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Protecting Japanese Tea Growers from
the Devastating Effects of Climate Change:
A Terroir Based Ecosystem Approach for Rural Development

Fitrio Ashardiono

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Policy Science Association
Ritsumeikan University
2-150 Iwakura-cho, Ibaraki,
Osaka 567-8570 Japan

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Abstract: Increasing occurrences of extreme climatic events and abrupt temperature fluctuations have not only affected agricultural cultivation directly, but are also impacting the socio-economic conditions of rural communities. To some extent these changes have been observed in the Uji Area, a well-known tea growing region in Japan, where its tea cultivation process has been affected, altering the tea harvest yield and quality. The terroir concept, which is derived from wine grape cultivation, describes the relationship between the inherent natural environment conditions and traditional agricultural practices. This concept is an important tool for tea growers to swiftly adapt to on-going climate changes while maintaining the yield and quality characteristics of the tea products. Through the terroir concept, the important factors in tea cultivation which lead to the unique quality characteristics are measured and analyzed. These factors are also utilizable as the basis for an Ecosystem-based Adaptation (EbA) framework that can swiftly cope with and adapt to the on-going effects of climate change. Furthermore, through applying the terroir concept, local communities will be able to learn and understand more about their natural environments, which in turn make them more aware of the adverse effects of climate change.

Keywords: *Terroir Concept, Uji Area, Tea Growers, Climate Change, Ecosystem-based Adaptation, Rural Communities*

1. Introduction

Currently, the rapidly transforming climatic conditions have been affecting many dimensions of human livelihoods such as the agriculture sector, a sector which is crucial for sustaining human life. Although the projected increase in the occurrences of extreme climatic events and abrupt temperature fluctuations will undoubtedly bring further detrimental effects to agricultural cultivation, the bulk of these on-going changes will directly affect the socio-economic conditions of the rural communities themselves. Currently, the impact of these climatic changes on agricultural cultivation has been observed to alter a crop's growth cycle, leading to changes in harvest yield and quality. In the worse cases, extreme climatic events in the forms of heavy rain, flooding, and frost, as well as prolonged drought, are seen to have completely devastated agricultural crops (Wijeratne et al., 2007; Ashardiono & Cassim, 2014).

With reduced harvest yield and quality, agricultural farmers are faced with economic income losses, which hurt their ability to sustain profitable agricultural cultivation. In the long run, as local agricultural cultivation becomes unsustainable, continuing economic losses will adversely affect the social conditions of rural communities, causing them to slowly collapse and eventually disappear altogether. The loss of these rural communities would mean an increased burden on the already strained agricultural production system; furthermore, in the case of historic agricultural regions, the existing unique traditional cultivation methods of these communities would be completely lost.

The Uji Area which is located in Kyoto Prefecture, Japan, is one of the oldest and most well-known tea production regions in Japan. The tea products originating from this region are revered among tea enthusiasts for their distinct quality which has become the benchmark for high-quality tea, especially for *matcha* (powdered green tea) in Japan. The Uji Area, as a historic tea cultivation region in Japan, has also been subjected to the on-going changes in climatic behavior, which have been observed to affect the tea harvest yield. Moreover based on anecdotal information from the tea growers, there are

indications that the high quality characteristics of its tea products have also been affected to some extent.

Owing to the traditional tea cultivation knowledge which has been traditionally inherited by each tea growing family, Uji Area tea growers have been able to adequately adapt to climatic extremes by using approaches derived from traditional tea cultivation methods. Although these approaches have provided a stopgap measure towards dealing with the current climatic conditions, along with the projected increase of extreme climatic events and abrupt temperature fluctuations, a more comprehensive adaptation framework would be crucial to ensuring the sustainability of the area as a tea cultivation region.

With a history of tea cultivation spanning more than 500 years, tea growers in the Uji Area have developed unique tea cultivation methods which take into account the natural environmental characteristics of the area. These methods have been developed over many successive generations of tea growers, and this vast accumulation of cultivation knowledge has been continuously passed down from generation to generation. Based on these historical aspects, it is important to ensure that the continuation of these traditional tea cultivation practices (fig. 1) is retained inside the Uji Area.

