NIWA
Taihoro Nukurangi

Anticipating local weather and climate outcomes using Māori environmental indicators

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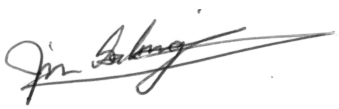

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Executive Summary

The ability to forecast local weather and climate is common among many indigenous peoples around the world. Through observing patterns and sequences in natural events - such as the behaviour of birds, the blooming of certain trees and flowers, and the movements of the stars - many indigenous peoples, including Māori, have relied on keeping a close eye on environmental indicators to help manage daily and seasonal activities linked with changes in local weather and climate conditions. This short report offers a preliminary examination of the use of Māori environmental indicators to forecast local weather and climate. The indicators identified were (and still remain) widely used by many Māori to monitor and plan activities that are sensitive to changes in weather and climate conditions. Learning about this knowledge provides an opportunity to understand what has helped Māori to cope and adapt to weather and climate variability in the past. It also provides clues on how to build resilience to weather and climate extremes (and related natural hazards), through greater awareness of the natural world and the inherent linkages between atmospheric and biophysical phenomena.

1. Introduction and background

When the first ancestors of Māori settled New Zealand they would have discovered a land that differed greatly from their former northern homes. They would have had to adjust to colder temperatures and different seasonal rhythms, to discover the resources of the country and the conditions it imposed upon them, and to invent new ways of acquiring clothing, tools and shelter. One of the most immediate challenges for the earliest Māori arrivals would have been to reduce their vulnerability by enhancing their ability to understand, monitor, plan for, and adapt to weather and climate variability and extremes. Subsequently, through interacting with local environments and processes over time, Māori learned and developed a detailed knowledge of biophysical processes and phenomena - including among other skills the forecasting of local weather and climate conditions. This short report documents some of the diverse indicators traditionally used by generations of Māori across New Zealand to anticipate weather and climate outcomes, and considers some of the benefits to be gained by learning (and applying) such knowledge. Before progressing, a brief review of international studies to have considered indigenous weather and climate knowledge forecasting is presented.

2. Indigenous weather and climate forecasting

A handful of international studies have explored the nature and character of indigenous weather and climate forecasting. Prominent among these is the early work of Kanani and Pastakia (2001). These authors examined indigenous meteorological beliefs and knowledge in Saurashtra (Northern India) and found that many indigenous groups across India predict the onset of the monsoon in June or July using environmental indicators such as the blooming of the golden shower tree and the direction of the local winds. One major outcome from this work was the establishment of the Ancient Rain Prediction Network (ARPN) where local experts and scientists come together to make predictions on the basis of collective assessment (using both local and scientific forecasts). These forecasts are used to make decisions about the monsoon and other climate related phenomena that affect cropping.

Shortly thereafter, Orlove et al, (2002) published their work ‘Ethnoclimatology in the Andes’ which examined from a scientific perspective the basis of traditional Andean rainfall forecasting. Farmers in Peru were found to use the mid-year appearance of the Pleiades star cluster to forecast the timing and quantity of precipitation in the wet season, months later. This knowledge of local climate also included comprehension of the timing and semi-regularity of El Niño events - which have only relatively recently been identified by the scientific community (circa 1900). Subsequently, the authors determined a seasonal forecast accuracy for rainfall of around 65% - a figure that

exceeded the accuracy of modern scientific forecasts with similar outlook periods by some 5-10%. Orlove et al (2002) concluded that the complementarities between 'modern and traditional' systems warrants further exploration – where learning and knowledge about the atmosphere could be shared by atmospheric scientists and indigenous people alike.

