A historical approach to understanding governance of extreme urban heat in Fukuoka, Japan

ABSTRACT

The paper analyses content of scientific journals produced by the not-for-profit Kyushu Environmental Evaluation Association in Fukuoka since the 1970s. The aim is to evaluate the shifting understanding and conception of a liveable urban environment within Fukuoka over time, and assesses how this narrative has informed capability to understand and manage extreme heat as an emergent disaster risk.

The purpose of the paper is to contribute to emergent understandings in research into urban climate change-related disasters (such as extreme heat), which recognise that present-day actions or failures of cities to address climate risk are rooted in a historical context.

The strong technical competences enabling Fukuoka to undertake evidence-based management of risks from climate-related disasters today exist at least partially because of earlier environmental concerns within the city, and an early emergence of techno-scientific competence within the city's research institutions working at the science-policy interface. The findings suggest a need to avoid uncritically exporting 'lessons' from apparent urban climate 'success stories' like Fukuoka in Asia or elsewhere, without full recognition of the historical context enabling production and utilisation of weather and climate knowledge in specific locations.

KEYWORDS: climate change adaptation; Fukuoka; Japan; urban heat; urban thermal environment.

1. Introduction

This paper evaluates the contribution of environmental history approaches in understanding contemporary management of climate change-related disasters, through the case of Fukuoka in southwestern Japan. This is attained by looking in particular at how a historical approach helps to make sense of how Fukuoka has come to have relative expertise within Japan – among the city's research community if not in practice – of managing extreme heat via greenspace and the built environment. The risk to human health and life from heatwaves is gathering increased attention, as seen in the engagement of the 2019 *The Lancet Countdown on Health and Climate Change* with climate change-related heat risks (Watts et al, 2019) and the exploration of urban heat risks within the Intergovernmental Panel on Climate Change's Cities and Climate Change stream (Prieur-Richard et al, 2018). Within Asian cities, the hotter and more humid climate and denser urban form has led to particular interest in the need to manage the risks of heat to the population (e.g. Boeckmann, 2016; Song et al, 2017). It is hence fair to say that under conditions of climate change, heatwaves and extreme heat in general constitute a significant and emerging disaster risk.

Configuring the built environment in response to climate and extreme weather is of course not a new idea, nor is it unique to Fukuoka. Even before more recent formalised ideas of urban climatological planning (Hebbert and McKillop, 2013), designing buildings and greenery to maximise cooling has long been understood, especially in the Asian tropics (e.g. Chee et al, 2011; Tan and Abdul Hamid, 2014). Yet despite the more recent global turn towards the urban as a scale and site for climate change responses (Rosenzweig et al, 2011; Parnell, 2016) and the early interest of Japanese cities in urban climatological planning (Hebbert, 2014), national-level mandates for climate adaptation in Japan have been criticised for being vague and limited in prescriptiveness (Hijioka et al, 2016). There are, however, cases where municipalities in Japan have developed more comprehensive plans for climate action than national government (Kameyama, 2016; Baba et al, 2017). Fukuoka City is one such example, making good progress at municipal level in preparing for and responding to climate change, including building of a strong techno-scientific evidence base for urban environment and climate (Mabon et al, 2019ab). The question is therefore how it can come to be that some locations – such as Fukuoka – can, within a comparatively wealthy, well-resourced and 'policy-driven' country, come to have the knowledges and competences to manage climate risk; and how can historical-type approaches help us to theorise and understand local present-day approaches to disaster prevention and management?

Academically, this paper speaks to growing awareness of how local historical context can shape vulnerability to heat and wider climate risk in the present day. Hoffman et al (2020) show how practices of 'redlining' in the early 20th Century – whereby neighbourhoods were denied access to mortgage lending on the basis at least partially of the racial makeup of the neighbourhood – continues to affect

presence of urban greenspace and thus exposure to intra-urban heat well into the 21st Century. In the South African context, Venter et al (2020) likewise illustrate how access to ecosystem services such as heat island mitigation remain divided along lines of poverty and ethnicity, a legacy of the Apartheid era. Conversely, Hebbert (2014) illustrates how the German city of Stuttgart – regarded as a pioneer and exemplar in urban climatological planning – originally came to develop knowledge of air flows within the city due to a need to manage air pollution in the 1930s, before later applying this knowledge to identifying cold air drainage areas. Newman (2014) similarly situates Singapore's efforts to reduce the urban heat island effect via the preservation of regional natural systems within a much longer vision of the city state as a 'garden city.'

Despite their diversity, common to these examples is a recognition that the success or failure of cities to protect residents from urban heat may be rooted in historical contextual factors. This paper makes a contribution to this body of scholarship, and to the wider policy and practice research on heat hazard as a disaster planning and management issue, by assessing the evolution of urban climate knowledge and its deployment in Fukuoka City, Japan, since the early 1980s. The study presented here builds on an existing body of research into Fukuoka's engagement with climate change adaptation, greenspace and the built environment. This research has touched on the role of epistemic communities in shaping local urban and environmental policy (Mabon et al, 2019a); the policy landscape and practical actions which have been undertaken within Fukuoka to facilitate climate change adaptation (Mabon et al, 2019b); public engagement and communication on climate change within Fukuoka (Mabon, 2020); and the work that boundary concepts have done in developing consensus between academics and policymakers for greening actions in the city (Mabon, forthcoming). What is new and distinct about this contribution is that it focuses on the environmental history elements of this work, and reflects on the value of historical approaches in understanding current-day adaptation to weather extremes in Asia and beyond.

2. Context and background

Figure 1: Location of Fukuoka City within Kyushu (adapted from map tiles by Stamen Design, under CC BY 3.0. Data by CartoDB and OpenStreetMap, under ODbL)

2.1. Geography and environmental history

Fukuoka is the largest city on the southern island of Kyushu, Japan. Approximately 1.5 million people live within the Fukuoka City municipal area as of April 2018 (Fukuoka City Statistics, 2018). The larger Fukuoka Prefecture has a population of approximately 5 million people, around 2.5 million of whom are in the urbanised areas of Fukuoka and Kitakyushu (Fukuoka Prefecture, 2018). The city has a subtropical climate and is located on the Sea of Japan (see Figure 1). For 2018 data, Fukuoka recorded

a mean daily maximum temperature of 34.5 degrees Celsius in August, the peak of summer (JMA, 2020).