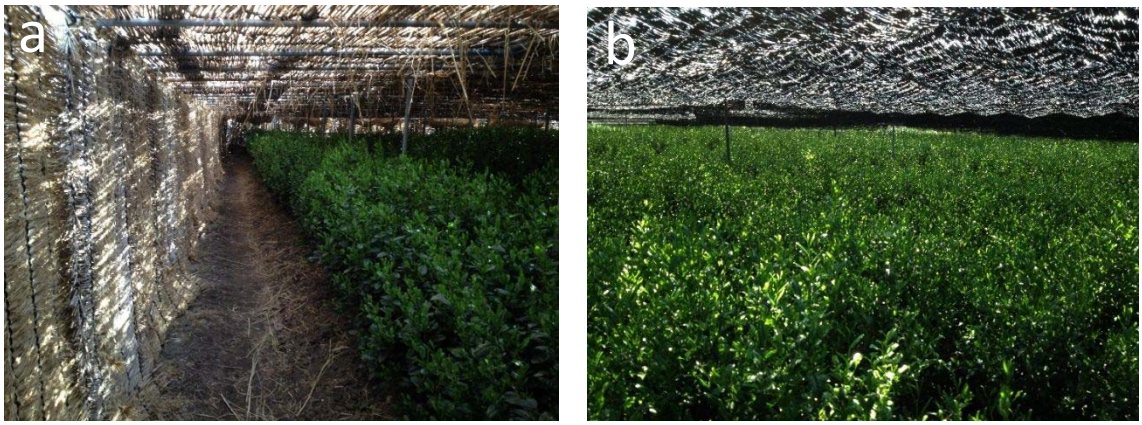

Fig. 1 Traditional Tea Cultivation Practices in the Uji Area

(a) Reeds and Straws Covering; (b) Black Vinyl Mesh Sheets Covering

Aside from the current impacts caused by the changing climatic behavior, there are clear indications that the number of tea growing families whose main income depends directly on tea cultivation and production have been declining steadily in the Uji Area (Ashardiono & Cassim, 2015). While this has mainly been due to the changing socio-economic factors, the impacts from changing climatic conditions have further exacerbated the issue. Based on these facts, it is clear that a comprehensive adaptation framework would be a crucial key to further understanding the interrelationship between the environmental, social, and economic factors which are deeply intertwined in this issue.

Because of its close proximity to large cities in the region such as Kyoto and Osaka, access and transportation to the Uji Area is relatively easy, and the area has gradually transformed from a rural agriculture society into a mixture of rural and urban societies. While the continuous urban development provides many beneficial impacts to the society, these socio-economic changes have made the younger generation less interested in continuing to run their family's tea cultivation work. Based on the current trends there

is a high possibility that this tea growing community will eventually disappear, to be replaced by a new rural-urban society.

As the on-going climatic changes have directly affected the tea cultivation processes, the tea growing community in particular possesses a higher awareness of this issue than other communities living in the area. For this reason, the tea growers must assume the important role of communicating this information to the rest of the society. In summary, the disintegration of the tea growing community would have negative consequences for the society of the Uji Area, such as the loss of traditional tea cultivation knowledge, and reduced awareness of the changing climatic conditions of the surrounding areas; thus, it would create a society which is disconnected from its natural environmental surroundings.

This inquiry attempts to address this important issue by suggesting a new approach to Ecosystem-based Adaptation (EbA) for sustainable rural development in the Uji Area, by utilizing the terroir concept to empower the tea growers to cope with the on-going environmental and socio-economic issues. Through this process, the inhabitants of the area would develop a deeper attachment to their roots, which would lead to a stronger and a more resilient society as a whole. Ecosystem-based Adaptation places more emphasis on the surrounding natural environmental conditions of a community, especially when the community's livelihood is dependent on it.

Derived from the wine industry, the terroir concept would clarify the relationship between the natural environmental characteristics and the traditional tea cultivation methods practiced by the tea growers, while maintaining the quality of the final tea products. Through this concept, the importance of natural environmental factors could be further elucidated and utilized to raise social awareness of climate change, especially in their local areas. In conclusion, the objective of this inquiry is to understand how to effectively implement the terroir concept in the EbA approach by focusing on the Uji region, which will lead to the construction of a comprehensive climate change adaptation framework for the society as a whole.