Climate researchers in Australia have also recently turned their attention to Aboriginal understanding of regional weather and climate patterns – including knowledge of biophysical phenomena that can reveal much about forthcoming weather and climate conditions (BoM, 2003). Coordinated by the Bureau of Meteorology, the 'Indigenous Weather Knowledge' project is focussed primarily on the indigenous knowledge held by Aboriginal groups in central and northern Australia. To date, the project has produced an online library that showcases Aboriginal interactions with, and knowledge of, local weather and climate change. The diversity of traditional environmental indicators documented illustrates understanding of complex linkages between biophysical phenomena and atmospheric changes. Although in its early stages, the website is expected to progressively expand to include information for additional Aboriginal groups and areas.

More recently, Lefale (2003) examined traditional Samoan knowledge of local weather and climate by interviewing extended family members across Samoa. His work detailed the Samoan seasonal calendar (which incidentally is based not on astronomy but rather the onset of weather and climate events); verified elaborate classification systems for local wind and clouds types (e.g. solid clouds, flying clouds, quiet clouds, beautiful clouds and clouds clinging to heaven, among others); and, reported various methods for monitoring and forecasting expected weather and climate conditions. Importantly, it was emphasised that knowledge of these different meteorological phenomena was critical to interpreting other environmental signs that when considered together could reveal the character of impending weather and climate conditions – including extremes such as tropical cyclones. Acute awareness of the inter-connections between atmospheric and biophysical phenomena led the author to conclude that Samoan culture possesses its own grounded techniques for observing, monitoring and predicting local weather and climate conditions which are crucially important for making decisions about climate-sensitive land and ocean-based activities. Lefale (2003) added that western scientific understanding of Samoan meteorology and climatology could well be improved by creating opportunities to integrate the different epistemologies. However, caution and respect were strongly recommended to those seeking to understand traditional practices and knowledge which are themselves embedded in culture, history, cosmogony, customs and language.

3. Traditional indicators used by Maori to forecast weather and climate

Although there are variations from place to place and between *iwi/hapu* [tribe/sub-tribe] across Aotearoa, the use of traditional 'indicators' or environmental 'signs' to forecast imminent local weather and climate conditions reflects the worldview that all things are connected by *whakapapa* [genealogy] and that subtle natural linkages in the environment can reveal much about atmospheric conditions. In the table below, a selection of environmental indicators used by Māori across New Zealand to forecast various aspects of weather and climate are presented. These indicators were sourced through preliminary interviews and land-walks with respected elders (often extended family members of the author team) as well as the review of written sources and historical ethnographies. While the indicators are context specific, many of the indicators are shared by different *iwi/hapu* in other locations. Some of these indicators are well-known and continue to be observed by different *iwi/hapu* and *whanau* [family] and others are less well-known.

Importantly, often more than one indicator is used to forecast for the day(s), month(s) or season(s) ahead. This can sometimes lead to discrepancies among the indicators and during these times a consensus-based approach is often taken. That is, if the majority of indicators point in a given direction then a forecast is made in that direction. This indigenous approach to weather and climate forecasting is not dissimilar to probabilistic seasonal forecasting methods that rely on the consensus among different computer models to forecast changes in climate.

Table 1: Selection of traditional Maori indicators to forecast weather

Name	Indicator	Expected Outcome	Iwi / Region
Ngā ngaru (Waves)	The deep sound of breaking waves up the valley	Approaching rainfall / inclement weather	Te Rōroa: NW North Island Pers. comm. Alex Nathan
Pakake (Sea kelp)	The furling and unfurling of hanging kelp	Approaching rainfall or storm	Ngāti Wai: NE North Island Pers. comm. Taukiri Thomason
Pukeko (Swamp hen)	Pukeko head for higher ground	Imminent storm and flooding	Ngāti Wai: NE North Island Pers. comm. Taukiri Thomason
Kaka (Native parrot)	Kakas begin acting up, twisting and squawking above the forest.	A storm is on its way.	Ngāti Pare: NE North Island Pers. comm. Te Hiringanuku Ngamane
Ruru (Morepork)	The shrill cries of more than one Ruru can be heard calling to each	Approaching rainfall and inclement weather.	Ngāti Pare: NE North Island Pers. comm. Te