The key climate risks identified by Fukuoka City requiring adaptation action are flooding from increased extreme rainfall and health risks from increased urban heat; plus drought risk, biodiversity loss, and threats to agricultural produce (Fukuoka City, 2016). As an illustration of the risks that heat posts to Fukuoka, 653 hospitalisations were attributed to heatstroke in 2019 within Fukuoka City, compared to 353 people in 2015 and 458 in 2016 (http://heatstroke.city.fukuoka.lg.jp/, accessed 29/07/2020). Dangers from heatstroke associated with mask-wearing and avoidance of crowded areas have also been identified by Fukuoka City Government as a notable risk-multiplier in summer in the context of the COVID-19 pandemic (*ibid*).

2.2. Institutions and policies

Table 1: key institutions supporting governance of urban climate in Fukuoka

Institution	**Sector**	**Key actions and contributions**
Fukuoka City Government	Municipal government	-sets tangible actions influencing urban thermal environment via urban planning, climate adaptation policy, and greenspace policies; -receptor of research expertise via expert committees; -commissioning of research (via national government funding) into heat island effect in central Fukuoka
Fukuoka Prefectural Government	Regional government	-provision of climate change adaptation policy for the wider Fukuoka region (including rural areas); -influence over urban climate via management of forests, rivers etc at landscape scale; -receptor of research expertise via expert committees.
Kyushu University	Academia	-undertake academic research on urban thermal environment in Fukuoka, through Department of Energy and Environmental Engineering; Department of Environmental Design; -engagement with urban and regional climate and built environment policy via participation in municipal and regional expert committees.
Kyushu Institute of Design	Academia (now part of	-early contributions to local scholarship on urban greening and the local climate through textbook (Nitta et al, 1981).

	Kyushu University)	
Fukuoka University	Academia	-leadership on early research into land use and greenspace distribution in Fukuoka; -leadership of regional climate change planning.
Fukuoka District Meteorological Observatory	Governmental organisation	-provision of weather data/climate scenarios to inform local and regional adaptation planning, including downscaling of IPCC scenarios to regional level.
Kyushu Environmental Evaluation Association	Independent organisation	-production of environmental data (remote sensing observations) for municipal government research into urban heat; -synthesis of locally-produced research (or at least research of interest to local audience) via annual *Environmental Evaluation* journals; -boundary-spanning organisation linking academia (joint positions with Kyushu University); government (undertaking of government projects); industry (undertaking of environmental impact assessments); and the public (engagement via hosting FCCCA).
Fukuoka Center for Climate Change Actions	Independent organisation	-public and community engagement on adaptation behaviours.
Fukuoka Asian Urban Research Center	Independent organisation	-synthesis and analysis of data on issues pertaining to Fukuoka City, to feed into and support local policy-making; -sharing experiences and best practices from Fukuoka on urban development internationally.

Table 1 summarises the main institutions involved in the production of data, knowledge and polices supporting the governance of the urban climate in Fukuoka since the 1980s. Fukuoka City Government produced its first Local Climate Change Plan in 1994, which was updated in 2001 and again in 2006. The city's Climate Change Action Plan to integrate measures for climate response – titled the *Fukuoka Cool and Adapt Project* for short – was produced in 2016, with Fukuoka Prefecture also having a regional climate change plan since 2006. Underneath this, Fukuoka City was one of two Japanese cities – along with Tokyo – to undertake production of an urban climate atlas in 2003 (Ichinose et al, 2003),

and has considered the role of land use and urban greening in managing the urban climate within its greenspace plan, the most recent published version of which is the *Fukuoka City New Green Basic Plan* (Fukuoka City, 2009). Heat island mitigation through greenspace is also considered in the *New Generation Environmental City Vision* (Fukuoka City, 2013). Fukuoka District Meteorological Observatory in 2014 produced a report of predicted climate effects on the Kyushu and Yamaguchi area based on the IPCC's A1B emissions scenario (Fukuoka District Meteorological Observatory, 2014). Scholarly research and government/public engagement on climate change effects in Fukuoka has also been undertaken by a number of universities and research institutions within the city including Kyushu University, Fukuoka University, and the Kyushu Environmental Evaluation Association[1].

This paper takes as its focus the *Environmental Evaluation* series of scientific journals produced by the Kyushu Environmental Evaluation Association (KEEA). KEEA was established as the Kyushu Water Quality Analysis Research Institute in 1970, then renamed KEEA the following year. Since then, KEEA has engaged with a breadth of environmental issues relevant to Fukuoka and the wider Kyushu area, notably analysis of the urban thermal environment as part of government projects and leadership of public engagement across Fukuoka Prefecture via the Fukuoka Prefecture Committee on Climate Change Action. KEEA is an independent research organisation, funded through a combination of public (through undertaking government research projects) and private (through environmental impact assessment work) sources. What makes KEEA a valuable focal point for understanding the complex range of actors and knowledges around the urban climate in Fukuoka is that they can be thought of as a boundary-spanning organisation linking academia (via joint chairs/positions with Kyushu University and an advisory board with a strong academic presence); local and regional government (via government research projects); industry (through environmental assessment and urban planning licences); and the public (via their hosting of the Fukuoka Center for Climate Change Actions).

As part of their activities, KEEA publish annually the *Kankyo Kanri* (Environmental Evaluation) journal series, which evidences the work of KEEA researchers and also relevant research from other researchers in Fukuoka and on occasion Japan more widely. As illustrated in previous research (Mabon et al, 2019a), what makes these journals a valuable indication of the wider science-policy context in Fukuoka at the time is that: (a) KEEA has been heavily involved in climate change policy in Fukuoka through engagement with expert committees convened by the city government; (b) KEEA's researchers have been in regular collaboration with academics at other institutions in the city on issues of urban thermal environments; and (c) researchers from institutions across Fukuoka (such as Kyushu University, Fukuoka University, Kyushu Sangyo University) publish in *Environmental Evaluation*. The journals

[1] For a fuller overview of the policy landscape governing greenspace and climate adaptation in Fukuoka City, see Mabon et al (2019b)

hence yield insight to the issues deemed to be of importance to researchers and institutions involved in influencing greenspace and built environment within Fukuoka over time.

