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Coastal adaptation to climate variability and change: Examining community risk, vulnerability and endurance at Mitimiti, Hokianga, Aotearoa-New Zealand

D.N. King., W. Dalton., J. Bind., M.S. Srinivasan., D.M. Hicks., W. Iti., A. Skipper., M. Home., D. Ashford-Hosking.

For any information regarding this report please contact:

Darren Ngaru King
Māori Environmental Research Centre / National Climate Centre
darren.king@niwa.co.nz

National Institute of Water & Atmospheric Research Ltd
41 Market Place
Auckland Central 1010
New Zealand

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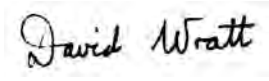
Dr Rob Bell

Programme Leader: Hazards and Risk, NIWA

Approved for release by:



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Dr David Wratt

Chief Scientist - Climate, NIWA

Approved for release by:

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Mr Henry Tahana

Chairperson, Mātihetihe Marae

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Mihimihi

Kua rongo te pō, kua rongo te ao, i te kōrero, i te wānanga, pūtakataka, pūāwhiowhio, he marama ahunuku, he marama ahurangi. He marama ka takoto i te hau o Tū. He marere kura, he marere pai. Tēnā te whaitua nui. Nei rā te mihi aroha ki a rātou kua mene atu ki te pō. Ko koutou ngā pou whakawairua i noho mai ki tō mātou nei taha. He maimai aroha tēnei ki a koutou, otirā, ki a Aterea Campbell kōrua ko Patrick Martin. Aue te mamae e.

E rere ana ā mātou mihi ki te whānau o Mitimiti i kaha tautoko i a mātou i roto i tēnei kaupapa rangahau. E mihi kau atu ana mātou ki ēnei tāngata i whai wāhi mai ki a mātou, i tuku mai anō i ā rātou kōrero me ō rātou wheako: Joe Adams, Aterea Campbell, Daniel Campbell, Lisa Campbell, Tunisia Campbell, William Campbell, Sally Cash, Steve Cash, Gerard Davey, Charlie Dunn, Aroha Harris, Andrew Kendall, Diane Kendall, Kura Kendall, Malcolm Kendall, Ani Leef, Charlotte Leef, Gemma Leef, Dixie Martin, Georgina Martin, John Martin, Peter Mingo Martin, Olive Martin, Patrick Martin, Chief Murray, Bob Newson, Spencer Penny, Lucy Ripia, Donald Ripia, Bob Stiles, Anne Te Wake, Karen Waiomio.

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Ko te nuinga o ngā pūtea tautoko i tēnei rangahau i ahu mai i Te Tūāpapa Toha Pūtea o Te Whare Wānanga o Wikitoria (Community Vulnerability and Resilience (Contract No. VICX0805) me te tautoko a te kaupapa rangahau o NIWA e kīia nei ko: Adaptation to Climate Variability and Change (Contract No. CO1X701).

Executive summary

Climate impacts, vulnerability and the capacity to respond and adapt are widely understood to be the result of complex relationships between human and biophysical systems. Yet, in spite of this understanding, few studies with specific populations and communities in Aotearoa/New Zealand have been carried out to appreciate the conditions that shape and determine community vulnerability and endurance (resilience) to climate risks and change. The work presented in this report explores some of these contextual (and legacy) conditions through a grounded analysis of climate change-induced coastal risks, vulnerability, endurance and adaptation facing the *hapū* of Te Tao Mauī from Mitimiti in the northern Hokianga, Aotearoa/New Zealand.

A step guide to conducting such work involved assessing the exposure, sensitivity and adaptive capacity of the community to present and future climate conditions and risks. Consideration was first given to how the community responds to direct and indirect climate stresses as well as those factors and processes that enable and constrain community choices and actions. Thereafter, downscaled projections of future global climate change were used to explore likely future climate-induced coastal impacts and risks - with specific attention given to sea-level rise and coupled stream flooding of the Mātihetihe Stream. The results from these mixed starting and end-point approaches were then integrated to identify options to eliminate and/or at least minimise vulnerabilities and to enhance the different skills and capacities across the community to cope with (and adapt to) future climate conditions and challenges.