	other at night.		Hiringanuku Ngamane
Tihirau (Cape Runaway)	The clouds in the sky above Tihirau.	Approaching rainfall or storm.	Te Whanau-a-Apanui: E North Island Pers. Comm. Wiremu Tawhai
Nga ngaru (Waves)	1. The booming sound of waves across the land. 2. The sound of waves hitting local rocks.	1. A storm is coming. 2. Rough or calm weather conditions are expected.	Te Whanau-a-Apanui: E North Island Pers. Comm. Wiremu Tawhai
Whakaari (White Island)	1. The plume lies left. 2. The plume is stretched intact across the horizon. 3. The plume flattens and the end breaks off.	1. Rainfall is expected. 2. Fair weather is expected. 3. Watch out extreme weather is expected.	Te Whanau-a-Apanui: E North Island Pers. Comm. Wiremu Tawhai
Ra (Sun)	A ring around the sun.	Bad weather is expected.	Te Whanau-a-Apanui: E North Island Pers. Comm. Wiremu Tawhai
Te Tatua o Te Kahu (A horizontal bank of clouds illuminated by the setting sun)	1. Te Tatua o Te Kahu is curved 2. The form of Te Tatua o Te Kahu is upright	1. Betokens bad weather 2. Betokens wind or bad weather	Ngai Tuhoe NE Central North Island Best, 1972
Kohoperoa (Long-tailed cuckoo)	The kohoperoa stops singing	The wind is about to blow from the south	Te Ati Awa: SW North Island Murdoch, 2001
Matuku (Bittern)	The continuing cry of the matuku as it moves around at night	Floods are likely	Ngāti Ruanui: SW North Island Murdoch, 2001
Rawaru (Blue Cod)	Stones in the belly of the rawaru	Bad weather is coming	Ngāti Koata: N South Island Personal Comm: Hori Elkington
Kōtuku (Heron)	The kōtuku are plentiful in summer	Gales and a heavy winter will follow	Ngāti Apa: N South Island Murdoch, 2001
Uenuku (Rainbow)	Appearance of the rainbow	Clear weather is expected	Kai Tahu: E South Island Beattie, J.H., 1990
Kapo (Lightning)	Lightning flickering above the horizon	The side the flashes are strongest indicates the direction from which the wind will come	Kai Tahu: E South Island Beattie, J.H., 1990
Marama (Moon)	1. A complete ring around the moon 2. A new moon lying on its back	1. A heavy fog 2. Rainfall; bad weather	Kai Tahu: E South Island Beattie, J.H., 1990
Patiti (Grass)	1. The grass is wet with dew 2. The grass is dry	1. A north-east wind is likely 2. A southerly wind is likely	Kai Tahu E South Island. Cormack and Orwin, 1997
Rā (Sun)	1. A vivid halo encircles the sun 2. A pale and dim halo encircles the sun	1. A storm is approaching 2. A storm is far way	Kai Tahu: E South Island Beattie, J.H., 1990
Ngā whetu (Stars)	In fine weather, if you go out and the stars are twinkling up north and not down south	A light northerly is likely the next day	Kai Tahu: E South Island Cormack and Orwin, 1997