2. Terroir Concept and EbA

(1) Ecosystem-based Adaptation (EbA)

As one of the many approaches to climate change adaptation, the ecosystem-based approach has slowly been gaining traction among climate change researchers. Based on the definition laid out by the Convention of Biological Diversity (2009), EbA is a climate change adaptation approach that utilizes the benefits from biodiversity and the ecosystem as part of an overall adaptation strategy to help people to counter the adverse effects of climate change. EbA focuses on the benefits that humans derive from biodiversity and ecosystem services, and how these benefits can be utilized in the face of climate change. Consequently, EbA is a people-centric concept, but one that acknowledges that human resilience depends critically on the integrity of ecosystems (Colls et al., 2009).

Through employing EbA, people and communities would become more attuned to their surrounding natural environment, and more able to understand the importance of environmental ecosystems in sustaining their livelihood. EbA also has the potential to deliver multiple economic, social and environmental co-benefits to the communities (Jones et al., 2012). These approaches include the management, conservation, and restoration of ecosystems that help in reducing climate change exposures (Munang et al., 2013).

In the agriculture process, EbA is referred to as the implementation of agricultural management practices that use or take advantage of biodiversity, ecosystem services or ecological processes to help increase the ability of crops or livestock to adapt to climate variability (Vignola et al., 2015). Agriculture depends on the ecosystem services; thus, applying management practices which are focused on conservation and sustainable ecosystem management is beneficial to the farmers, as it will help them adapt to climatic variability not only in the short term but potentially in the long term (Jones et al., 2012; Munang et al., 2013; Vignola et al., 2015).

EbA management practices take advantage of local or traditional knowledge and are based on the locally available inputs. On the utilization of EbA, tea growers in the Uji Area have to some extent conducted these management practices in the cultivation of their tea products. As mentioned previously, up until this day the tea growers still continue practicing traditional tea cultivation techniques and maintaining a high proportion of locally available input in their tea plantation. EbA practices focus on ensuring the sustainability of key benefits provided by the ecosystem itself, with less external input (reduced fertilizers, agrochemicals, and machinery) to reduce greenhouse gas emissions, which is similar to the traditional cultivation methods developed by tea growers in Uji.

While EbA practices would help the tea growers to further adapt to climate change and sustain the tea cultivation practices in the area, this approach is not comprehensive enough to address the socio-economic issues faced by the tea growing community. EbA practices would help tea growers to maintain the delicate natural environmental ecosystem supporting the tea plantations, which would in turn allow them to adapt to the changing climatic conditions. However, EbA methods have limitations when appraising the added economic values of unique agricultural products such as the traditional tea products from the well-known historic region of Uji.

(2) Terroir Concept

The terroir concept explains the values of agricultural products in relation to their original place of cultivation, which complements EbA approaches when utilized for unique agricultural products, where the concept highlights the relationships between the quality characteristics of a product, the physical traits of its cultivation area, and the cultivation methods utilized. Namely the terroir concept assesses the utilization of a natural environment ecosystem in the cultivation of an agricultural product.

The terroir concept describes the relationship between the characteristics of an agriculture product and its geographical origin (van Leeuwen & Seguin, 2006). The latter, which includes traditional agricultural practices, influences the characteristics of the former. Through the notion of terroir, it can be argued that the special quality of an agricultural product can be 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 (Berard & Marchenay, 2006), which affects the quality of the resulting agricultural products.

Based on these definitions, the terroir concept can be defined as the relationship between the natural environmental element and the agriculture practices element, where these elements are directly influencing the characteristics of an agricultural product (Ashardiono & Cassim, 2015). In this definition, the terroir concept consists of

two elements, which are: 1) The Natural Environmental Element and; 2) The Agriculture Practices Element. These two elements represent the natural and human geographical characteristics, where the knowledge of cultivation is continuously accumulated and passed down through generations of tea growers in the area (fig. 2).

