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Application of the Terroir Concept on
Traditional Tea Cultivation in Uji Area

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Abstract

Climatic changes and extreme temperature fluctuations have been occurring more frequently with evidences of increasing degree in its intensity. Direct effects of these changes are especially felt by agricultural industries especially those which are utilizing natural environmental elements in its cultivation, such as the tea cultivation in Uji Area. As the oldest and most famous green tea producing region in Japan, the reputation of Uji Tea has been built through the distinct characteristics of its products as the result of following long-running traditional agriculture practices. Changes in the climatic conditions, especially temperature fluctuations, have directly affected the perceived quality of tea leaves in the region, as there has been more temperature variability during the growth of the first flush tea leaves. The problem is further exacerbated by frost events, drought, heavy rain and temperature extremes which have directly affected the quantity of the tea production. Based on analysis of climatic data and tea production statistic, it has showed the correlation between mean air temperature drops with low harvest yield. Observations and surveys conducted in Uji Area have showed that these changes were not only affecting the cultivation process, but also indirectly leading to socio-economic issues within the tea grower community. It is necessary to develop a new cultivation concept which takes account the natural environmental elements and the agriculture practices elements such as are found in the terroir concept utilized in France wine industry. Through this new concept the Uji tea growers would be able to proactively adapt to the on-going changes and this will ensure the sustainability of Uji area as a well-known tea-growing region.

Keywords: *Climate Change Adaptation; Uji Tea Cultivation; Terroir Concept; Traditional Agriculture Knowledge.*

1. Introduction

Although the brand name of Uji Tea might not be a familiar name in the world, among Japanese people, Uji Tea is very popular as a high-quality green tea for the tea ceremonies and is regarded as a delicacy among green tea enthusiast. Although there are many types of green teas produced in Japan, what is commonly known outside Japan would be *matcha* or *sencha*. In comparison with wine products from France, where the information regarding vineyard location as well as the type of winegrapes used is printed on the label of a wine bottle, unfortunately, on most of the tea product packages sold in Japan, information about the tea plantation where it is produced is not written. For Japanese green tea enthusiast, teas which are cultivated and produced from Uji Area, especially the powdered green tea which is known as *matcha*, is considered as the benchmark for high-quality green tea in Japan.

For generations, tea growers in Uji Area retain traditional cultivation methods which rely heavily on manual labor for most of the cultivation processes, as well as hand-plucking tea leaves during the harvesting period. One of the unique cultivation methods utilized by the tea growers in the area is the use of traditional covering methods in the tea cultivation processes. The knowledge of this practice is passed down through generations of tea growers, whereas this method is unique to Uji Area and especially essential to produce high-quality *matcha* and *gyokuro*.

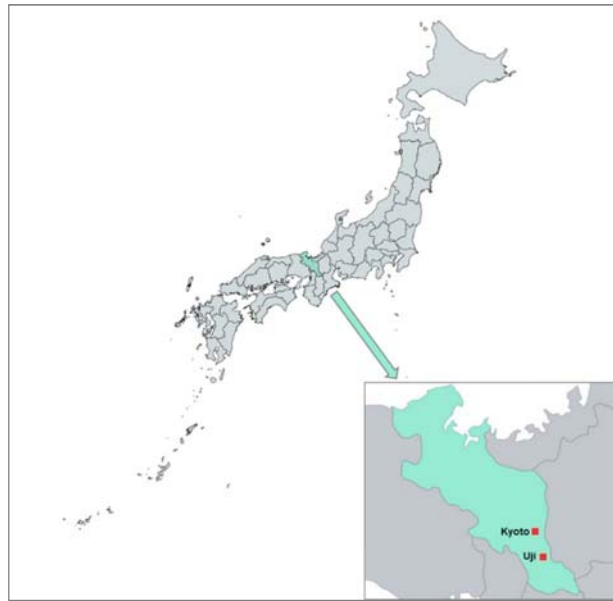


Fig. 1 Location of Uji Area

In this special method, as documented by Kimura & Kanda (2013) from the Kyoto Tea Industry Research Institute, tea bushes are covered with sunlight-blocking materials after the first leaf bud break occurred, which lasted for approximately three to four weeks. In the first two to three weeks of the covering, the light intensity is reduced by 95 percent, and in the last week before harvest, the light intensity is further reduced to 98 percent. With reduced sunlight condition, it is believed that the tea plants would produce more chlorophyll in the tea leaves thus increasing amino acid and reducing catechin level, whereas it is believed to give more taste and sweetness to the tea products.