Table 2: Selection of traditional Maori indicators to forecast climate

Name	Indicator	Expected Outcome	Iwi / Region
Koekoea (Long-tailed cuckoo)	The Koekoea returns.	Improved weather is on the way.	Ngāti Pare: NE North Island Pers. comm. Te Hiringanuku Ngamane
Kowhai	Beginning of flowering.	The 'kina' are fat and juicy – warmer weather has arrived.	Ngāti Pare: NE North Island Pers. comm. Te Hiringanuku Ngamane
Pipiwharauroa (Shining cuckoo)	The return of Pipiwharauroa.	The beginning of warmer weather (spring).	Ngāti Pare: NE North Island Pers. comm. Te Hiringanuku Ngamane
Puahou (Five Finger)	1. The lower branches blossom first 2. The top branches blossom first	1. 'Tau ruru' - A warm, bountiful season will follow 2. 'Tau matao' - A cold, unproductive season will follow	Ngāti Awa: N Central North Island Best, 1942
Poanganga (Clematis)	Periodic blooming	A warm season lies ahead with gentle breezes	Te Whanau-a-Apanui: E North Island Pers. Comm. Wiremu Tawhai
Marama (Moon)	In the first five nights of the lunar month: 1. The moon is lying on its back. 2. The moon is at an angle or straight up and down.	1. A month of spilling water is ahead. 2. A dry month lies ahead.	Te Whanau-a-Apanui: E North Island Pers. Comm. Wiremu Tawhai
Parearau (Jupiter)	The shimmer of Parearau is light and misty.	Wet conditions for the next month.	Te Whanau-a-Apanui: E North Island Pers. Comm. Wiremu Tawhai
Karaka	Heavy flowering	Drought	Ngai Tuhoe: NE Central North Island Best, 1925
Kowhai	Beginning of flowering	The beginning of more favourable weather (spring season)	Ngai Tuhoe: NE Central North Island Best, 1925
Kuaka (Godwit)	The return of Kuaka	The season of warming has begins	Ngai Tuhoe: NE Central North Island Best, 1925
Matariki (Pleiades)	1. The stars of Matariki appear wide apart 2. The stars of Matariki appear close together	1. Warmer temperatures and plentiful season ahead 2. Cooler temperatures and lean season ahead	Ngai Tuhoe: NE Central North Island Best, 1925
Matariki (Pleiades)	1. The stars in Matariki are indistinct, or 'quiver', when the group first	1. A sign of a cold, unproductive season to follow	Ngai Tuhoe NE Central North Island

	appears about June 2. Each star of the group stands out clear and distinct	2. A warm, prolific season will ensue"	Best, 1972
Tu-mata-kokiri (Meteors)	1. Tu-mata-kokiri flies downwards 2. Tu-mata-kokiri flies more horizontally through space	1. A windy season follows 2. A fine season ensues, with easterly winds, a prolific season	Ngai Tuhoe NE Central North Island Best, 1972
Riroriro (Grey Warbler)	1. If the side entrance of the nest faces north 2. If the side entrance of the nest faces south 3. If the entrance of the nest faces west 4. If the entrance of the nest is east-facing	1. The wind of spring blows from the south 2. The wind of spring blows from the north 3. A mild and fruitful season is expected, lulled by warm east wind 4. This indicates cold showers from the west	Ngai Tuhoe NE Central North Island Gordon, 1938
Whanui (Vega)	1. Whanui appears to move slowly 2. Whanui appears to move quickly, as if blown along by the wind	1. A fruitful season is at hand 2. A lean season is expected	Ngai Tuhoe: NE Central North Island Best, 1925
Pohutukawa	1. The tree flowers on the upper branches or the blossoming begins there and goes partially down 2. The tree starts to flower at the bottom and goes upwards in the ordinary manner	1. A 'tau –huka' or cold and winter-like season will follow 2. A 'tau-mahana' or warm and pleasant season lies ahead	Te Arawa: N Central North Island. Best, 1925
Pohutukawa	Early flowering	Long summer and drought	Ngāti Porou E North Island. Best, 1925
Kōtuku (Heron)	The kōtuku are plentiful in summer	Gales and a heavy winter will follow	Ngāti Apa: N South Island Murdoch, 2001
Atutahi (Canopus)	1. Atutahi is standing far apart from the milky way in about October 2. Atutahi twinkles brightly on one side, but is dim on the other	1. A dry summer will follow 2. The wind will blow hard from the bright side	Kai Tahu: E South Island Beattie, J.H., 1990
Riroriro (Grey Warbler)	1. The Riroriro builds high in the tree-tops 2. The Riroriro chooses to build a home low down among sheltering branches.	1. The mild warm winds of the west … would ensure a good summer 2. Cold southerlies expected - bad for the food crops	Kai Tahu: E South Island Gordon, 1938