In-depth semi-directive interviews were carried out between November 2011 and July 2013 with 31 participants who reside within, and/or have close involvement with, the community. During these group, paired and individual engagements, the interviewees shared their experiences of climate and coastal hazards at Mitimiti - including knowledge of coastal change, areas susceptible to flooding, and those 'things' or 'matters' that enable as well as obstruct *whānau* from effectively 'dealing with' climate related impacts, risks and stresses. Subsequently, analysis of how *whānau* and different *hapū* and *iwi* activities deal with, and/or are affected by, climate hazards and related socio-ecological changes, resulted in the identification of four key determinants that influence the sensitivity and adaptive capacity of the community to deal with climatic risks. These determinants comprise:

(i) Social-cultural networks and community change,

(ii) Resourcing, self-reliance and innovation,

(iii) Knowledge, skills and expertise,

(iv) Community structures and decision-making.

The importance of social-cultural networks and values held by the community were recognised as fundamental to being able to 'deal with' climate and coastal related hazards and risks at Mitimiti. Much of this capacity is rooted in the collective strength of *whānau* and *hapū* relationships, as well as more elemental cultural principles defined by *whakapapa* and *tikanga*, and thereafter actioned through practical values of *whanaungatanga, manākitanga, kotahitanga* and *aroha.* However, major changes in the composition of the community, in combination with low levels of economic development and the appearance of new values

and behaviours, were regularly identified as constraints to 'getting things done'. Notwithstanding these challenges, the importance of strengthening connections between the *ahi-kā* and non-resident *whānau* was emphasised, particularly in terms of realising *hapū* priorities and aspirations.

Limited employment opportunities' and associated resourcing constraints to adequately reduce risk and exposure to potential impacts dominated many conversations – particularly limited funds to upgrade and future-proof Mātihetihe Marae. Such constraints were recognised as making it harder for *whānau* to realise "healthier" living arrangements, and thereby were seen to exacerbate the sensitivity of different *whānau* to climate-related hazards and associated stresses when they arose. However, attributes of independence, self-reliance and innovation were also evident through the interviews. These included the importance of solutions that emerge from the *whānau* such as planning and being prepared, to more simply supplementing household supplies (and incomes) through fishing, hunting, and gardening. Together all these factors influence and shape everyday living for *whānau* at Mitimiti.

Māori knowledge and the maintenance of close relationships with the land and sea were acknowledged by a number of interviewees as crucial to understanding, and dealing with, local hazards and environmental risks at Mitimiti. However, rapid changes in community structure were commonly identified as having affected the transfer of *hapū*–specific knowledge. Examples typically ranged from the loss of understanding about the reasons behind traditional practices to interpreting environmental signals about local hazards and risks (among other forms of knowing). The importance of Mātihetihe School for engaging *rangatahi* was thereby regularly cited, including the challenge to finds ways to support traditional and non-traditional educational opportunities that allow young people to draw from more than one intellectual tradition to realise new knowledge and skills.

The roles and effectiveness of community structures to 'deal with' complex and integrated challenges such as climate change were also raised. Commonly, the *ahi-kā* as well as those *whānau* who live away from Mitimiti emphasised the importance of Mātihetihe Marae and Mātihetihe School in bringing the community together, identifying community relevant issues, and 'making things happen'. Such community arrangements were also recognised to provide formal governance structures for dialogue at the *hapū* and *iwi* level, as well as linkages with external organisations such as local and regional authorities. However, the diminishing numbers of *ahi-kā* to meet the various requirements and services provided by Mātihetihe Marae as well as shortages in expertise to deal with increasingly complex social-ecological issues (and decision-making) facing the community were identified as future challenges.