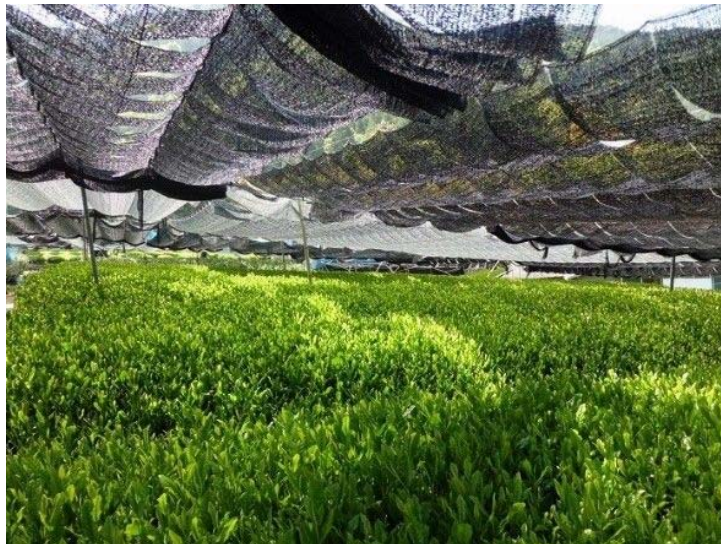


Fig. 2 Covering Method Using Black Vinyl Mesh Sheet



Fig. 3 Covering Method Using Woven Reeds and Straws



Fig. 4 Tea Leaf Plucking Under Shade

Based on surveys and observations, it is revealed that each tea growers has their methods and system in achieving reductions in light intensity. The observed variation includes 1) selection of covering material; 2) layering methods and installation height; and 3) duration of covering period. Covering materials used in this method are traditionally using woven reeds and straws, although other artificial materials like black vinyl mesh sheets are also used. This method contributes directly to the characters of the tea flavor and taste. Because of this complex and resource consuming cultivation method, tea harvest in Uji Area can only be conducted once a year during the spring season (April to May).

As general information, there are three types of tea which are produced in Uji Area which are *tencha*, *gyokuro*, and *sencha*. Most of these tea types are usually produced using tea leaves from the same tea cultivars (cultivated varieties), whereas the differences lie mostly during the cultivation process. *Sencha* is the most popular green tea consumed in Japan, whereas this type of tea is grown fully under the sun. In contrast with *sencha* cultivation, *tencha* and *gyokuro* are grown under shade or covering for about 21 days before harvest. Depending on the period of cover, the

harvested tea leaves can be processed into gyokuro (less than 21 days of covering) or tencha (more than 21 days of covering), whereas the latter is stone ground to become matcha.

Currently, Uji Area which is located in the south of Kyoto City is one of the oldest and most famous tea growing region in Japan, whereas based on historical archives, the tea cultivation in the area began in the 13th century (Uji City, 2010). Originally Uji Tea refers to the tea products which are cultivated and processed inside Uji Area itself, whereas it is well known for its extraordinary quality, as it was only used to cater for the nobility. Because of its resource consuming cultivation methods, traditionally the tea produced in Uji Area is only available in a low volume. In order to comply with the continuous high demand from consumers in the last decade, *Kyoto-fu Chagyokumiai* [Kyoto Tea Cooperative] (2006), a wholesaler collective, defined the Uji Tea as tea products which are cultivated in four prefectures in Japan which are Kyoto, Nara, Shiga and Mie; and processed by a tea wholesaler based in Kyoto Prefecture using techniques derived from Uji Area.

Although this approach might be beneficial to ensure the continuity of Uji Tea as a brand name, in the long run it will have a negative impact for the traditional tea cultivation activities in Uji Area, as the current definition did not consider the significance of Uji Area's natural environmental characteristic towards the quality of tea products. This approach is the opposite of the terroir concept which is implemented on the wine industry in France, whereas the combination of natural environmental characteristics of the region with the winemaking techniques is considered crucial towards the quality characteristics of the wine products.

2. Changing Climatic Condition

Recorded climatic data from long-term observations have indicated that in general, the average temperature is increasing in many parts of the world. The increase in the average temperature might be beneficial for agricultural production as colder climate region become warmer, as cultivation of crops which before was impossible becomes feasible. However, on the contrary, currently, well-known cultivation regions might become unsuitable for cultivation in the future as the temperature gradually becomes too warm.

In the winegrape cultivation, it is predicted changing cultivation condition might trigger a shift in a suitable location for some varieties of cultivation to obtain high-quality harvest (Jones, 2007). These changes in cultivation regions would lead to a loss of cultivation knowledge which has been accumulated in the original cultivation regions, especially on adapting and utilizing the natural environmental characteristics. The influence of higher temperature towards the tea cultivation is predicted to reduce the tea production yield as stated by Wijeratne (1996).

Changes in climatic conditions, especially air temperature will have a direct effect on the growth cycle of the tea plant and are especially crucial during the bud break and flush harvest periods. Moreover, the high-quality leaf can only be obtained from tea plants which are grown under stable climatic conditions, as the formation of leaf fiber and growth are influenced heavily by the climatic conditions (Watson, 2008). The textures of tea leaf fibers play a very important role for deciding what types of tea would be produced using the harvested tea leaves, whereas leaves with smooth and soft fibers (fine leaves) are essential to produce high-quality teas. Slightly fibrous leaf (medium leaves) and matured fibrous leaf (coarse leaves) are in general will be processed as lower quality tea products (Konomoto et al., 2006; Watson, 2008).