4. Contributions to science and natural hazards management

From the preliminary selection of environmental indicators documented in the previous section it is evident that different *iwi/hapu* possess a diversity of traditional knowledge to forecast local weather and climate conditions. This diversity has developed in response to variations in bio-geography as well as the demands placed upon different *iwi/hapu* to understand different land and sea-scapes. Perhaps more importantly still, the requirement to develop such environmental knowledge was (and continues to be) fundamentally about managing risk or adverse/harmful outcomes linked with daily and/or seasonal changes in local weather and climate conditions. This point was frequently made by Te Whānau-ā-Apanui elder Wiremu Tawhai who explained not only how specific indicators should be interpreted but also the actions and activities that were/are so dependant. For instance:

> *"Along the beach from Omaio to Otuwhare where I live we can predict the weather by where the sound is coming along the beach - and the quality of the sound. The hollowness and quality of the sound could be used to predict rainfall within hours. And we know when to start to take wood inside because it's going to rain and we won't get anything dry - by listening to the sound moving along the coast".*

Similarly, he described how the volcanic plume of 'Whakaari' (White Island), which can be seen from the shoreline at Omaio some 27 km away, was used to determine a range of expectant weather conditions that when properly observed would keep *whanau* safe when sea-going:

> *"The thickness of the plume, its constancy, shape, angle and the side on which the plume lies all indicate the type of rain, wind direction and storm intensity that can be expected. When the plume flattens and the end breaks off – watch out. Under these conditions no one would go out on the water".*

From accounts such as these, it is evident that environmental indicators provide a range of benefits that contribute to the capacity of *iwi*/*hapu*/*whanau* to understand, monitor, plan for, and adapt to weather and climate extremes and related hazards. But how skillful or reliable are these predictive methods – particularly in view of increasing local recognition of more changeable weather and climate conditions; how widely are these indicators used today; and how might such environmental understanding benefit or contribute to science and the wider community?

While it is beyond the scope of this preliminary work to test the actual skill or hit-rates of the indicators, the subject of forecasting success was raised on a number of

occasions in interviews. In particular, some elders remarked directly upon the efficacy of some traditional indicators to provide reliable information on which to base forecasts of local weather and climate due to the increasing variability seen in local weather and climate conditions. Select accounts from Te Whanau-a-Apanui elders are provided below – including commentary from Mr Hori Elkington (Ngāti Koata) in his evidence to the Waitangi Tribunal:

> *"As I remember when we were growing up, this wind [hau-waho - northwest-wind off the sea] would blow at that time, day one, for example, and finish at that time. Day two, it would start 20 minutes or half an hour later and finish earlier. Day three it was shorter until on day seven it just puffed up and ended. That's how obvious it was. We don't get the same pattern now. Recently I said is that the hau-waho now starting? And then it suddenly changed direction and I thought no that's not the hau-waho". (Tawhai, W. 25/05/2005)*

> *"The trees are flowering much earlier now and they don't tell us what they used to". (Kemara, G. 25/05/2005)*

> *"There were several frosts a week in the old days. There are far less frosts now. Quick changes characterise the weather…and the ability to predict is reduced". (Tawhai, W. 25/05/2005)*

> *"When we were growing up our old people could tell three weeks in advance what the weather was going to be like, from the cycles of the moon and from the appearance of the moon and the sun. We [also] had other methods of knowing weather patterns. For example, when we gutted blue cod, if they had stones in their belly, we knew that bad weather was coming. The cod swallowed stones to give them ballast so that they would not be thrown around as much by the swell…We relied a lot upon reading the sky and reading other signs. I can still tell the weather using the old ways but with far less reliability. It was easier when we were growing up because the weather was far more settled than it is now…". (Elkington, 2003: 4-5)*