3. Sources and methods

As above, the core material consulted to construct the narrative in this paper was KEEA's *Environmental Evaluation* journals, which are publicly available online in Japanese at http://www.keea.or.jp/kankyokanri.html. All journals in the series (from 1972 to present) were reviewed, screening the contents pages for articles relevant to weather, climate, urban planning and greenspace. As this paper represents a single case study (Yin, 1984) with the primary aim of making a conceptual contribution to scholarship on the historical context around extreme urban heat, the primary interest is in understanding issues that were deemed to be of interest and concern at the science-policy-practice interface for heat in Fukuoka over time, rather than looking at how research produced in and about Fukuoka was received internationally. Accordingly, the outputs from a 'local' journal hosted by a boundary-spanning organisation such as KEEA were deemed valuable in understanding the evolution of applied research with the aspiration of shaping municipal environmental policy and practice over time.

To assess how the relationship between the scholarly research undertaken in Fukuoka and reported in *Environmental Evaluation* may filter through to current-day adaptation actions, the review of journal articles was supported with review of current and recent polices pertaining to greenspace and urban planning in Fukuoka, including the *Fukuoka City Climate Change Countermeasures Action Plan* (2016); *Fukuoka City Green Basic Plan* (1999) and *New Green Basic Plan* (2009); and *Fukuoka City New Generation Environmental City Vision* (2013). Relevant extracts were noted and translated, and used to develop a narrative and chronology of consideration of extreme weather, climate change and the planned environment in Fukuoka, which forms the basis of Section 4[2]. For wider context on additional research being undertaken on the urban climate in Fukuoka and by Fukuoka-based institutions across the same time period, the Japan Society for the Promotion of Science's KAKEN grants database was searched for relevant projects relating to urban heat, the thermal environment and urban planning. The author takes responsibility for all translations.

4. Narrating the evolution of a liveable urban climate in Fukuoka through the Kyushu Environmental Evaluation Association's annual reporting

[2] A further directed content analysis of the *Environmental Evaluation* papers was undertaken, and is reported in a separate study (Mabon et al, 2019a).

Figure 2: relations between key organisations producing and using knowledge relating to climate and extreme events (especially heat) in Fukuoka

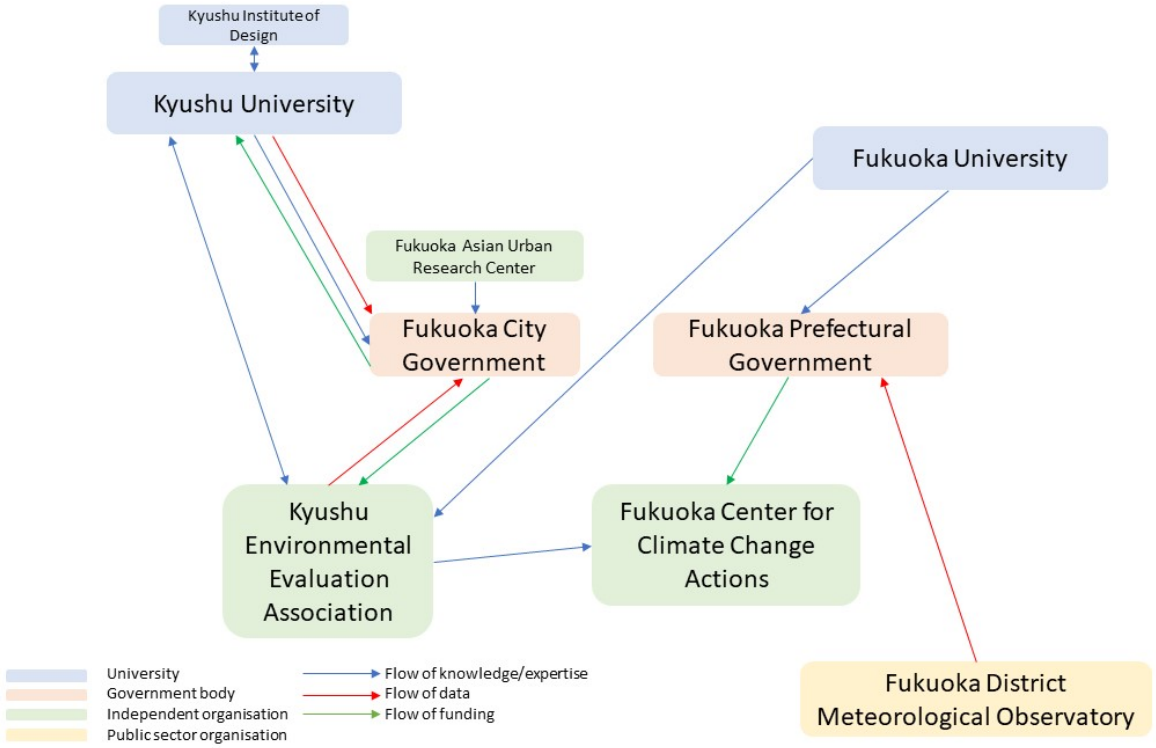

Table 2: summary of key *Environmental Evaluation* papers addressing the city's climate and relation to extreme events

Article title	**Year**	**Authors and institutions**	**Disciplinary background**	**Methods**	**Notable visuals and imagery**
Weather and Food in the 1980s	1981	Kyushu University Department of Agriculture	Agriculture, medicine	Synthesis of existing climate data / viewpoint.	Satellite image of weather for whole Japan on journal cover.
The City and a Liveable Environment	1985	Kyushu University Department of Engineering	Engineering	Environmental history / synthesis of existing practice.	
Around preparing a liveable urban environment: issues from law and policy	1988	Fukuoka University Faculty of Law	Law	Aerial photography to map land use change in Fukuoka.	
Global environmental protection and local action	1992	Fukuoka University Faculty of Law	Law	Policy review / viewpoint	