Climate change effects towards the cultivation of tea, in general, can be categorized into two types, which are: 1) Average temperature increase (warming of the climate) and; 2) Increasing occurrences of extreme weather events (drought, high-

intensity rainfall, and frost event) (Japan Meteorological Agency, 2018). Tea cultivation possesses similar traits with winegrape cultivation especially on its sensitivity towards changes in the micro-climatic conditions. Therefore, the results derived from observations aimed to understand how these changes are affecting the tea plants would become important references for other agriculture cultivation processes. Regarding tea production, Wijeratne (1996) also mentioned that increasing temperature and changing rainfall pattern, are very harmful to the growth of the tea plants, and these changes would ultimately affect the quality and quantity of the final tea products. Changes in the rainfall pattern could be observed as longer drought, increasing occurrences of erratic rainfall pattern which is accompanied by a sudden increase in the volume and intensity of rainfall.

The rapid transformation of climate behavior such as increasing temperature as well as increasing occurrences of extreme weather events is predicted to affect the tea cultivation process significantly. From widespread observation shows that winegrapes harvest dates have advanced, especially in the last 10-30 years (de Orduna, 2010), while in the case of Japanese tea, the harvesting period has shown a tendency to become later than the previous years (Ashardiono & Cassim, 2014). These changes were also identified in Uji Area, thus, from the preliminary findings it is most likely these abnormal climatic events will be occurring more frequently in the Uji Area. Based on research findings, in the period of 2002-2012 the observed changes in Uji Area are: 1) a sudden drop in temperature during the spring season (March to May); 2) higher temperature during fall season (October to November); 3) changes in quantity and period of rainy season (May to June); 4) longer periods of drought; 5) diminishing morning fog; which from these five points lead to the diminishing characteristics of high-quality Uji Tea (Ashardiono & Cassim, 2015).

To further understand the occurring changes, analysis is conducted on climatic data (2002-2014) obtained from Kyoto Prefecture Tea Industry Research Institute, which consist the hourly data of the first flush cultivation tea cultivation period, starting from the beginning of January to early May (1: January; 2: February; 3: March; 4: April; 5: May), and averaged into beginning [the first 10 days of the month] (a), mid [the 11th day until the 20th day] (b) and late [the 21st day onwards] (c). The average air temperature in Uji Area from January to May (2002-2014) can be seen in Table 1 - Average Mean Air Temperature in Uji Area and Fig. 6 Average Mean Air Temperature in Uji Area, from these data it could be observed how the fluctuations in the average mean air temperature on each period have become more apparent in the past years.

Table 1 Average Mean Air Temperature in Uji Area

	1a	1b	1c	2a	2b	2c	3a	3b	3c	4a	4b	4c	5a
2002	3.9	1.3	3.7	4	3.6	5.6	5.1	6.8	10.3	12.4	14.7	13.1	17.8
2003	3.5	7.1	4.3	5	3.6	8.3	6.7	10.7	10	14.2	14.6	17	18.8
2004	5.1	4	2.7	3.8	5.6	8.1	5.3	9.4	10.3	11.9	17.5	15.2	18.7
2005	3.7	4.1	4.2	4.3	5.4	3.5	6.2	6.7	8.7	13	14.1	17.3	18.1
2006	2.5	4.9	3.2	3.2	5.6	6.9	6.7	6.2	7.5	10.6	13	13.2	18.8
2007	4.9	4.6	4.9	6	6.2	7.4	8	4.6	10.3	10.4	13.1	16	18.5
2008	5.3	4	3.8	2.9	3.4	4.1	5.9	11.5	10.7	12	14.5	16.4	19.1
2009	5	3.6	5.9	5.1	7.1	7.5	7.9	9.7	8.3	11	17.5	14.1	18.1
2010	4.4	3.7	4.9	5	4.6	11.4	8.8	9.9	7.4	12.6	13	13.1	18.8
2011	2.3	1.5	1.7	3.9	3.2	8.5	4.4	6.9	6.2	10.1	11.2	12.3	17.5
2012	3.1	3.5	2.5	2	1.9	4.4	7.9	5.1	7.2	8.4	12.8	16.8	17.2
2013	1.8	2.7	3.3	4.4	2.3	3.6	6.8	8.6	8.8	11.8	11.9	11.9	13
2014	3.3	1.6	3.8	3.5	1.9	5.9	4.3	7.4	10.2	10.6	11.7	14.6	15.7
Mean	3.75	3.58	3.76	4.09	4.18	6.55	6.46	7.96	8.91	11.46	13.82	14.70	17.70
Median	3.70	3.70	3.80	4.00	3.60	6.90	6.70	7.36	8.80	11.80	13.10	14.65	18.10
Std. Dev	1.15	1.59	1.12	1.06	1.70	2.32	1.43	2.17	1.49	1.49	1.98	1.88	1.68