The first terroir element, which represents the natural environment, consists of four factors: 1) Climate; 2) Soil; 3) Topography; and 4) Cultivars. These factors represent the unique environmental characteristics of a particular cultivation area. Moreover, a combination of these four factors has shaped and created the natural environmental conditions, which are unique to that area alone. A crop such as the tea plant which is grown under these unique conditions would produce an agricultural product which has distinguishable quality characteristics when compared with a similar product from another region.

The second important element is the agriculture practices element, which represents the basis of traditional cultivation knowledge in a particular region. This knowledge is largely a family inherited knowledge which is passed down through successive generations of tea growers. The agricultural practices element describes the influence and the importance of human factors in the agriculture process. In this inquiry in particular, it can be observed how traditional tea cultivation techniques have played a significant role in the tea cultivation process in the Uji Area. The unique methods and special techniques of the tea cultivation processes are utilized mainly based on two deciding factors: 1) the timing of cultivation processes; and 2) the types of cultivation processes applied during tea cultivation.

Fig. 2 Terroir Concept in Tea Cultivation

The decision-making processes in these two factors are solely based on the conditions of the four factors derived from the natural environmental element. Thus, the decision on when to conduct the cultivation processes is mostly based on the climatic factors, while the selection of types of applicable cultivation processes relies on the tea grower's intuition in predicting the climatic effects on the soil, topography and cultivar factors. Based on their individual preferences, the tea growers have been conducting their unique cultivation processes to produce good yields with high-quality characteristics.

This paper proposes that based on this definition, the terroir concept would further enhance the EbA management approach in a well-known historic cultivation region such

as the Uji Area. By applying this concept it could be possible to identify the important factors in the natural environment ecosystem, that are crucial for producing tea products which possess the region's unique quality characteristics. Based on the identification of the important terroir factors, it will be argued that the EbA approach could be designed more specifically to strengthen the local ecosystem against the effects of climate change and preserve its benefit to the local inhabitants.

Furthermore, by recommending the adoption of the terroir concept, it is intended that the society will have a greater understanding of the uniqueness and importance of tea cultivation in the Uji Area, as information on the quality traits and the historical relationship between tea products and the cultivation region will be objectively published to the general society. If this knowledge were available, it is hoped that the local society would develop a stronger attachment to its roots, which would ultimately increase awareness of the impact of climate change on the Uji Area, and ultimately it could be utilized in other rural communities throughout Asia.

3. Tea Cultivation in the Uji Area

(1) The Terroir of Uji Area

The Uji Area is conveniently located to the south of Kyoto City and can be easily reached from the city in about thirty minutes by train. As previously mentioned, this close proximity to larger cities has brought many benefits to the Uji Area society, especially from the social and economic perspectives. Over the years Uji has gradually transformed into an urban-fringe area, where most of the population is no longer involved in agriculture, which in this case is tea cultivation. While the area is well-known as a tea cultivating and producing region, in reality, most of the residents working in the tea related industries are only involved in tea production and sales.

Despite these changes in the social conditions, the Uji Area tea growers continue to grow and cultivate tea in a similar way to their predecessors, although over the years their numbers have been declining because the younger generation is becoming less interested in tea cultivation. While the information and knowledge on the current micro-climatic conditions in the Uji Area is shared among the members of tea growing community, this type of information is unknown to the other members of the society. As the Uji Area grows more urbanized, the residents as a whole are becoming less aware of the changing climatic conditions occurring in the surrounding area.

From the total land area of Uji, which is approximately 67.55 km^2, based on Kyoto Prefecture government data (2017) the current total land area which is being utilized for tea plantations is only 0.8 km^2, and there is a tendency for this number to continue to decline. Although this area is famous for tea cultivation, in 2017 there were only 112 active tea growers and 21 registered tea plantations inside the Uji Area, in comparison with the total population (2017) of 184,687 residents. The topographical situation of the Uji Area consists of a river plain and flat land with hills in the east and south part of the area.

Currently Uji Area is the oldest and most famous tea growing region in Japan, where according to historical archives, tea cultivation in the area began in 1191 AD (Kyoto Prefecture Government, 2011). Through hundreds of years of observing the natural environmental conditions, each tea growing family has developed special techniques which allow the full exploitation of nature in their tea plantations. Most of the tea plantations are located around the river plains and on the hilly areas, and according to anecdotal information, the tea growers regard tea cultivated in these two locations to

have different characteristics, where the differences are seen to be caused by the natural environmental conditions of each location.

