrôlée (AOC) in France established "by the Law of the 30th of July of 1935 has created a specific type of French wine: AOC wines. These wines use the notion of *terroir* to distinguish themselves from the other wines. A *terroir* relies on natural and human factors and their specificities." See Calboli and Gervais (2015).

[2] Economists classify product attributes into search, experience and credence. Search attributes are those that can be discerned by inspection (e.g., blemishes on fruit) at the point of purchase. Experience attributes are those that can be determined through consumption (e.g., the tenderness of a pork chop). See Hobbs (1996).

[3] The monopoly only extends to the use of the name associated with the GI in marketing. It does not prevent competitors from entering the market with a similar (or exact duplicate) product as long as they do not use the GI in their marketing. For example, wine makers in South Africa can make sparking white wine using the same method as producers in the Champagne region of France as long as they do not market it as Champagne.

[4] There may be some long-standing GIs based simply on production being located in particular geographic areas that were *grandfathered* when modern legal regimes for GIs were established.

[5] Others argue that the conception of *terroir* is socially constructed to privilege certain actors and modes of development over others (see Banks & Sharpe, 2006; Bowen & Zapata, 2009; Gade, 2004; Moran, 1993).

[6] Organoleptic properties are the aspects of food, water or other substances that an individual experiences *via* the senses including taste, sight, smell, and touch.

[7] Yeung and Kerr (2011) provide a discussion of the limits to the protection provided by GIs. Of course, GIs do not prevent the production and marketing of duplicate or similar products as long as the GI label is not used—for example, fortified red wine marketed as *Pipe* in Port style bottles (Kerr, 2006).

[8] For example, olive oil produced using improved crushing technology and, hence, not conforming to the standards of the GI that specifies traditional crushing methods.

[9] Of course, enjoying a GI designation is not a guarantee of profitability (Giovannucci et al., 2009; Yeung & Kerr, 2011).

[10] In the EU *sui generis* system: "Procedures should be laid down to allow the amendment of product specifications after registration" (European Union, 2012). The group holding the GI devises the procedures. While changes to specifications pertaining to *terroir* may be changed in response to climate change, we argue in what follows that obtaining agreement among the farmers holding the GI may be difficult as climate change will likely affect them to different degrees.

[11] This is not typically the case with *new world* (e.g., the Antipodes, the Americas, South Africa) wine producers whose marketing emphasises grape varieties.

[12] As is the case with the Champagne GI.

[13] Of course, having a monopoly does not ensure profitability (Yeung & Kerr, 2011).

[14] There is also a question related to the potential of those outside the territory specified in the GI to challenge the validity of the designation as climate change alters *terroir* (i.e., could it be argued that the GI for Champagne is no longer valid given that the *terroir* in the region is changing.). If so, the result could be that the GI would revert to a generic designation, which could be used by producers of sparkling wine outside the geographically designated area of the previous GI.

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