Next, the mapping results from our assessment of projected sea-level rise impacts along the Mitimiti coastline for 2040 and 2090 AD indicated that an increase in base sea-levels of 0.4 m by 2040 AD would result in broader areas of coastal land being inundated by the ocean more frequently. The most pronounced changes show extensive inundation of stream discharge zones such as low-lying farm-land surrounding the Moetangi Stream and Taikarawa Stream. Not unexpectedly, our assessment indicates that an increase in sea-level of 0.8 m by 2090 AD would lead to more extensive areas of coastline being inundated with present low-lying farm-land and dune-fields surrounding the streams at Moetangi and Taikarawa in the future tidal zone. Other changes indicated for a sea level rise of 0.8 m would include the formation of a tidal embayment around Moetangi Stream, and greater

propagation of the tide is evident around Mātihetihe Stream where increasing water extent and depth are indicated as far upstream as the Mātihetihe Marae complex.

Assessment of flooding surrounding the Mātihetihe Marae complex due to the combined effects of extreme rainfall under the mean B2 and A2 climate change scenarios and projected higher sea-levels for 2040 and 2090 AD, indicated that future peak flood flows would likely be 20% and 30% greater respectively than the flows experienced by home people during the January 1986 reference flood event. Notwithstanding this outcome, our modelling indicated for both scenarios minimal differences in projected flood extents when compared to the January 1986 reference flood event. This somewhat unexpected outcome is mostly due to the relatively steep land around the edges of the flooded area where the water level can change without much corresponding change in the extent of flooding. Finally, while the frequency of extreme flood events under future climate change scenarios was not determined in this study, heavy rainfall events are projected to become more frequent in many parts of Aotearoa/New Zealand, especially where mean rainfall increase is predicted.

The most notable change from this modelling exercise is the gradual and on-going encroachment of water at the seaward end of the Mātihetihe Marae complex. Relatively large differences in flood extent and water depth are also evident between the dune-field and the marae complex from 2040 and 2090 AD. This is likely to exacerbate existing erosion problems and increase the risk of damage to waste-water infrastructure at the back of the marae complex. An increase in inundation extent from 2040 and 2090 AD is also depicted across the areas currently used for car-parking on the southern side of the marae complex. Beyond these new flood extents, the modelling for both 2040 and 2090 AD under the mean of the B2 and A2 climate change scenarios indicates increasing water depth around the *whare-tūpuna* and *wharekai* located centrally within the marae complex. This is likely to increase the risk of direct flood damage under both scenarios given the expectations for slightly higher peak flood levels and possibly increased flow rates.

Integrating these results, it is evident that climate is only one of several factors that influence the vulnerability and endurance of the ‘community’ at Mitimiti to cope and deal with climate threats and stresses. From this perspective, risk, vulnerability and endurance to climate variability and change are not random outcomes, but rather are issues inextricably linked to sustainable development, political institutions, and natural hazards management. This point is critically important for *hapū/iwi* leaders and decision makers across a range of scales and institutions, as well as the *ahi-kā,* because the way we talk about issues and the way in which we conceptualise them are fundamental to the outcome of planning, policy, action and behaviour. Not surprisingly, many interviewees recognised the need to strengthen the social, cultural and economic capacities of *whānau* across the community to help assess, plan, and respond to the direct and indirect challenges brought on by changing climate regimes and conditions.

It is further evident that the constraints and strengths identified in this study represent points of entry for strategic community, *hapū/iwi* and government level planning and policy development that can minimise (or eliminate) existing sensitivities and enhance (as well as introduce new) coping and adaptive capacities. As expressed above, such points of entry are deeply connected with existing social-economic-political and environmental conditions; and therein the capacity of the community to deal with future climate risks, largely rests upon responding to existing issues linked to infrastructure and resourcing, political participation,

community governance, *whānau* health and education, cultural capital and the management of risk associated with natural hazards. There are, of course, numerous complexities and uncertainties that will affect the management of future climate risks facing the community – including among others, the capacity (and willingness) to create management practices and governance frameworks that can accommodate changing risk over time.