At the moment the local Uji City government does not have any on-going activities to promote an awareness of climate change among residents, although they are focusing on promoting the tourism sector of the area through "Uji Tea" publications and advertisements. It is also important to point out that the name 'Uji Tea' does not refer to tea products which are exclusively cultivated inside the Uji Area. Traditionally, only a small quantity of tea is actually produced in Uji Area because of its resource consuming cultivation methods.

Therefore, in order to comply with the continuous high demand from consumers, in 2006 the Ujicha Cooperative (*Kyoto-fu Chagyo-kumiai*), a wholesaler collective, defines Uji Tea as tea products which are grown in four prefectures: Kyoto, Nara, Shiga and Mie; and processed inside Kyoto Prefecture by a tea wholesaler based in Kyoto Prefecture using techniques derived from the Uji Area.

Although this definition successfully sustained the production of tea labeled as Uji Tea, in reality, under this definition, most of the tea products sold by the tea wholesaler contain only a small percentage of tea leaves which are grown inside the Uji Area. The bulk of the tea leaves for tea production are obtained from areas neighboring the Uji Area.

There is a need to define the tea products further based on their region of cultivation, where by applying the terroir concept it should be expected that different areas will yield different quality characteristics. It is important for the general public, especially the society of the Uji Area, to appreciate the unique characteristics of the tea leaves actually cultivated in their area, while also understanding how the climatic impacts will affect this quality characteristic. It is hoped that through this framework both the general Uji Area Society and the tea growers will collaborate hand in hand to adapt to the on-going climate changes swiftly.

(2) Research Methodology

This inquiry is conducted using a mixed method utilizing both quantitative and qualitative analyses to further understand the inter-relationship between the environment and socio-economic conditions in the Uji Area, especially when confronted with the changing climatic conditions. Both methods are necessary as the objective of this research is to construct a comprehensive climate change adaptation framework for the sustainable development of rural communities.

Quantitative analysis is utilized to analyze climatic data obtained from the tea growers as well as from the local weather station which is operated by the Kyoto Prefecture Tea Industry Research Institute. The analyzed data sets consist of measurements and recordings of the climatic factors such as air temperature, humidity, wind speed, precipitation and solar radiation. From the soil factors the data sets consist of soil temperature and soil moisture.

In prior analysis, these data sets were averaged into three parts for each month, where each part consists of values which have been averaged for ten days. The three parts are the first ten days of the month (early), the second 10 days of the month (middle) and the last ten days of the month (late). The analysis utilized methods such as regression and variance analysis to understand the correlation between the climatic and soil factors with tea cultivation yield and quality.

Complementing the quantitative analysis, a qualitative approach is utilized for conducting social surveys and observations in this inquiry. This approach is critical for obtaining detailed information from the tea growers and the general society of the Uji

Area. The utilized approaches are direct interviews and observations of the tea cultivation processes, which are necessary to understand the tea grower's inherited traditional cultivation knowledge, as well as gathering the general public's opinion in the area.

The interviews are conducted using a semi-structured style approach, where the questions are structured and organized to gather information on: 1) demographic information; 2) perceived climatic impacts; 3) traditional tea cultivation processes; 4) identification of terroir factors; and 5) socio-economic and environmental issues. The targeted interviewees are the tea growers, local government officers, and the local residents of the Uji Area.

The inquiry is focused on assessing the local communities' perceived climatic impacts in the area through interviews and climatic data analysis, in relation to the traditional tea cultivation processes. Following this process, the terroir factors which are seen to be directly influencing the tea cultivation processes are identified. Based on the analyses results, a new comprehensive climate change adaptation framework is constructed with focal points based on key terroir factors in the Uji Area. This framework will function as a platform for climatic information exchanges between the tea growers and the local communities, thus both sections of the society could obtain precise information regarding the climate and the current conditions of tea cultivation processes.

