# IMPLICATIONS OF CLIMATE CHANGE ON CHERRY BLOSSOM VIEWING AND AUTUMN FOLIAGE TOURISM IN TOKYO: EVIDENCE FROM THE HOLIDAY CLIMATE INDEX (HCI)

**David Williams**
*Josai International University, Japan*

## INTRODUCTION

Climatic resources contribute significantly to destination attractiveness and tourist choice (Hu & Richie, 1993) and influence the timing and location of tourism activities (Lise & Tol, 2002). In this sense tourism can be said to be “predicated” on the climate of a destination (Scott & McBoyle, 2001). Japan’s wide latitudinal spread means the country has a variety of climate-dependent cultural events to attract visitors including the well-established tourist events of hanami (cherry blossom viewing) and momijigari (autumn foliage viewing). Tokyo has more than 50 recognized locations for cherry blossom viewing and no fewer than 40 for autumn foliage viewing (Weathernews, 2022; 2023) and in the wake of the Covid-19 pandemic the city is keen to re-welcome overseas visitors to experience them both (NHK World, 2023).

With more than 1000 years of known history cherry blossom viewing (CBV) is a highly important representation of spring in Japan (Weathernews, 2013) and one of the most culturally significant events in the country’s tourism calendar. Taking place during the flowering of cherry blossom trees, CBV is an outdoor picnic or promenade with friends or colleagues to view the blossoms; in recent years it has also become a major draw for international visitors. Autumn foliage viewing (AFV) on the other hand has been a part of Japanese domestic travel for some 400 years and is the most recognised form of contemporary autumnal tourism (Liu et al., 2019). Both CBV and AFV feature heavily in marketing to international visitors (JNTO, 2023), are known to bring tangible impacts on the economy (Li et al., 2022; Sakurai et al., 2011), and have even been shown to improve psychological wellbeing (Jo et al., 2022).

As a result of the deep cultural roots linking Japan, its people and its climate the Japan Meteorological Agency (JMA) maintains extensive phenological records of the country’s flora (Primack et al., 2009). This includes the flowering dates of cherry blossoms, and the coloration and leaf fall for a range of autumnal leaves. These records inform us that the periods for CBV and AFV in Tokyo are changing with earlier flowering in spring (Aono & Kazui, 2008) and later shedding of leaves by many species of trees in autumn (Ge et al., 2013; Parmesan, 2007).

These changing phenological circumstances can be both a benefit or a hinderance for tourism. For example, evidence suggests the delay in the coloration of autumn leaves will produce more vivid colors and increase visitation but at the same time altered viewing periods may negatively impact visitor numbers (Kyne & Diver, 2012). Nagai et al. (2019) suggest “moderate warming” may increase the value of the cherry blossom to the tourist industry, but also that enhanced warming could shift the flowering period from its ‘expected’ period. These observations are consistent with the IPCC 6th Assessment Report (IPCC, 2021) which indicates as growing seasons change temporally so will flora-based tourism.

These arguments inform about the resource itself, but what about the climate visitors themselves are experiencing during CBV and AFV? Has the tourism climate improved or deteriorated during the peak periods of flowering/coloration when tourists most want to visit? These are important questions since CBV and AFV are inherently climate-dependent and changes in the flora resource will affect tourists and tourism industry stakeholders alike and ultimately the economic and cultural sustainability of the two events (Moriuchi & Basil, 2019; Sakurai et al., 2011). One way to assess these questions is through the use of a tourism climate index such as the Holiday Climate Index (HCI:urban).

Over the past 40 years tourism climate indices have been widely used and progressively improved to represent the climate tourists experience (de Freitas et al., 2008; Mieczkowski, 1985). In recent years the Holiday Climate Index (HCI:urban) (Scott et al., 2016) has established itself as one of the most widely used tools for objectively assessing tourism climate favorability worldwide (Demiroglu et al., 2020; Mahtabi & Taran, 2018; Rutty et al., 2020; Yu et al., 2020). The index incorporates the weighted climatic variables of air temperature, relative humidity, cloud cover, precipitation and wind speed to produce an index value that reflects a destination's climatic suitability to tourism. The HCI rates tourism climate on an 8-point scale from 0-100 for which 90-100 represents 'ideal' tourism conditions, while a value of less than 10 indicates 'dangerous' ones.

In an attempt to better understand the tourist climate in Tokyo during the cherry blossom and autumn foliage viewing periods the current research examines an extended longitudinal record of the Holiday Climate Index (HCI:urban). In doing so it aims to highlight the temporal changes to the tourism climate during peak viewing periods and in light of the findings better inform tourists and tourism stakeholders about the favorability of the climate to cherry blossom and autumn foliage viewing.

## METHOD

To investigate the tourism climate during the CBV and AFV periods the current research utilized the online archive of the Japan Meteorological Agency (JMA, 2023) for 1976-2023. The peak viewing periods were constructed by visual analysis of cherry blossom flowering dates over a 48-year period, and maple and ginko leaf coloration over 42 years. This yielded an 'ideal' 21-day CBV period and an equivalent 20-day AFV period. Due to temporal changes in flowering/coloration over the 40-plus year study period the longitudinal record was split into two periods (CBV = 1976-2000 and 2001-2023; AFV = 1981-2000 and 2001 -2022). In order that the respective later periods matched flowering/coloration the 21-day CBV was *advanced* 5 days for 2001-23 while the AFV was *delayed* 5 days for 2001-2022.