Thinking about urban planning in the style of environmental protection: balancing environment and development in the local area	1993	Kyushu University Department of Engineering	Environmental systems engineering	Citizen surveys assessing concern on key environmental issues.	Schematic of urban ecology.
Expansion of new urban development from the perspective of environmental issues	1995	Tohoku University of Art and Design	Architecture	Nationwide data on district heating and cooling; conceptual models on urban density.	Graphs of urban density versus ecological effects.
Environmental Observation and Observation Data Analysis Equipment	2007	Fukuoka Women's University	Applied chemistry	Review article / viewpoint.	
Assessing the ecosystem value of forests and watersides through a biosphere habitat model	2008	Kyushu Environmental Evaluation Association	Ecological engineering	Species analysis via spatial analysis and GIS; biological habitat modelling.	Visualisations of city-wide biological habitat model for Fukuoka.
Simultaneous observation of thermal environments in control open areas in the centre of Fukuoka City	2009	Kyushu Environmental Evaluation Association	Urban climatology	Assessment of urban thermal environment at building / neighbourhood scale via remote sensing.	Satellite image of neighbourhood greenspace in central Fukuoka.
Creating a multifaceted river with consideration for sediment control	2013	Kyushu Environmental Evaluation Association	Environmental engineering	Observation-based monitoring of species diversity and river characteristics.	
Fifth-generation environmental basic plan and the SDGs	2017	Fukuoka University Faculty of Law	Law	Policy review.	
An approach to local adaptation to	2017	National Institute for Environmental Studies, Center	Socio-environmental systems research;	Prefectural-level data on adaptation actions.	

the effects of climate change		for Climate Change Adaptation	integrated assessment modelling		

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200 Table 3: summary of projects relevant to the urban thermal environment involving researchers from
201 Fukuoka and using Fukuoka as a case study, recorded in the Japan Society for the Promotion of
202 Science's KAKEN Database

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Project title	**Year**	**Participating institutions/departments local to Fukuoka**	**Methods**
Environmental maintenance/improvement and land use system in cities and suburbs	1985-87	Fukuoka University, Law	Aerial photography and field surveys to assess land use change.
Comprehensive survey on the effects of water and green in the formation of urban thermal environment	1988-89	Kyushu University, Engineering; Fukuoka University, Engineering Kyushu Institute of Design, Design; Kyushu Sangyo University, Engineering.	Field observations of wind direction and surface temperatures at multiple points; predictive modelling of urban thermal environments.
Studies on quantitative effects of water surface and vegetation on urban thermal environment	1992-93	Kyushu University, Engineering; Kyushu Institute of Design, Design.	Remote sensing to assess land use and land cover; field measurements of surface temperature and cooling effects.
Design Approach for Sustainability in Urban Environment	1994-96	Kyushu Institute of Design, Design.	Field observation; review work.
Thermal effect of the greens on the urban living environment	1996-98	Kyushu Institute of Design, Design	Field observations of surface temperatures at multiple points.
For the reasonable arrangement of urban green spaces based on distribution and function of green spaces	1996-98	Kyushu University, Agriculture	Mapping of greenspace sufficiency.
Research on controlling the climatic environment for enhancing the comfort in urban living spaces	1999-2001	Kyushu Institute of Design, Design	Modelling of street blocks to estimate urban thermal environment; wind tunnel tests on models of street blocks; questionnaire surveys to assess residents' clothing choices year-round.
Basic research on green space maintenance that contributes to	2001-02	Kyushu Institute of Design, Design	Pedestrian surveys for frequency of visits and movement in different urban areas of Fukuoka; field

reducing the effect of ultraviolet B in outdoor living environment			measurements of presence of green features; field measurements of UVB radiation.
Research on Sea and Land Breezes Affecting to Urban Climate on Coastal Cities	2013-2017	Kyushu University, Design	LIDAR upper air observation; meso-scale meteorological modelling.

Tables 2 and 3 provide an overview of relevant research and knowledge in and/or relating to the urban thermal environment in Fukuoka from the start of the 1980s – when the first materials on climate change and urban heat relevant to Fukuoka appear in the reviewed materials - to present. Figure 2 visualises the flows of data, expertise and funding between institutions who have been involved in researching and governing the urban climate in Fukuoka over the study period.

4.1. Evolution of knowledge and policy

This first section sets present-day climate adaptation in Fukuoka in a larger context of scientific engagement with extreme weather and climate change within the *Environmental Evaluation* journals (see summary in Table 2). The first mention of changes in local weather patterns in Fukuoka, and of their possible connection to human activity, comes in a 1981 article titled *Weather and Food in the 1980s*, written by Kyushu University Department of Agriculture Professor Tsutomu Sakagami in the context of recent changes observed in the local environment and weather (Sakagami, 1981). Although human activity is only given as one likely cause of the weather patterns in Sakagami's synthesis of environmental data, the possible links between human activity, atmospheric change and local weather patterns are visible. It is also noticeable that human activity is mentioned in the context of a *changing* climate, not a *warming* one. In any case, by 1988 scholars based in Fukuoka had come to have a role in national-level research on the role of land use in maintaining environmental quality. Fukuoka University Professor Naohito Asano published an extensive review on the legal frameworks for creating a liveable urban environment (Asano, 1988: 15), the outcome of a Japan-wide project using satellite imagery to assess land use and distribution of green spaces across Japanese cities including Fukuoka (see Table 3).

Asano has had an important role in the evolution of urban climate change adaptation in Fukuoka City. He has served on the climate change adaptation plan development committees for both Fukuoka City and Fukuoka Prefecture (Fukuoka City, 2016; Fukuoka Prefecture, 2017), and alongside the work described above also engaged with legal action relating to Minamata Disease earlier in his career (Asano, 1992). It is noteworthy that Asano's academic career has been centered on Fukuoka, and that his specialisation is in environmental law. Urban environmental and latterly climate policy in Fukuoka has

thus been influenced, at least in part, by locally-situated expertise with a knowledge base located not only in the natural sciences, but also the legislative landscape around urban governance.

By 1993, understanding emerged of the specific demands required for undertaking urban planning in the age of climate change – seen in the writing of Hidefumi Imura (Kyushu University) in a piece titled *Thinking about urban planning in the style of environmental protection: balancing environment and development in the local area*. It is also around this time that *Environmental Evaluation* articles show more interest in the urban thermal environment. The contribution of Miura (1995) raises the potential of urban greening – specifically maintenance of a green network – to deliver multiple climate adaptation benefits including managing the thermal environment. The availability of such knowledge within Fukuoka City at this time – especially in the reporting of a key institution such as KEEA - tallies with Hebbert's (2014) observation that Fukuoka is among the Japanese cities to have engaged early with ideas of urban climatological planning; and reflects the breadth of national research projects involving Fukuoka-based researchers around this time (see Table 3).