Source: Kyoto Prefecture Tea Industry Research, 2015

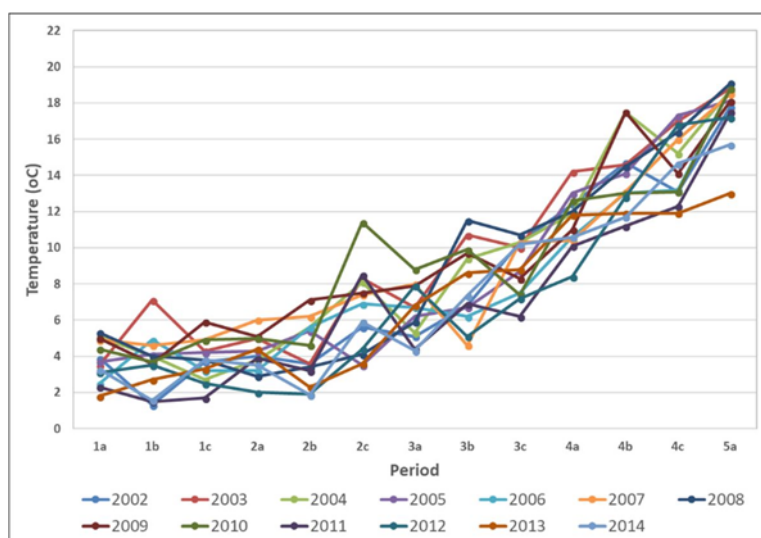


Fig. 6 Average Mean Air Temperature in Uji Area

Further observation of the statistical data showed that in general, the average temperature values during the first flush cultivation period have been declining over the years. Although it is also observed, there were identifiable temperature fluctuations in the temperature values in late February (2c) and mid-March (3b). From these results, it could be interpreted, while the main trend of average temperature values for each period is on the decline, there are indications of temperature fluctuations towards higher temperature especially on late February (2c) and mid-March (3b).

The on-going changes in the climatic conditions of Uji Area have clearly shown the evidence of increasing trends in extreme weather events. These events undoubtedly will affect the tea cultivation process cycle, importantly because tea plants are sensitive toward changes in the micro-climatic conditions, especially to temperature fluctuations. To achieve a desirable quality of tea products, young leaves need to be plucked before their fibers become too hard; observations have shown how exposure to extreme air temperature fluctuations would accelerate the hardening process of tea leaf fibers, hence diminishes the quality of the tea products. Moreover, because of its traits, Wijeratne (1996) mentioned that increasing temperature and changing rainfall pattern is very harmful to the growth of the tea plants, which ultimately affects the quality and quantity of the final tea products.

Social surveys conducted inside Uji Area tea grower's community have also shown evidence how the occurrences of extreme climatic events have become more frequent over the past ten years. In the social survey conducted with 15 tea growers which are representing 15 tea plantations out of the total 21 tea plantations in Uji Area, almost all of the interviewed tea growers have claimed that climate change has affected the tea cultivation process, whereas it is attributed to temperature fluctuations (36%), drought (32%), frost event (18%), and excessive rainfall (14%) (Ashardiono & Cassim, 2015).

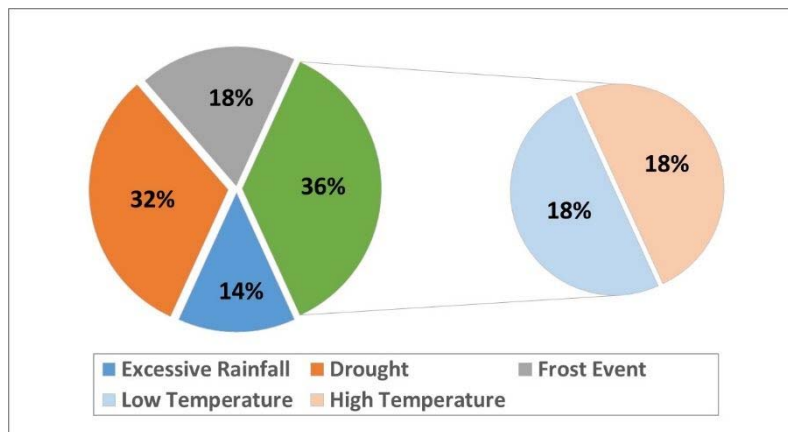


Fig. 7 – Perceived Changes of Climatic Factors in Uji Area

3. Burgundy Winegrape Cultivation and Uji Tea Cultivation

Based on the current climatic condition in Uji Area, it is necessary to develop new tea cultivation and production concept which could swiftly and effectively adapt to the on-going climatic changes. Not only to be utilized for developing new adaptation methods, but a new cultivation method based on the new concept could also provide value addition to the tea products. To achieve those objectives, the new concept would need to take into account the unique characteristics derived from Uji Area natural environment as well as the traditional cultivation methods practiced in Uji Area. Deriving some of the concepts from the winegrape cultivation, new tea cultivation concept could be constructed with the objectives to ensure the sustainability of the tea cultivation region from the socio-economic perspectives.