By adopting this framework, communities will be able to swiftly adapt to the on-going changes in the climatic conditions, as well as sustaining and enhancing their livelihoods. In the broader correlation, this condition would bring in and increase the socio-economic benefits for the Uji tea growers' community by the preservation of traditional tea cultivation methods, as well as increasing the community's awareness of climate change impacts.

4. Research Results and Discussion

(1) Social Survey Result

Based on the demographic data obtained from Kyoto Prefecture (2017), there are 112 tea growers in the Uji Area. From this number only 21 tea growers are registered as full-time tea growers, who own and manage their own tea plantations in the area. Through this data, it can be understood that currently there are only 21 tea plantations which are actively conducting tea cultivation in the area, whereas in comparison there are 26 tea manufacturing factories in the same area. The number of Uji residents who are working or indirectly involved in the tea related business is estimated to be less than 1,000 residents, which is very small in comparison with the total population in 2018 (187,290 residents).

By observing this situation, although the Uji Area is a historical tea cultivation region, currently only a small number of the residents are involved in tea-related industries. The demographic data also showed that most of the residents are working outside the Uji Area, while the number of residents working inside the area is estimated to be less than 20,000. From this analysis, it can be concluded that the residents of the Uji Area are most likely not directly related with the rural communities in the area, especially the tea growing community.

Through social surveys, it can be confirmed that currently there are only 21 active tea grower families who are conducting tea cultivation processes as their full-time work; although it was also found that there are several tea grower families who conduct tea cultivation as their part-time work beside their main occupations. In most of the cases

when a tea grower family decides to cease its involvement in the tea cultivation work, it is due to the lack of a successor to take over the family business.

This issue arises because the successor has decided to work in other sectors outside the Uji Area, to which the contributing factors are: 1) lack of interest in tea cultivation; 2) economic instability as a tea grower; 3) perceived higher income as an office worker; 4) parental preferences not to have their successor engaged in manual labor; and 5) continuous decrease of tea grower's income. These families, who have ceased to conduct tea cultivation, are either renting their tea plantations to other tea growers or converting the land plot to be used for different purposes.

On the topic of the perceived climatic impacts, the interviewees indicated that they have been experiencing more climatic instability in the past two to three years, with increased extreme climatic fluctuations, and increased torrential rain, as well as increased typhoon occurrences. The tea growers expressed their growing concern with the on-going climate change, whereas, despite their confidence to be able to maintain the tea harvest yield, they think that the leaf quality will be affected leading to a decrease in the tea unique quality characteristic.

The information related to the perceived climatic impacts on the tea growers provides further insight into how each tea grower has optimally used the influencing terroir factors for tea cultivation. The vast knowledge on tea cultivation which they have inherited from the previous generations of tea growers has provided them with detailed information about the natural environmental element in their tea plantations, thus allowing them to conduct their own special cultivation processes to obtain the desired result.

Through effective and optimal utilization of these terroir factors, the tea growers have been able to adapt to the current climatic changes by altering the usage of the leaf covering, as well as adjustment in the application of organic fertilizer and soil maintenance. These methods are selected because most of the tea growers identified the soil factor as the most important, followed by the inherent micro-climatic conditions of each tea plantation.

From the social survey, it was also found that over generations most of the tea growing families have developed their own tea cultivars which they regarded to be better suited to the conditions on each of their particular tea plantations. Interestingly the leaves from these special cultivars are not for sale, although they always use these leaves when preparing for their entry to the annual tea competition.

However, even winning the annual tea competition does not guarantee any increase in the tea grower's income from tea sales, where through an individual sales agreement between the tea wholesaler and the tea growers, the pricing for most of the harvested tea yield has already been fixed beforehand. As previously mentioned, the tea wholesalers are sourcing the tea leaves from several areas, before mixing and blending the tea leaves according to the types of the products, thus the tea products manufactured using tea leaves sourced only from the Uji Area are limited and usually sold at a premium price.

These price differences have made the tea growers feel uneasy about their economic conditions, where through a social survey it was also found that the tea cultivation expenses have been increasing despite a decrease in the harvested tea leaves' sales value in the past years. While the tea growers are in a position to start manufacturing their own tea products, the unique relationship between the tea growers and the tea wholesalers has become somewhat of an inhibiting factor for the tea growers to change the distribution system, let alone for them to become independent.