Indeed, the knowledge base within Fukuoka for consideration of climate issues within the urban landscape further developed with Fukuoka being one of the first two Japanese cities (as well as Tokyo) to produce an urban climatological atlas focusing on climate functions and greenspace starting 1998 under the guidance of the Ministry of Land, Infrastructure and Transport (Ichinose, 2003). In 2003, Fukuoka City Government commissioned researchers from KEEA to undertake assessment of urban heat island effects within the city, data which was subsequently further nuanced with evaluation of cooling effects (Tanaka, 2009). The city has since made plans to trial cooling measures in the 'hot' areas of Tenjin and Hakata Station (Fukuoka City, 2009), with cooling forming part of the city's climate change adaptation strategy (Fukuoka City, 2016) and also its greenspace plan (Fukuoka City, 2009). Beyond cooling, knowledge of other environmental benefits from a city-wide green network such as biodiversity richness and its change over time (Ooi, 2008) have also been assessed within the city with a purpose of supporting policy decisions. Indeed, argumentation around evidence-based urban governance emerge even in KEEA's more natural science-focused outputs from the last decade, in the context of quantifying habitat change and heat island effects respectively (Ooi, 2008; Tanaka, 2009).

The above narrative, as well as Table 3, indicates that recent urban climate actions within Fukuoka are supported by a much longer understanding among environmental knowledge communities within the city of the role that the configuration of the built environment may play in resolving environmental issues and creating a liveable environment. Perhaps critically this encompasses not only natural science knowledge but also competence in understanding the planning and policy landscape. Moreover, it is perhaps also significant that this knowledge is produced almost entirely within Fukuoka itself. That is, whilst habitat mapping, urban heat island expertise and strategic land use are not in themselves unique

or outstanding to Fukuoka, it is notable that the competences to produce all of this 'evidence' can be found in the city through KEEA, Kyushu University, Fukuoka University and others. The shifting conception of urban and climate problems within Fukuoka is the subject of the next section.

4.2. Changing understanding of urban environment and climate problems

In accordance with the development of a knowledge base for urban climate action over time, it is also interesting to note how the way in which urban environmental problems are discussed has shifted in *Environmental Evaluation* articles over time. This gives us deeper insight into how and why in-depth knowledge of the urban environment emerged in Fukuoka. This section of the paper hence looks at how the conception and justification of action around the urban environment and response to climate problems shifts over time.

Given the environmental of northern Kyushu, which experienced water pollution incidents in Minamata from the 1950s onwards and air pollution issues in Kitakyushu shortly after, it is not surprising that an early focus of knowledge production is on monitoring of water and air quality (as per Section 2, KEEA themselves opened branch offices in Minamata City and Kitakyushu City in the 1970s). In his 1988 review, Asano too notes that environmental issues had thus far been considered largely through the lens of pollution, but that thinking in terms of a comfortable or liveable environment offers an alternative way to conceptualise outcomes of environmental policy at the local level (Asano, 1998). As discussed elsewhere (Mabon et al, 2019a; Mabon, forthcoming), the term *kaiteki kankyo* (comfortable or liveable environment[3]) and indeed the idea of comfort begins to emerge in *Environmental Evaluation* outputs around this time and also in broader scientific research carried out within Fukuoka. Comfort or liveability as a justification or end point for management of the urban green environment is raised in *Environmental Evaluation* in the context of amenity (Mitsuyoshi, 1985); environmental policymaking (Asano, 1988); and also aesthetic benefit and temperature control in a textbook written by Kyushu Institute of Design professors (Nitta et al, 1981).

The urban environment – especially green space and open space – thus reflects a turn towards an emerging conception of a 'liveable environment' as a response to pollution and the negative effects it has on citizens' daily lives. The broader landscape of funded KAKEN projects in Table 3 reflects this trend, with the emergence of projects in the early 1990s looking at the urban thermal environment and the potential implications for citizens' thermal comfort. For instance, the project 'Studies on quantitative effects of water surface and vegetation on urban thermal environment' led by researchers

[3] In related outputs, *kaiteki kankyou* has been translated varyingly as 'liveable environment' (Mabon et al, 2019a) or 'comfortable environment' (Mabon, forthcoming). In this paper, 'liveable environment' is used for consistency.

at Kyushu University's Faculty of Engineering assesses the potential cooling effects provided by green spaces within Fukuoka, employing not only field observations but also remote sensing techniques to assess land cover which project researchers themselves describe as novel and innovative.

Reflecting wider awareness within Japan and elsewhere of policy responses to environmental issues following the Rio Declaration and the establishment of the UN Framework Convention on Climate Change, the discourse in KEEA's reports on urban environmental matters in the 1990s shifts towards the balancing of environment and development imperatives and – indeed – urban planning in response to climate change. This is visible in both Imura's (1993) *Thinking about urban planning in the style of environmental protection: balancing environment and development in the local area* and Miura's (1995) *Expansion of new urban development from the perspective of environmental issues*. These two articles show the situating of the urban as the scale at which environment and climate problems are sensed (e.g. urban heat island effect as a manifestation of global environmental change) yet can also be resolved in Fukuoka. Also noticeable here is the acknowledgement – in Imura's mentioning of 'soft' systems – of awareness that urban climate governance in the Fukuoka context is a social issue as well as a techno-scientific one. Through to the 2000s, this evolves into a more specific and nuanced narrative on the relationship between humans, ecosystems and climate, with reference to discrete climate-related problems such as heat island effects and also to the heterogeneity of problems within the city (e.g. Takagi, 2007; Ooi, 2008; Tanaka, 2009).