As observed, the tea growers in Uji Area have been cultivating tea for many generations, and most of the tea grower families have been around for several hundred years. These tea growers have been able to fully utilize the characteristics of natural environmental factors in their tea plantations for cultivating desirable, high-quality tea products. This approach is similar with the winegrape cultivation in France's Burgundy Area, whereas to produce wines which could be associated with its origin, winegrape growers in each area applied traditional cultivation methods which are unique only to the areas where the winegrapes are being grown (Gade, 2004; van Leeuwen & Seguin, 2006; Gergaud & Ginsburgh, 2008).

Winegrape growers in Burgundy Region are using their traditional cultivation knowledge which has been passed through from their predecessors to select optimal cultivars which are suitable with the natural environment condition of their vineyard. The ripening condition of the winegrape plays a crucial role in determining wine products quality. This condition is varied on each vineyard as it is highly dependent on the unique micro-climatic conditions on each area (van Leeuwen & Seguin, 2006).

Winemaking requires a certain level of winegrapes quality which highly influenced by the natural environment conditions where the vines were grown. Winegrape growers are taking account the natural environment factors such as climatic conditions, soil types, and other exposures in cultivating the vines, thus at the shortest, a typical old world French vineyard would need 20 to 30 years before its able to produce a good quality winegrape harvest (Gergaud & Ginsburgh, 2008). Tea cultivation possesses similar traits with winegrape cultivation especially in the sensitivity of the plants towards changes in the micro-climatic condition, whereas through observation it is understood how natural environmental factors have been affecting the tea plants. Furthermore the observation analysis would also become an important reference for other agricultural based cultivation.

The factors above have been incorporated in the *terroir* concept (van Leeuwen and Seguin, 2006), incorporating traditional cultivation practices which originated and were developed in the region. Together, these factors are important for defining the products' characteristics, quality, and quantity. Based on this concept, the *terroir* concept is employed to identify the changes that occurred in the region, especially concerning the links between climatic conditions and tea production characteristics.

Through the notion of *terroir*, it can be argued that the special quality of an agricultural product is determined by the character of the place where the product comes from (Gade, 2004). In growing grapes for wine, human factors such as history, socio-economic conditions, as well as viticultural and oenological techniques, are also part of *terroir* (Seguin, 1986). In regards to the original concept and the scope of this research, the *terroir* concept is also linked to the unique biophysical properties of a particular area (Bernard and Marchenay, 2006) which affects the quality of the resulting agricultural products.

Historically, the *terroir* concept in the wine industry is incorporated in the winemaking process as a means of showing the strong relationship between wine products with the area, and community where the product is produced. This inquiry aims to identify and implement the *terroir* concept for tea cultivation, especially in Uji Area, whereas tea cultivation in the area has been conducted for more than 800 years. There are many indications of similar elements between traditional old world style winegrape cultivation with the tea cultivation in Japan, especially in both cultivation processes, the importance of natural environmental elements is highly regarded. Winegrape growers, as well as tea growers, conduct meticulously detailed processes into the cultivation methods, carefully utilizing the environmental elements to their advantage. With these similarities in the cultivation elements, utilization of the *terroir* concept in the tea cultivation will add further value and optimize the cultivation process as well, thereby ensuring the sustainability of the area as a well-known tea growing region.

4. Terroir Concept for Uji Tea Cultivation

Implementation of the *terroir* concept in Uji Area would lead to the identification of important *terroir* elements, furthermore understanding how these elements interacted would provide further comprehension on its effect towards the character of the tea products. Based on the general *terroir* definition, the elements could be divided into two main part which are the natural environment and agriculture practices. In this definition, the relationship between on-going changes in the climatic condition could be seen as a factor which are affecting the *terroir* elements to a certain extent.

Based on these definitions, the *terroir* concept is defined as a relationship between natural environment element and agriculture practices element where these elements directly influenced the character of an agricultural product (Ashardiono & Cassim, 2015). These two elements represent the natural and human geographical characteristic of Uji Area, which includes the accumulation of cultivation knowledge that is inherited down through generations of tea growers in the area.

A natural environmental element consists of climate, soil, topography, and cultivars. Among these four environmental factors, this research especially emphasizes the climatic factors as because, on-going changes in the climatic conditions will have a direct and indirect effect towards the tea cultivation process and its final products. The other important element in the *terroir* concept is the agriculture practice element which is the basis of tea cultivation knowledge in Uji Area, whereas this knowledge is largely family inherited knowledge, passed down through successive generations of the tea grower's family.