Importantly, it was recognised at the same time that the natural world can be unpredictable and consequently the use of environmental indicators to forecast weather and climate can sometimes result in conditions that are unexpected. As described in Section 3 this uncertainty is typically 'dealt with' by observing more than one indicator to make a forecast based on consensus across indicators. Without pursuing these testimonies further here, the authors consider that the continued use and transmission of traditional environmental indicators from one generation to another is about practicality and realising advantage, and that if the indicators failed to regularly perform they simply would not have endured.

Next, while there are no formal figures available on how widely environmental indicators are used today; preliminary discussions by the authors with key elders revealed that traditional environmental indicators are still used – albeit far less frequently than in the past. Our discussions revealed further that particular families and persons are now more likely to hold (and apply) such knowledge over others – particularly those Māori who have managed to maintain continued associations with specific places, communities and traditional ways of doing things. Modern living arrangements, cultural homogenisation and disrupted channels of oral communication (among other pressures) were regularly raised as challenges to the maintenance and transmission of such knowledge - leading often to the decline and/or eventual loss of such knowledge. In spite of these sentiments (and deep concerns in many cases), our discussions also showed that it is now common to read and listen to daily weather forecast information from print-media, radio and television, while simultaneously remaining aware of traditional environmental signs to enrich and provide location specific details on local weather and climate conditions.

Finally, a number of inter-disciplinary researchers have already pointed out that the intellectual processes upon which Māori knowledge is based are not unlike those used in scientific paradigms where knowledge is acquired based on observation, verification and application (Berkes, 1999; Hill and Coombes, 2004). This common-ground is now being increasingly promoted as a space to exchange knowledge and information that might contribute valuably to improved problem solving and decision making (Berkes, 1999; Orlove et al., 2002; Lefale, 2003). In line with these arguments, the authors of this short report – while remaining cognisant of distinct cultural scripts and biases that exist within Māori and scientific knowledge systems – similarly contend that there are a number of unrealised opportunities where the use of environmental indicators can contribute to not only the academy of science but also the wider community.

Some preliminary contributions are identified below to stimulate thinking and future work on these matters:

- Learning about and applying this knowledge can help to understand what has helped Māori to cope and adapt to weather and climate variability in the past.

- Learning about and applying this knowledge can enhance community awareness about environmental conditions that lead to extreme events and thereafter more informed decisions about weather and climate related risks.

- Learning about and applying this knowledge can help to detect changes taking place in the environment and can assist assessments of environmental change.

- Learning about and applying this knowledge might help to promote the drawing together of Māori and scientific knowledge systems as a way to improve and increase the accuracy of local weather and climate forecasts.

- Learning about and applying this knowledge can present us with valuable starting points to generate questions and therein better understand the nature of local environments.

- Learning about and applying this knowledge can promote awareness of the natural world and the inherent linkages between biophysical (includes people) and atmospheric phenomena.

5. Concluding remarks

The ability to forecast local weather and climate is common among many indigenous peoples around the world. Through observing patterns and sequences in natural events - such as the behaviour of birds, the blooming of certain trees and flowers, and the movements of the stars - many indigenous peoples, including Māori, have relied on keeping a close eye on environmental indicators to help manage daily and seasonal activities linked with changes in local weather and climate conditions. This short report has offered a preliminary examination of the use of Māori environmental indicators to forecast local weather and climate; as well as considered some of the benefits/contributions to be made to science and the wider community. Learning and promoting this environmental knowledge provides not only an opportunity to understand what has helped Māori to cope and adapt to weather and climate variability in the past; it also provides important clues on how to build resilience to weather and climate extremes (and related natural hazards) in the future, based on closer awareness of the natural world and the inherent linkages between atmospheric and biophysical phenomena.

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