Today, the appropriateness of urban-scale management of climate change responses is not novel (see, for instance, the IPCC's emerging interest in cities, and the New Urban Agenda adopted by UN Habitat III (e.g. Parnell, 2016)). In Fukuoka, however, the comparatively early awareness of issues around understanding and responding to urban climate may be considered the latest iteration of a much longer tradition of research into and governance of 'environmental problems' within the city. Such research is conducted both by academics in the city in the name of scientific research (see Tables 2 and 3) and also commissioned by the city and/or national governments and conducted by local researchers (see Table 1; Ichinose et al, 2003; Tanaka et al, 2009). The rationale for such scholarly activity shifts from pollution to environment and development through to urban climate in response to the local context. As discussed now, however, this has consistently been underpinned by notions of a 'liveable urban environment'.

4.3. Quality of daily urban living – the constant factor?

In spite of the evolving knowledge base and shifting rationales for governing the urban climate in Fukuoka, the quality of life at the local level emerges in *Environmental Evaluation* articles on the urban environemnt as a consistent factor. The motivation of undertaking environmental research and

knowledge-building in the public interest is narrated in KEEA's own organisational overview, particularly in response to Minamata Disease (KEEA, 2015a)

This public interest narrative can be seen from the earliest mentions of weather and climate in the KEEA archives. Even at a time when knowledge of climate change at the local level was still emerging, the value of 'green planning' to citizens' life quality was acknowledged (Sakagami, 1981; Mitsuyoshi, 1985). Two recurring phrases throughout the 1980s and 1990s are *kaiteki kankyou* (快適環境, liveable environment) and *machidukuri* (まちづくり, loosely translated as urban development), reflecting the idea that management of the urban environment (and increasingly climate) serves the direct purpose of maintaining quality of daily life for citizens. Open space and planning a green network comes to be portrayed as having a central role within this, both in scholarly outputs focusing on green and open space as amenity (Mitsuyoshi, 1985; Asano, 1988) and also a body of remote sensing-based observational; research published outside of *Environmental Evaluation* addressing the thermal comfort benefits provided by green spaces in Fukuoka (Katayama et al, 1990; Katayama et al, 1991).

By the mid-1990s and in articles also making reference to the Rio Declaration and UNFCCC development, the nature of urban development is still connected to quality of life, but has morphed further into something which is a prerequisite for quality urban living rather than an addition to it. Imura (1993) for example considers the idea of the urban environment reaching environmental 'capacity' (a generic idea rather than quantitative limits set for policy purposes) due to problems associated with air pollution, traffic, waste, water resources, greenery and others. There is here a move towards responding to a range of climate and environmental problems, and the associated planning/management of open space, as necessary to securing this 'liveable environment'. The urban environment – and especially greening and spatial planning – start to be discussed in the *Environmental Evaluation* outputs and the rationale of KAKEN-funded projects as a central means of resolving a range of environmental issues which underpin the quality of life, and not just a source of pleasure and aesthetic quality. As raised in Section 4.1., Miura's 1995 contribution *Expansion of new urban development from the perspective of environmental issues* goes on to refer to German climatological planning, and by the time of Fukuoka City's Greenspace Plan in 2009 explicit mention of the need to construct and preserve wind corridors is made (Fukuoka City, 2009). In other words, addressing climate and environmental issues becomes inseparable from working to maintain the key motivating factor of *kaiteki kanyou*.

Even with the more specific focus on monitoring environmental issues *within* the city in the 2000s, issues such as ecosystem health and biodiversity become drawn into the quality of urban life, as outlined in Section 4.1. Indeed, a sustained focus on local environmental quality – and research for the benefit of people at the local level - remains central to KEEA's own management philosophy (KEEA, 2015b).

Research aimed at understanding the localised effects of climate change not only fits with the knowledge systems established to address air and water pollution issues in the 1970s and 1980s, but also ties in well with an overarching research objective of sustaining living quality for the residents of Fukuoka and Kyushu and with a possible shared normative believe held by the community of researchers working on green space and the thermal environment in Fukuoka (Mabon et al, 2019a). Placing current day adaptation actions within the context of a longer narrative encompassing not only specific planning and research actions, but also the underlying justifications and motivations for these actions, hence gives us clues as to why the current-day interest in managing extremes in the urban environment in Fukuoka may have arisen.

5. Discussion and conclusions

Let us return to the idea of extreme heat as an increasing disaster risk in cities under the thread of climate change. In a Japanese context, Hijioka et al (2016) and Hijioka (2017) argue that Japan's long history of managing and planning for disasters such as earthquakes, tsunamis and typhoons mean the country's municipalities are perhaps well prepared to address new disaster risks associated with climate change. It should thus perhaps not be surprising that Fukuoka, as a relatively large and well-resourced city within Japan, has been able to draw on existing expertises and policies to work towards evidence-driven management of risks (particularly heat) associated with a changing urban climate.

However, the narrative presented in this paper suggests that the way in which Fukuoka City has been able access to the knowledges and competences to understand and manage the urban climate in the recent present is no accident, nor is it simply the result of a general awareness of natural hazards across Japan in general. Existing scholarship recognises that the production, interpretation and utilisation of 'scientific' knowledge and evidence for the mitigation of extreme heat hazards in cities is itself a social and political process (e.g. Corburn, 2009; Hebbert and McKillop, 2013). There is broadening interest in the socio-political dimensions of evidence-driven policy for climate in cities (e.g. Hughes and Romero-Lankao, 2014; Acuto et al, 2019). A previous strand of Fukuoka-specific research has looked at how an epistemic community of locally-situated scholars has worked to shape ideas of what constitutes appropriate evidence for managing the city's urban thermal environment (Mabon et al, 2019a). Based on the findings presented in Section 4, however, it is worth reflecting more specifically on the value of historical approaches to extreme events such as heat, which have the potential to become disasters, within urban climate adaptation.

Fukuoka illustrates that the success of urban climate governance actions based on techno-scientific knowledge in the present may be a result of social, political and cultural circumstances in the past. These observations match with the way in which present-day heat mitigation activities in Stuttgart

(Hebbert, 2014) and Singapore (Newman, 2014) may have their roots in historical efforts to understand and create a comfortable urban thermal environment. Recent years have seen a groundswell of networking initiatives designed at sharing best practices for managing climate-related risks in cities, such as the IPCC's Cities and Climate Change Science stream (Bai et al, 2018), C40 Cities, 100 Resilient Cities and the Asian Cities Climate Change Resilience Network; and a similar number of research networks working across topics and case studies such as the Urban Climate Change Research Network (the fact Fukuoka features very rarely in these is itself a topic that warrants separate further investigation). Yet sharing 'best science' and 'best practice' may be of limited value if one does not understand the social, cultural and historical context that has allowed practices relating to climate and weather knowledge to emerge in some locations but not others. Fukuoka scientists - no less robust and evidence-driven than the international colleagues with whom they networked – may have been trusted because they addressed immediate local issues. In among the calls for greater involvement of the social sciences and humanities in the urban climate research agenda (e.g. Chan et al, 2018), the Fukuoka case indicates there may be an important yet underappreciated role for environmental history-type research in explaining and understanding what is possible in the present and near future and why when it comes to the management of extreme climate-related events at the local level.