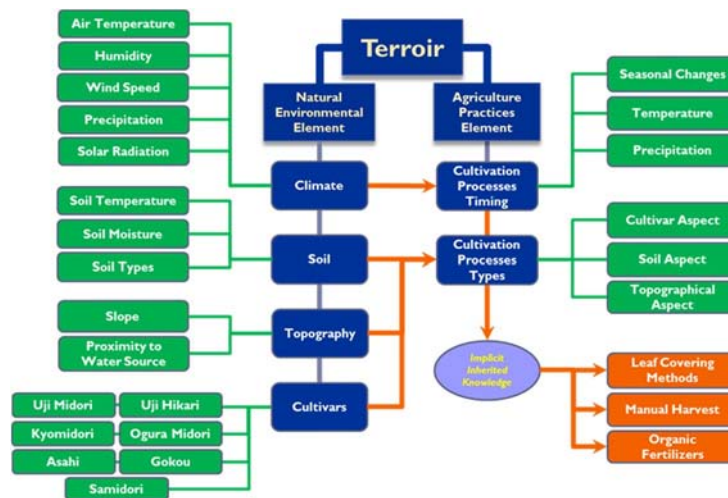


Fig. 8 Terroir Concept in Uji Area Tea Cultivation

4.1 Natural Environmental Element

As one of the important elements in the terroir concept, natural environment element consists of factors which represent the unique characteristics of the environmental condition in a certain cultivation area. The important factors are climate, soil, topography, and cultivar (cultivated varieties). Combination of these four main factors has shaped and created a natural environmental condition which is unique for that area. Hence, agriculture plants, such as tea, which is grown under those specific conditions would produce agricultural products which have certain characteristic derived from the unique natural condition. To fully understand these factors, measurements and analyses are required to identify the interacting factors.

Climatic factor consists of several aspects which are directly related to the micro-climate and meso-climate condition of the agriculture area, whereas other environmental related aspects are directly influenced by the changes in the climatic conditions. Because there are indications of rapid transformation in the climatic condition, the changes will undoubtedly affect the characteristic of other environmental aspects. The five aspects listed below are considered crucial factors in the tea cultivation (Wijeratne; 1996; Konomoto et al., 2006; Watson, 2008): Air Temperature ($^{\circ}\text{C}$), Humidity (%), Wind Speed (m/S), Precipitation (mm), Solar Radiation (W/m^2).

Other advanced aspects which are a combination of several aspects, are also important to understand the impact of changing climatic conditions, especially during important periods in the cultivation process. Air temperature is one of the most important aspects of the climate factor. It can be further broken down into average temperature, minimum temperature, and maximum temperature. Tea plants, in general, are active in conditions where the air temperature is above 10°C and would enter a dormant state when it is below 10°C . It is clear that these internal mechanisms of the plants, which are crucial in the cultivation process, are largely dependent on the air temperature condition cultivation (Wijeratne; 1996; Konomoto et al., 2006; Watson, 2008).

Humidity is largely affected by air temperature and precipitation level, additionally occurrences of evapotranspiration from the soil and plant leaves would directly influence the humidity level. Wind speed also indirectly affects not only humidity factor but also the air temperature. The absence of wind can increase humidity level, whereas on the other hand, a strong wind can lead to a sudden gust, heavy downpour and further dropping the air temperature, as well as causing frost events. The quantity of solar radiation received by the plants would become the signal

for plant's metabolism to continue its phenological processes. Excess quantity of solar radiation would also lead to the increase of maximum daytime air temperature, and in extreme instances, this will lead to serious issues such as drought especially when accompanied by the absence of precipitation.

Soil factor mainly consists of aspects which are referred to as the physical properties and conditions of the soil. They include Soil Temperature ($^{\circ}\text{C}$), Soil Moisture (cb), and Soil Types. The conditions in these factors are largely influenced by changes in the air temperature and quantity of precipitation. The areas covered by plant also influenced these changes, acting as a buffer zone limiting penetration of sunlight, and thereby minimizing the temperature changes on the surface of the soil. Generally, in Uji Area, there are two types of soil, namely those where clay or sand predominate. In several tea plantations, tea growers are mixing these two soil types to obtain certain results. Based on anecdotal information obtained from tea growers it was mentioned that tea plants which are grown on sand type soils would produce teas with better tea aroma and deeper green color, whereas those which are grown on clay type of soil would produce teas which have a strong flavor.

Among different soil types, sandy soil has large particles, and because there are spaces among the particles, in general, it has low water retention, and nutrients leaching is more frequent. Clay soil on the opposite it has small particles with smaller space in between, which made clay soil have a good water retention properties. It was also found through the social surveys and observations data, how the soil factors are also closely linked to the traditional cultivation practices, as the tea growers are applying different types of organic fertilizers in different timings, and conducted deep soil maintenance periodically. These activities would ensure the soil health within their tea plantation, as well as ensuring that enough nutrients are available for the tea plant to grow.

The topographical factor in Uji Area is closely related with soil factors, whereas clay soil type is found on the hillside while sand soil type is mostly found near the river bed and flatlands. In general, the topographical factors in Uji Area consist of Slope (degree), Proximity to the water reservoir (m), furthermore these factors directly influenced the tea cultivation practices. Tea plantations which are in the hillside are subject to lower winter temperature and fewer frost incidents, with a lower probability of experiencing drought. Also, because clay soil has better moisture retention, and because of the surrounding areas are mostly forest with a high canopy, they shade the tea growing area and minimize water loss. Because of its location, on slopes, cultivation practices are slightly more complex since the topographical gradient of the plot should be such that it achieves optimal water flow.