Longitudinal HCI ratio plots for the 21-day CBV and 20-day AFV were constructed using equation (1) and Mann-Kendall trend analysis performed on the HCI:urban and its constituent meteorological parameters. To more clearly identify climate favorability for tourism a modified 6-point HCI scale, 'excellent' (HCI= 80-100), 'very good' (70-79), 'good' (60-69), 'marginal' (50-59), 'poor' (40-49) and 'unacceptable' (<40) was employed in place of the 8-point scale of Scott et al. (2016).

$$\text{HCI:urban} = 4(\text{thermal comfort}) + 2(\text{cloud cover}) + (3(\text{precipitation}) + \text{wind}) \quad (1)$$

## FINDINGS

The phenological record indicates that in spring the mean date of full flowering of cherry blossoms in Tokyo has advanced 7 days between 1976 and 2023 (April 5$^{th}$ – March 29$^{th}$). In autumn while no delay is apparent in the date of maple leaf *coloration* there is a 5-day delay in the *leaf fall*, and for ginko leaves coloration occurs 6 days with a 6 days delay and remains for an additional 3 days. Mann-Kendall analysis indicates the advance of cherry blossom flowering and delay in autumn leaf coloration are statistically significant ($p<0.0001$).

In tandem with the phenological changes to the leaves themselves, the Holiday Climate Index (HCI:urban) shows the tourism climate has changed with the CBV period becoming more favorable to tourism and the AFV slightly less so. As shown in Table 1, average CBV conditions rated as 'good' (HCI = 67) in 1976-2000 have improved to 'very good' (HCI = 71) in 2013-2023 with 37% of all days rated as 'excellent' (HCI >= 80). By contrast, AFV period conditions rated as 'very good' (HCI = 71) in 1976-2000 have declined to 69 ('good') in 2013-22 with the ratio of 'excellent' AFV days remaining unchanged.

**Table 1. HCI during Cherry Blossom Viewing and Autumn Foliage Viewing (1976-2023)**

| | 1976-2000 | | 2001-2023 | | Last 10 Years | |
|---|---|---|---|---|---|---|
| Viewing Period | HCI | Ratio of Excellent Days* | HCI | Ratio of Excellent days* | HCI | Ratio of Excellent days* |
| ***Cherry Blossom*** (3/26~4/15; 3/21~4/10) | 67 (good) | 27% | 70 (very good) | 30% | 71 (very good) | 37% |
| ***Autumn Foliage*** (11/16~12/05; 11/21~12/10) | 71 (very good) | 23% | 69 (good) | 21% | 69 (good) | 22% |

*Holiday Climate Index (HCI) >=80

Mann Kendall trend analysis indicates that, although the mean changes in HCI:urban are modest, both CBV (Z = 2.418, p = 0.016) and AFV (Z = -1.994, p = 0.046) are statistically significant. During the cherry blossom viewing period more favorable conditions are driven by the increase in maximum air temperature (Z = 2.444, p = 0.015), and the incidence of dry days (<1mm/day) (Z = 1.661, p = 0.097), while less favorable conditions during the autumn foliage viewing period are associated with a *fall* in the incidence of dry days (Z = -2.952, p = 0.003), an increase in the number of wet days (>6mm/day) (Z =2.148, p = 0.032) and increased cloudiness (Z = 2.384, p = 0.017).

## IMPLICATIONS or CONCLUSION

As climate change advances we can expect the climate suitability of destinations will change both temporally and spatially (Scott et al., 2019). According to the findings of this research the suitability of the tourism climate during the cherry blossom viewing period is improving, but during the autumn foliage viewing it appears to be in decline. At the same time the appearance and longevity of the flora-based resource is changing over time. This complex situation can present challenges and opportunities for destinations and events with climate-dependent tourism resources and supports the notion that tourists and tourism stakeholders are on the “front line of climate change” (Broadbent and Lantto, 2009).

One implication of the change in favorability of the tourism climate is the imperative to continue and expand monitoring of the flora and the wider tourism climate. In addition to the dates of full blossoming (CBV) and coloration (AFV) the expected dates of blossom fall and leaf color quality are key metrics for the tourist experience of both events. Moreover, although public messaging of flowering /coloration dates is well-developed for Japan’s domestic market (Primack et al., 2009) it seems less so for its international one. In 2023 the JNTO platform held images of cherry blossoms on its April page rather than March and autumn foliage in October rather than November (JNTO, 2023). These anachronistic representations of CBV and AFV contradict the findings made here, and could misinform visitors planning visits to Tokyo.

A second consequence of changing tourism climate is on tourism flows and destination facilities. Although better tourism climate conditions during CBV may encourage more visitors this has the risk of giving rise to problems associated with overtourism or destination fatigue. While improved tourist flow management may offer locations a temporary solution, with more than 50 sites to view cherry blossom in Tokyo informed marketing that can nudge visitors to less visited locations is recommended. During autumn, despite the longer leaf coloration period, the increased incidence of wet days is a significant challenge to autumn foliage viewing. Enhancing or repurposing in-door visitor center facilities that can provide an alternative autumn foliage experience should be considered to counter this threat. Finally, the temporal creep of the AFV period into December should be seen as an opportunity for Tokyo to develop a new market niche. Underpinning these ideas is the implicit need for the strategic integration of tourism climate and climate-dependent events into urban planning.

It is hoped the current study can make a contribution to understanding the changing climate during the cherry blossom and autumn foliage viewing periods. Both events are invaluable to Tokyo's tourism profile as it seeks to re-establish itself as one of the world's most visited capitals. The current research is limited in that it only considers tourism climate and the resource in one city and does not assess tourist demand. In future, tourism climate research focusing on other climate-dependent events (such as Sapporo's Snow Festival) and ideally with a demand/climate agenda is highly desirable as a means to better understand the complex and dynamic relationship between tourism, tourism climate, and climate change.

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