Experience gained through this work confirms that integrated assessment of the environment and human development is arguably the most important yet most difficult "systems" problem that society faces. New interdisciplinary approaches and deeper forms of analysis are therefore needed to improve the integration of information from scientists, policy analysts, and decision-makers across indigenous and non-indigenous worlds. This would help to strengthen the conclusions reached in this congested and complex space as well as help to facilitate actual plans and actions that respond to existing vulnerabilities, and that support different adaptation options. On-going analysis of the comparative climate change risks facing different Māori communities is also required to ground-truth diverse exposures, sensitivities and adaptive capacities. More specific issues to be addressed include how to engage with the most vulnerable groups within communities, and how to reaffirm traditional ways and build capacity to use scientific knowledge for adaptation. Given that perceptions of risks are known to be important in influencing communities' actions, tailored information and the 'right people' to communicate such information would greatly assist such gaps.

Climate change will not create new hazards, but it may change the frequency and intensity of existing risks and hazards, as well as introduce some long-term shifts in climate regimes throughout Aotearoa/New Zealand. For other Māori communities interested in examining in their own climate change challenges, it is important to emphasise that consideration of community vulnerability and endurance does not require the science of climate "prediction" to be more developed and nor does it require location-specific climate information of the kind produced in this report. Rather, first-order climate change projections and associated guidance on sea-level rise are readily available and these can be used to enhance awareness about potential impacts and associated risks. Perhaps more importantly, strategies and policies to tackle vulnerability and enhance adaptability to future climate risks can be developed in spite of the uncertainties, because most of the factors and processes that constrain choices and actions intersect existing issues of social-ecological well-being and related *whānau*/*hapū*/*iwi* development.

He Whakarāpopototanga

Ko ngā pānga āhuarangi, ngā whakaraeraetanga, me ngā āheinga ki te aro atu, kia takatū anō, he mea hua i ngā whanaungatanga matatini i waenga i te tangata me ngā momo taiao. Heoi, ahakoa tēnei māramatanga, he iti noa ngā kaupapa rangahau e aro pū ana ki ngā taupori me ngā hapori motuhake o Aotearoa, e kimi māramatanga ana ki ngā āhuatanga whai pānga ki te whakaraeraetanga me te aumangea o te hapori ki ngā mōreareatanga me ngā rerekētanga āhuarangi. Ko tā tēnei pūrongo rangahau he whakatewhatewha i ētahi o ēnei āhuatanga ā-horopaki (tuku iho anō), mā te āta tātari i ngā hua o ngā rerekētanga āhuarangi ki te *hapū* o Te Tao Mauī o Mitimiti i te raki o Hokianga, Aotearoa, pēnei i ngā mōreareatanga ki te ākau, otirā, te whakaraeraetanga, te aumangea, me te āheinga o te *hapū* nei kia takatū.

Hei mahere ārahi i ngā mahi nei, i tātaritia ngā pānga, ngā whakaraeraetanga, me te āheinga o te hapori kia noho takatū ki ngā āhuatanga āhuarangi me ngā mōreareatanga o nāianei, o anamata anō. I whai whakaarotia tā te hapori aro atu ki ngā momo pēhitanga āhuarangi tōtika, autaki hoki, me ngā momo āhuatanga, tukanga hoki, ka tautoko, ka tāmi rānei, i ngā kōwhiringa me ngā mahi ka hua ake i te hapori. Kātahi ka whakawhāitihia ngā matapae mō ngā rerekētanga āhuarangi o anamata ki te ao whānui, kia tirohia ai ngā pānga me ngā mōreareatanga ki te ākau o anamata, tērā tonu pea ka hua i te āhuarangi – ka aronuitia te piki haere o te taumata moana me te waipuketanga ngātahi o te kōawa o Mātihetihe. I whakakotahingia ngā hua o ēnei ahunga pito tīmata, whakamutunga hoki, kia kitea ai he ara hei whakakore atu, hei whakangāwari anō/rānei i ngā whakaraeraetanga, hei whakapakari hoki i ngā pūkenga me ngā āheinga o te hapori kia tū pakari tonu (kia takatū atu anō) ki ngā āhuatanga āhuarangi me ngā uauatanga o anamata.