Lastly, it is important to note that what we have here is only one narrative of responding to heat risks within Fukuoka. Whilst KEEA is an independent organisation directed at undertaking applied science in the public interest, the construction of knowledge and interpretation of how it benefits society reported here comes from a largely 'expert' natural science (and also male) perspective. Societal engagement rarely appears in *Environmental Evaluation* until the last 20 years, and even then very much in the context of information provision or on surveying public opinion on pre-determined courses of action. Missing from this is the role of citizens, especially women, in demands for and undertaking of environmental data collection (Fujikura, 2001); and also the narratives of how technical actions for urban climate adaptation such as growth of green curtains (Fukuoka City, 2016) are put into practice 'on the ground.' Even in a very well-resourced, highly developed and seemingly equitable urban context such as Fukuoka, a broader range of narratives may be required in order to assess whether the very advanced climate science and policy actions aimed at reducing climate-related disaster risk can truly be considered 'effective' in delivering benefit to urban living.

REFERENCES

Acuto M et al (2018) *Science and the Future of Cities: Report on the global state of the urban science-policy interface* Report of the International Expert Panel on Science and the Future of Cities: London and Melbourne.

Asano N (1988) 'Around preparing a comfortable urban environment: issues from law and policy' Environmental Evaluation 17: 14-26. http://www.keea.or.jp/pdf/keea_kankyou_17.pdf

Baba K, Matsuura M, Kudo T, Watanabe S, Kawakubo S, Chujo A, Tanaka H and Tanaka K (2017) 'Climate change adaptation strategies of local governments in Japan' in *Oxford Research Encyclopaedia, Climate Science* Oxford University Press: Oxford DOI: 10.1093/acrefore/9780190228620.013.597

Bai X, Dawson RJ, Urge-Vorsatz D, Delgado GC, Barau AS, Dhakal S, Dodman D, Leonardsen L, Masson-Delmotte V, Roberts D and Schulz S (2018) Six research priorities for cities and climate change *Nature* 555, 23-25.

Boeckmann, M. (2016). Exploring the health context: A qualitative study of local heat and climate change adaptation in Japan. *Geoforum*, Vol. 73, pp. 1–5.

Chan S, Gordon D, Lecavalier E, Johnson C, Hsu A, Stehle F, Hickmann T, Bansard J and Romero-Lankao P (2018) 'A Global Response to Climate Change: In, through, and for Cities?' http://duckofminerva.com/2018/04/a-global-response-to-climate-change-in-through-and-for-cities.html

Chee L, Chang J-H, with Wong BCT (2011) Introduction –'Tropicality-in-motion': Situating tropical architecture. *Singapore Journal of Tropical Geography* 32 (3), 277-282.

Corburn, J. (2009). Cities, Climate Change and Urban Heat Island Mitigation: Localising Global Environmental Science. *Urban Studies*, *46*(2), 413–427.

Fujikura R (2001) 'A Non-confrontational Approach to Socially Responsible Air Pollution Control: The electoral experience of Kitakyushu' *Local Environment* 6(4): 469-482.

Fukuoka City (2009) *New Green Basic Plan* Fukuoka City Government: Fukuoka.

Fukuoka City (2013) *New Generation Environmental City Vision* (in Japanese) Fukuoka City Government: Fukuoka.

Fukuoka City (2016) *Fukuoka Cool and Adapt Project: Fukuoka City Climate Change Countermeasures Action Plan* Fukuoka City Government: Fukuoka.

Fukuoka City (2018) *Fukuoka City Statistical Information* Fukuoka City Government: Fukuoka http://www.city.fukuoka.lg.jp/shisei/toukei/

Fukuoka District Meteorological Observatory (2014) *Information on climate change predictions for Kyushu and Yamaguchi Prefecture*. Fukuoka District Meteorological Observatory: Fukuoka.

Fukuoka Prefecture (2017) *Fukuoka Prefecture Climate Change Countermeasures Action Plan* Fukuoka Prefectural Government: Fukuoka.

Fukuoka Prefecture (2018) *Fukuoka Prefecture Open Data Site* Fukuoka Prefectural Government: Fukuoka https://www.open-governmentdata.org/fukuoka-pref/

Hebbert M and McKilliop F (2013) 'Applied climatology in urban planning: a knowledge circulation failure' *International Journal of Urban and Regional Research* 37 (5):

Hebbert M (2014) 'Climatology for city planning in historical perspective' *Urban Climate* 10(2): 204-215.

Hijioka, Yasuaki, Takano, S., Oka, K., Yoshikawa, M., Ichihashi, A., Baba, K., & Ishiwatari, S. (2016). Potential of existing policies of the Tokyo Metropolitan Government for implementing adaptation to climate change. Regional Environmental Change, 16(4), 967–978. https://doi.org/10.1007/s10113-015-0809-y

Hijioka Y (2017) 'An approach to local adaptation to the effects of climate change' Environmental Evaluation 46: 19-25. http://www.keea.or.jp/pdf/keea_kankyou_46.pdf

Hoffman, J. S., Shandas, V., & Pendleton, N. (2020). The Effects of Historical Housing Policies on Resident Exposure to Intra-Urban Heat: A Study of 108 US Urban Areas. *Climate*, *8*(1), 12. https://doi.org/10.3390/cli8010012

Hughes S and Romero-Lankao P (2014) 'Science and institution building in urban climate change policymaking' Environmental Politics 23(6): 1023-1042.