Tea plantations which are located around the river bed and flatlands, are mostly near the residential areas and have better access compared to the one on the hillside. Because of its location, these plantations are more vulnerable to extreme weather events such as high temperature, drought and face the risk of flooding during a heavy downpour. In parallel with its vulnerabilities, easy access to the water reservoir and direct proximity to the city drainage system would allow tea growers to manage the water flow in their tea plantation effectively.

Cultivars are defined as cultivated varieties which are native to the area or specially created through selective plant breeding to further utilize the characteristic of the natural environment elements. Tea seeds first came to Uji Area from China around 1191 AD and soon after that tea cultivation began in Uji Area. For more than 800 years of tea cultivation, the natural adaptation capabilities of the tea plant have made it suitable to grow in the climatic conditions of Uji Area optimally. With these qualities, the tea plants have developed characteristics which are only attributable to those

categorized as a native plant. Apart from this, varieties of tea plants in Uji Area have also grown from selective plant breeding conducted by the tea growers.

To achieve certain desired traits of the tea plant, especially to further optimize them to the micro-climate condition, tea growers have to select and breed tea plants based on each characteristic carefully. As mentioned previously there are seven varieties of tea plants which are developed inside Uji Area: *Uji Midori*, *Kyomidori*, *Samidori*, *Asahi*, *Uji Hikari*, *Ogura Midori*, and *Gokou*. Although officially these are the only varieties of tea plants which are originated and registered from Uji Area, there are many other undocumented varieties of tea plants which are exclusively bred and cultivated by many of the tea growing families in Uji Area.

Currently, the samidori cultivar is the most widely cultivated variety by tea growers in Uji Area, with the composition of samidori cultivar in most of the tea plantations, are around 70 percent to 80 percent while other tea cultivars make up the rest. Although samidori cultivar does not produce high-quality tea leaves, because of its long window of harvest period and the resistance to the cold, it is selected to mitigate risk factors due to climatic and environmental conditions.

4.2 Agriculture Practices Element

The element describes the influence and the importance of human factors in an agriculture process, especially in this inquiry on Uji Tea cultivation. As part of the important elements in the terroir concept, the tea cultivation practices which are being used by the tea growers in Uji Area are distinct and irreplaceable for cultivating Uji Tea. These practices utilize cultivation knowledge, which is an accumulation of experiences obtained by previous generations of tea growers, continuously passed down in their family until the present day. This tea cultivation knowledge is unique and native to Uji Area, as it has been developed based on the natural characteristic of Uji Area's environmental element. Cultivation methods and special cultivation techniques which have been developed by the tea growers are designed by taking the unique environmental characteristics into account.

Application of these cultivation methods is based on two deciding factors which are: timing on conducting cultivation processes and types of cultivation processes selected. Both of these deciding factors are influenced by the four environmental factors, whereas the tea growers have exploited these factors to obtain their desired level of tea production. These types of interactions between Uji Area environmental factors with the cultivation processes utilized by the tea growers are unique and exist only in Uji Tea cultivation. Each tea grower needs to fully comprehend the interactions between the terroir elements, for them to be acknowledged as a full-fledged tea grower in Uji Area.

Through years of experiences and observations, the tea growers were able to understand how the micro-climate condition in their tea plantation changes, down to the smallest plot. By understanding these conditions, the tea growers were able to identify the correlation between micro-climatic conditions with the phenological process of tea plants. Based on this knowledge the tea growers in Uji Area were able to conduct cultivation processes which are best suited to those conditions, especially to bring out the unique character of their tea products. Based on preliminary observation, the timing of cultivation processes conducted by the tea growers are mainly based on seasonal changes, temperature, and precipitation.

Some of the original cultivation processes, such as leaf covering, organic fertilizer, and soil maintenance are conducted depending on the season and the changes in climatic factors. Tea growers generally would start covering the tea leaves around mid-spring when the temperature is warm. Application of fertilizer and soil maintenance are also conducted depending on the season and precipitation level. From this

information, it can be correlated with how changing climatic conditions are affecting the decision on when to conduct cultivation processes.

The second factor in the agriculture practices describes the types and kinds of cultivation processes which are utilized in Uji Area. The types of cultivation processes selected by the tea growers are mostly motivated by each grower's objectives. They will utilize cultivation processes which are most suited to their plantation's natural environmental condition. Based on this observation, most of the decision on selection of cultivation processes types are based on cultivar aspect, soil aspect, and topographical aspect.

Depending on the combination of soil conditions, the slope of the tea plantation and types of varieties planted, tea growers can select the most suitable cultivation processes to achieve desirable harvest quality and quantity. Regarding these aspects, there is varying degree on types of cultivation processes which are selectable by the tea growers. Some of the cultivation processes types include the utilization of the watering system, frost protection fans, and other techniques.