I whakaritea he uiuinga ruku hōhonu, he mea āta ārahi, atu i te Noema 2011 tae atu ki te marama o Hurae 2013 ki ētahi kaikōrero 31 ka noho atu, ka whai pānga nui anō/rānei, ki te hapori. I roto tonu i ēnei uiuinga ā-rōpū, takirua, takitahi anō, ka kōrero te hunga nei mō ō rātou mōhiotanga ki ngā mōreareatanga āhuarangi, ki te ākau anō, ki Mitimiti - tae atu ki ō rātou mōhiotanga ki ngā rerekētanga ki te ākau, ngā wāhi ka kaha waipuketia, me ngā 'mea', ngā 'take' rānei, e tautoko ana, e whakataimaha rānei ana i te *whānau* e aro tōtika atu ana ki ngā pānga, ngā mōreareatanga me ngā pēhitanga āhuarangi. Whai muri iho, nā te whai whakaaro ki te āhua e aro atu ai ngā momo mahi *ā-whānau, ā-hapū, ā-iwi* hoki ki ngā mōreareatanga āhuarangi me ngā rerekētanga pāpori-kaiao whai pānga, ki nga pānga anō/rānei o aua āhuatanga, ka kitea ake he mea matua e whā ka whai wāhi ki te whakaraeraetanga me te āheinga o te hapori kia takatū atu ki ngā mōreareatanga āhuarangi. Anei rā aua mea:

(i) Ngā whanaungatanga pāpori-ahurea me ngā rerekētanga ki te hapori,

(ii) Ngā rauemi, te mana-motuhake me te auahatanga,

(iii) Te mātauranga, ngā pūkenga me ngā mōhioranga,

(iv) Te hanga o te hapori me te whakarite whakatau.

I kitea ake he mana nui tō ngā whanaungatanga pāpori-ahurea me ngā uara o te hapori, ki te āheinga o te iwi ki te 'aro atu' ki ngā mōreareatanga āhuarangi, ki te ākau hoki, ki Mitimiti. Ko te tūāpapa o tēnei āheinga ko te pakari o ngā whanaungatanga ā-whānau, ā-hapū hoki, me

ngā mātāpono ahurea taketake ka tohua e te whakapapa me ngā tikanga, kātahi ka whakatinanatia ki ngā uara o te whanaungatanga, te manaakitanga, te kotahitanga me te aroha. Heoi i kaha kīia ake, ko ngā rerekētanga nui ki te hanga o te hapori, āpiti atu ki te iti noa o ngā whanaketanga ōhanga me te pupūtanga ake o ētahi uara me ētahi whanonga hōu, he here e whakataimaha ana i te 'whakatutukihanga o ngā kaupapa'. Ahakoa ēnei uauatanga, i tino kōrerotia te whai take nui o te whakapūmau i ngā hononga i waenga i te *ahi-kā* me ērā o te *whānau* kei waho atu o Mitimiti e noho ana, mātua rā mō te taha ki te whakatutuki i ngā take nui me ngā tūmanako o te *hapū*.