Based on these findings it can be summarized that although the tea growers are concerned about the on-going climate change, they are confronted with the immediate economic issue in regard to their livelihood. Furthermore, because most of the residents

of the Uji Area do not have any direct relation to the rural communities, they are less interested in the current tea cultivation conditions in the area, although they are sympathetic to the possible direct implications of climate change on the tea industry.

(2) Terroir-Based EbA Framework

By analyzing all these findings, it is clear how the terroir-based EbA framework is suitable for application in the Uji Area, as it will enable the tea growers to confidently take ownership of their cultivated tea products, thus providing a stronger sense of attachment to the Uji Area. In addition, this framework will be a means of connecting the urban residents of the Uji Area with its rural communities. Utilizing this framework, tea growers could firmly establish the connection between the quality characteristics of the tea products and the tea plantations where the tea is cultivated. This will strengthen the recognition of the tea products among the residents of Uji, as something cultivated in their local area. Additionally, the tea products will be presented as a local brand to appeal to the local communities in the Uji Area.

By continuous monitoring and measurements of the important terroir factors, the tea growers could further understand how the terroir factors have been influencing the quality characteristic of their tea products. From these measurements and monitoring, precise bioclimatic information regarding the real condition of the tea plantation can be easily obtained by the tea growers. By utilizing this precise bioclimatic information, the tea growers can conduct effective and optimal tea cultivation processes to maintain and further improve the tea harvest quality and yield, as well as to formulate a swift adaptation method to counter the on-going climatic change.

With the on-going climate condition continuously monitored and measured (fig. 3), the tea growers can utilize the bioclimatic information in conjunction with their inherited knowledge to formulate new cultivation methods to add more value to the tea products, and to enhance the tea quality characteristics, as well as to conduct cost-effective cultivation intervention. Through the terroir-based EbA framework, these bioclimatic data are further analyzed into precise bioclimatic indicators, thus by having access to these indicators, the tea growers will be able to strengthen their resilience to the on-going climate change.

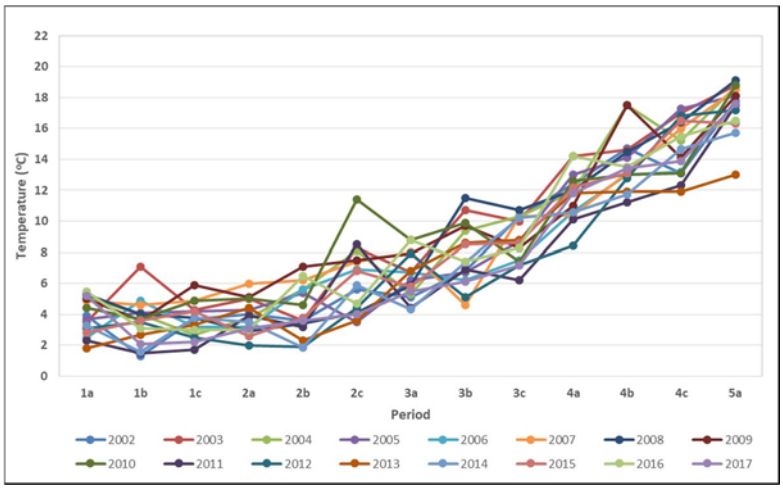

Fig. 3 Average Mean Air Temperature in the Uji Area from Early January (1a) to Early May (5a) (2002-2017)

Utilizing the bioclimatic indicator, the terroir concept can also be used as a functional indicator to delineate the boundaries of a particular tea cultivation area, in relation to the quality characteristics of its tea products. The terroir concept will provide the justification to differentiate the tea products which are cultivated inside the Uji Area, where these products should possess a unique quality characteristic which can only emerge through the combination of the terroir elements in the area. The data obtained through monitoring and measurement are also useful to create a detailed traceability record of the tea products, thus providing safety and quality assurance to the consumers, which include detailed information on the terroir elements contributing to the product's characteristics.