Ichinose T, Mikami T, Niitsu K and Okada N (2003) *Counteractions for Urban Heat Island in Regional Autonomies Activities in Councils of MoE, Japan* Ministry of Environment: Japan DOI: 10.11298/taiki1995.37.6_A71

Imura H (1993) 'Thinking about urban planning in the style of environmental protection: balancing environment and development in the local area' Environmental Evaluation 22: 77-86. http://www.keea.or.jp/pdf/keea_kankyou_22.pdf

Japan Meteorological Agency (2020) 'Monthly mean air temperature (°C): Fukuoka' https://www.data.jma.go.jp/obd/stats/etrn/view/monthly_s3_en.php?block_no=47807&view=1, accessed 28/07/2020.

Katayama T, Ishii A, Tsustumi J, Nishida M, Hayashi T, Shiotsuki Y, Kitayama H and Takayama K (1990) 'Field observation of thermal environment around a park with a water surface' Engineering Sciences Reports; Kyushu University 11: 403-412.

Katayama T, Hayashi T, Shiotsuki Y, Kitayama T, Ishii A, Nishida M, Tsutumi J and Oguro M (1991) 'Cooling Effects of a River and Sea Breeze on the Thermal Environment in a Built-up Area' Energy and Buildings 15-16: 973-978.

KEEA (2011) *Environmental Evaluation 40: 40th Anniversary Commemorative Issue* KEEA: Fukuoka.

KEEA (2015a) *Overview of KEEA* http://keea.or.jp/outline.html

KEEA (2015b) 'Management philosophy' KEEA: Fukuoka http://www.keea.or.jp/aboutus.html

Mabon, L, Shih, W-Y, Kondo, K, Kanekiyo, H, and Hayabuchi, Y (2019) 'What is the role of epistemic communities in shaping local environmental policy? Managing environmental change through planning and greenspace in Fukuoka City, Japan' Geoforum DOI: 10.1016/j.geoforum.2019.04.024

Mabon L, Kondo K, Kanekiyo H, Hayabuchi Y and Yamaguchi A (2019) Fukuoka: Adapting to climate change through urban green space and the built environment?' Cities DOI 10.1016/j.cities.2019.05.007;

Mabon, L (2020) 'Making climate information services accessible to communities: what can we learn from environmental risk communication research?' Urban Climate DOI: 10.1016/j.uclim.2019.100537

Mabon, L (forthcoming) '*Kaiteki Kankyo:* a comfortable environment as a boundary concept driving greenspace policy in Fukuoka City?' in Miyauchi T and Fukunaga M *Title TBC* Springer Japan: Tokyo.

Mitsuyoshi K (1985) 'The City and a Liveable Environment' Environmental Evaluation 14: 2-9. http://www.keea.or.jp/pdf/keea_kankyou_14.pdf

Miura H (1995) 'Expansion of new urban development from the perspective of environmental issues' Environmental Evaluation 24: 31-37. http://www.keea.or.jp/pdf/keea_kankyou_24.pdf

Newman, P. (2014). Biophilic urbanism: a case study on Singapore. *Australian Planner*, *51*(1), 47–65.

Nitta S, Azuma S and Ishii A (1981) Design of micro-weather in urban greening (in Japanese) Kajima: Tokyo.

Parnell S (2016) 'Defining a Global Urban Development Agenda' *World Development* 78: 529-540.

Ooi K (2008) 'Assessing the ecosystem value of forests and watersides through a biosphere habitat model' Environmental Evaluation 35: 31-36. http://www.keea.or.jp/pdf/keea_kankyou_37.pdf

Prieur-Richard, A.-H., Walsh, B., Craig, M., Melamed, M. L., Colbert, L., Pathak, M., … Ürge-Vorsatz, D. (2018). *Extended version: Global Research and Action Agenda on Cities and Climate Change Science*. Montreal

574 Rosenzweig C, Solecki WD, Hammer SA and Mehrotra S (2011) *Climate Change and Cities: First Assessment*
575 *Report of the Urban Climate Change Research Network*. Cambridge University Press: Cambridge.
576
577 Sakagami T (1981) 'Weather and Food in the 1980s' Environmental Evaluation 10: 47-51.
578 http://www.keea.or.jp/pdf/keea_kankyou_10.pdf
579
580 Song, X. P., Richards, D., Edwards, P., & Tan, P. Y. (2017). Benefits of trees in tropical cities. *Science*, *356*(6344),
581 124
582
583 Svancara, L., Brannon, R., Scott, M., Groves, C., Noss, R., & Pressey, R. (2005). Policy-driven versus evidence-
584 based conservation: A review of political targets and biological needs. *BioScience* 55(11), 989–995.
585
586 Sugiyama, N., and Takeuchi, T. (2008). Local policies for climate change in Japan. *The Journal of Environment*
587 *and Development* 17, 424-441.
588
589 Takagi M (2007) 'Environmental Observation and Observation Data Analysis Equipment' Environmental
590 Evaluation 36: 1-2. http://www.keea.or.jp/pdf/keea_kankyou_36.pdf
591
592 Tan, P Y and A R B Abdul Hamid (2014), "Urban ecological research in Singapore and its relevance to the
593 advancement of urban ecology and sustainability", *Landscape and Urban Planning* Vol 125, pages 271–289.
594
595 Tanaka K (2009) 'Simultaneous observation of thermal environments in control open areas in the centre of
596 Fukuoka City' Environmental Evaluation 38: 31-36. http://www.keea.or.jp/pdf/keea_kankyou_38.pdf
597
598 Venter, Z. S., Shackleton, C. M., Van Staden, F., Selomane, O., & Masterson, V. A. (2020). Green Apartheid:
599 Urban green infrastructure remains unequally distributed across income and race geographies in South Africa.
600 *Landscape and Urban Planning*, *203*, 103889.
601
602 Watts, N., Amann, M., Arnell, N., Ayeb-Karlsson, S., Belesova, K., Boykoff, M., … Montgomery, H. (2019,
603 November 16). The 2019 report of The Lancet Countdown on health and climate change: ensuring that the health
604 of a child born today is not defined by a changing climate. The Lancet, Vol. 394, pp. 1836–1878.
605 https://doi.org/10.1016/S0140-6736(19)32596-6
606
607 Yin, R. (1984). *Case Study Research: Design and Methods*. Thousand Oaks, CA: SAGE Publications Ltd.