I kaha rangona ngā kōrero mō te iti noa o ngā ara whai mahi me te torutoru noa o ngā rauemi hei whakangāwari i ngā mōreareatanga me ngā pānga ka tūpono hua ake - mātua rā, te iti noa o ngā pūtea hei whakapaipai, hei whakapakari hoki i a Mātihetihe Marae kia toka-tū-moana ai hei ngā rā o anamata. I kīia ake, nā ēnei here i uaua ake ai mā te *whānau* te whai āhua noho "whai oranga ake", ā, nā konā i kino ake ai te noho whakaraerae o ētahi *whānau* ki ngā mōreareatanga me ngā pēhitanga ka hua ake i te āhuarangi. Heoi, mā roto mai anō i ngā uiuinga ka rangona he huanga o te tū motuhake, o te mana-motuhake me te auahatanga. Ko ētahi o ēnei ko te mana nui o ngā hua ka puta i te *whānau*, pēnei i te whakamahere me te noho rite, tae atu ki te whakawhānui i ngā rawa ā-whare (me ngā hua moni) mā te hī ika, te kohi kaimoana, te whakangau me te hopu kararehe, me te mahi māra. Ko tā ēnei āhuatanga katoa he tohutohu i te āhua o te noho a ngā *whānau* ki Mitimiti.

Ko tā ētahi o ngā kaikōrero, me mātua whai i te mātauranga Māori, me whakapūmau hoki i ngā whanaungatanga ki te whenua me te moana, kia whai māramatanga ai, kia taea anō ai te aro atu ki ngā mōreareatanga ā-takiwā, ā-taiao hoki ki Mitimiti. Heoi, i kaha kīia ake, nā te tere rawa o ngā whakarerekētanga ki te hanga o te hapori i raru ai te tukuhanga atu o ngā mātauranga motuhake ki te *hapū.* Ko ngā tauira i kōrerotia i whakaatu ake, kua mimiti iho te māramatanga ki ngā take mō ētahi tikanga tuku iho, te āheinga ki te whai māramatanga rānei i ētahi tohu taiao mō ngā momo mōreareatanga ā-takiwā (me ētahi atu momo āhuatanga whai mōhiotanga). Nā konā i kaha kōrerotia te mana nui o Te Kura o Mātihetihe hei whakahihiko i te hunga *rangatahi*, tae atu ki te wero kia kimihia he ara hei tautoko i ngā kaupapa mātauranga taketake me ngā kaupapa hōu anō, kia taea ai e ngā reanga whakatupu te whai hua i ētahi momo tikanga mātauranga whānui, kaua i tētahi momo noa iho, kia whai mātauranga ai, kia whai pūkenga hōu anō ai.

I kōrerotia anō ngā tūranga o ngā hanganga ā-hapori, me te pai, te ngoikore rānei o ēnei, hei 'whakatutuki' i te taha ki ngā wero matatini, ahotini hoki, pēnei i ngā rerekētanga āhuarangi. I kaha whakapūmautia hoki e te *ahi-kā* me te *whānau* e noho ana ki waho atu o Mitimiti, te mana nui o Mātihetihe Marae me Te Kura o Mātihetihe hei pou herehere i te hapori, hei tohutohu i ngā take whai mana ki te hapori, hei mea 'whakatutuki kaupapa' anō hoki. I kīia ake hoki, nā ēnei momo whakaritenga ā-hapori i whai hanganga whakahaere ōkawa ai te hapori hei whakawhiti kōrero ā-hapū, ā-iwi hoki, hei whakarite hononga hoki ki ngā ohu o waho, pēnei i ngā mana ā-takiwā, ā-rohe anō. Heoi i puta hoki te kōrero, he wero mō anamata hoki te tokoiti haere o te hunga *ahi-kā* hei whakatutuki i ngā kaupapa me ngā ratonga o Mātihetihe Marae, me te iti noa o ngā pūkenga hei aro pū atu ki ngā take pāpori-kaiao o te hapori e piki haere ana te āhua matatini (hei whakarite whakatau hoki).