Fig. 9 Bioclimatic Indicators in the Terroir Concept of Uji Tea Cultivation

Through utilization of the terroir concept in Uji Area tea cultivation, possible new bioclimatic indicators could be developed derived from the winegrape cultivation. These new indicators would function as a tool for the tea growers to further understand the phenological elements in the tea cultivation processes, as well as to provide precision bioclimatic information. In the long run, this tool would become the foundation for developing new tea cultivation processes. Bioclimatic indicators will be the basis for new tea cultivation knowledge which is explicit and transmittable among the tea growers to complement the implicit cultivation knowledge, which they have already inherited from inside their family.

Application of terroir concept and its bioclimatic indicator derivatives in the tea cultivation would actualize the development of tea cultivation process which is more optimized and efficient, while at the same time preserving its traditional cultivation methods, that would further bring out the unique quality characteristic of the tea products. Through the application of these advanced cultivation methods Uji Area, the tea growers would be able to cope and swiftly adapt to the changing climatic conditions

as well as leading to the prediction of tea production yield and quality. Application of this concept would also ensure the sustainability of the region as a tea producer.

5. Conclusion

Currently, Uji Area tea growers to some extent have already understood the impact of rapid climatic changes, especially on its adverse effects towards tea cultivation. Despite knowing the potential dangers of climatic impacts in the future, they are less worried about the worst possible scenario, even though the current indications have shown that Uji Area is heading towards that direction. This is mainly because the tea growers are already facing several issues besides climatic changes. Although they have a well-known status, the tea growers are facing issues which are mostly originated from an economic perspective, in which declining sales value and increased expense in the tea cultivation have slowly affected the tea grower's financial condition.

Additionally, this condition has made the younger generation in the tea grower's family becoming less interested in continuing their family business because of these economic uncertainties. Before they could be involved in the tea cultivation, young tea growers would encounter challenges in understanding the intricate and complex traditional cultivation and distribution processes in the tea cultivation, thereby further increasing their reluctance to enter the industry. From the social survey result, it is evident that securing a successor have also become an important issue in Uji Area, despite its reputation as a premier tea producing locality in Japan.

Explained in this study, the new terroir concept would derive bioclimatic indicators, as utilized in the wine grape cultivation, the tea growers in Uji Area could utilize it to maintain and improve the tea production yield. The combination of the tea growers inherited tea cultivation knowledge, with the precision information from bioclimatic indicators values would significantly increase the tea grower's capabilities to effectively select appropriate land plot and cultivars for tea cultivation, as well as on decision making for conducting appropriate cultivation processes, that could further optimize and improve the tea cultivation methods.

Currently, most of the tea growers in Uji Area obtained climatic information from external sources such as electronic media, newspaper and the internet. These sources only provide information on a region-wide meso-climatic scale, and to a certain degree, additionally it requires corrections to reflect the real micro-climatic condition on each tea plantation. With the current rapid climatic changes, these open climatic data sources would not be able to provide precise climatic information. Without these information, the tea growers would become less aware of the changes in the tea plantation and might lead to cultivation processes decisions which are ineffective and resource consuming. From this analysis, it could be argued that it is critical for the local government and agricultural institutions to put more focus on assisting the tea growers in obtaining precise micro-climatic condition on their tea plantations.

To utilize the bioclimatic indicators, the tea growers would have to constantly monitor and record micro-climatic changes in their tea plantations, whereas through these monitoring activities, the tea growers would be able to further understand the micro-climatic conditions in their tea plantation and their impacts on the tea production quality. This, in turn, would make them more aware of the significance of changing climatic conditions toward their livelihood and allow them to adapt to any of the changes swiftly.

It could be concluded from this inquiry, through the combined applications of traditional cultivation knowledge and terroir derived bioclimatic indicators, the tea growers would be able to maintain the quantity and quality of the tea products cultivated in Uji Area. Furthermore, it could lead to the creation of new product value

based on the characteristic of the natural environmental elements. The new product values would emerge in two forms, which are values internal to the tea plant and externally generated values. The new internal values would likely to emerge as an improvement to the tea products' characteristics themselves, such as fragrance, color, taste and health benefit. The new external values would come from developing detailed systematic records of the tea cultivation process which could be translated into product traceability, safety and quality assurance aspects.

The combination of these detailed records (external values) and the sensory attributes of the tea itself (internal values) could be used to create a strong brand value for the tea product based on the rational, evidence-based investigation. These new values of the tea products would create new market demands, leading to new economic benefits for the tea growers and their community in Uji Area. This would, in turn, make it easier to find successors within tea growing families and to lower barriers to new entrants attracted by the dynamism and profitability of tea cultivation. On this note, securing a successor in the tea cultivation industry would contribute to the socio-economic benefit of Uji Area, which ultimately ensuring the sustainability of Uji Area as a tea growing region

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