5. Conclusion and Further Research

Through the terroir-based EbA framework, the Uji Area tea growers can utilize the bioclimatic indicators as a functional tool to assist them in developing new cultivation methods to swiftly adapt to the on-going climate changes (fig. 4). It was observed in this research that the Uji Area tea growers were able to conduct appropriate cultivation processes based on the macroclimatic data. With precise bioclimatic indicators, they can conduct further cultivation processes which are effective and optimal based on the related tea products. These indicators are also an important tool to analyze the quality characteristics of tea products, thus providing scientific analyses to the unique characteristics of the tea products cultivated in the Uji Area.

By utilizing the terroir-based EbA framework, the Uji Area tea growers can confidently take ownership of their cultivated tea products, which in turn will ensure the sustainability of their socio-economic conditions and thus attract new generations of tea growers into the area. By securing a successor to continue the tea cultivation work, the tea growing communities in the Uji Area can continue their businesses, ensuring the preservation of traditional tea cultivation practices in the area.

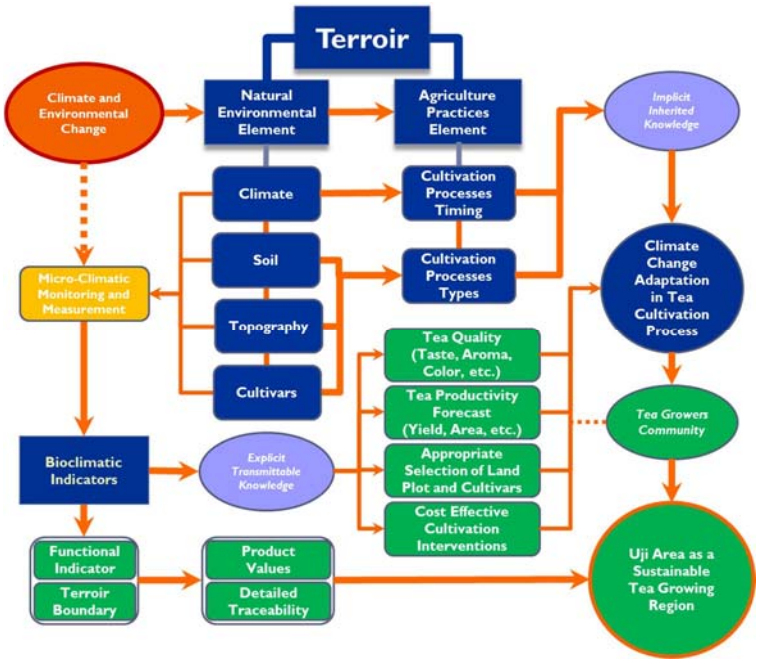

Fig. 4 Bioclimatic Indicators in Terroir Based Adaptation Framework

Furthermore, through the utilization of bioclimatic indicators, high precision scientific data regarding the tea cultivation processes are obtained and clearly documented, where through this data, inexperienced young tea farmers can easily understand and carry on the traditional tea cultivation practices inherited in their tea growing families.

Based on the terroir-based EbA framework, the obtained bioclimatic information, especially climatic data should be shared among members of the tea growing communities, enabling them to further understand how the climate influences the inherent natural environmental characteristics. This information will also be shared among the general residents of the Uji Area; thus, the information will become an eye-opener to the general residents' understanding of the impacts of climate change, especially those which are occurring in their surrounding areas.

With the current rapidly changing climatic conditions, open source climatic information would not be sufficient to provide up-to-date information constantly, while at the same time there are limitations and time constraints on the tea grower's ability to continuously monitor the micro-climatic conditions on their tea plantation directly. Therefore, it could be argued that, with the local economy in mind, it is critical that the local government, agricultural institutions, and the general public put more focus on assisting the tea growers to access the technology necessary to obtain precise micro-climatic information. The collected data could also be utilized by the local government as a regional development tool to increase awareness of climate change, as well as an economic development tool stemming from agriculture tourism.

In addition, from this paper we can understand that the application of a terroir-based EbA framework can be applied to other cultivation regions, especially as a tool to improve the long-term sustainability of rural communities in urban-fringe areas. These conditions are clearly observable in the Southeast Asian Region, where there is an increasing trend in specialized agricultural products cultivation in the rural areas, such as coffee, tea and spices. Based on this, further research on terroir-based framework needs to be done to realize the agricultural potential of the region.

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