Hei whai ake, i whakamahere haere mātou i ngā pānga ki te ākau o Mitimiti hei te tau 2040 AD me te tau 2090 AD ka tūpono hua ake i ngā whakapikinga taumata moana e matapaetia ana, ā, ko tā ēnei e tohu nei, ki te piki ake te taumata moana taketake mā te 0.4m tae ake ki

te tau 2040 AD, ka whānui ake ngā whenua ki te ākau ka auau te whakaparawhenuatia e te moana. Ko ngā rerekētanga matua e tohu ana, ka whakaparawhenuatia mārikatia ngā rohe putanga awa, pēnei i ngā whenua-pāmu tāpotupotu kei te takiwā o ngā awa o Moetangi me Taikarawa. Ehara hoki i te mea ohorere te kitenga o tā mātou arotakenga e tohu ana, ki te piki ake te taumata moana mā te 0.8m tae ake ki te tau 2090 AD, ka whānui noa ake ngā whenua ki te ākau ka whakaparawhenuatia, kā mutu, ko ngā whenua-pāmu tāpotupotu me ngā rohe-tāhuahua kei te takiwā o ngā awa o Moetangi me Taikarawa, ka tau ki roto tonu i te rohe tai moana o anamata. Ko ētahi atu rerekētanga ka hua ake i tētahi pikinga taumata moana e 0.8m, ko te hanganga mai o tētahi kokoru ki te takiwā o te awa o Moetangi, me te horapa whānui ake o te tai moana ki te takiwā o te kōawa o Mātihetihe, e matapaetia ana ka whānui ake te hora, ka hōhonu ake anō ngā wai, tae ake ki te takiwā o Mātihetihe Marae.

I arotakengia ngā matapae waipuke i te takiwā o Mātihetihe Marae ka tūpono hua ake i te hekenga mārika o te ua, e ai ki ngā wawaenga o ngā tūāhua rerekētanga āhuarangi B2, A2 hoki, me ngā taumata moana teitei ake e matapaetia ana mō te tau 2040 AD me te tau 2090 AD, ā, ko tā ēnei e tohu nei, ka 20%, ka 30% hoki te pikinga ake o ngā taumata waipuke i ērā i rangona e te hau kāinga i te wā o te waipuke nui o Hanuere 1986 i kōrerotia e ngā kaikōrero. Ahakoa tēnei kitenga, i tohu ake ā mātou mahere mō aua tūāhua e rua, ka iti noa ngā rerekētanga i waenga i ngā whānuitanga o ngā waipuke, ki te whakatauritehia ki te waipuke o Hanuere 1986. Ka hua ake tēnei kitenga āhua ohorere nei i te hanga tāheke o ngā whenua kei ngā tahataha o te rohe waipuke, nā konā, ka taea ai te pikinga haere o ngā wai, heoi, ka kore e whānui mārika ake te hora o te waipuke. Otirā, ahakoa kāore i matapaetia i roto i te rangahau nei te auau o ngā waipuke nui e ai ki ngā tūāhua rerekētanga āhuarangi mō anamata, e matapaetia ana ka auau noa ake ngā hekenga ua mārika ki ngā tini tōpito o Aotearoa, ā, ka mātua pērā i ngā takiwā e matapaetia ana ka piki ake te taumata ua wawaenga.

Ko te rerekētanga matua i kitea ake i tēnei mahi whakamahere ko te āta horapatanga, me te horapa tonutanga o te wai i te pito o Mātihetihe Marae kei te tahamoana. E matapaetia anō ana he rerekētanga nui i te whānuitanga o ngā waipuke me te hōhonutanga o ngā wai i waenga i te rohe-tāhuahua me te marae hei te tau 2040 AD me te tau 2090 AD. Nā konei e kore e kore ka kino ake ngā raru horo whenua, ka kino ake hoki te tūponotanga kei raru ngā hanganga hari wai-para kei muri iho i te marae. Ko te matapae anō, ka whānui ake te horapa o te wai hei te tau 2040 AD me te tau 2090 AD ki ngā whenua e whakamahia ana i āianei hei tūnga waka i te taha tonga o te marae. Atu i ēnei horapatanga waipuke hōu, e tohu ana ngā mahere mō te tau 2040 AD me te tau 2090 AD e ai ki ngā wawaenga mō ngā tūāhua rerekētanga āhuarangi B2, A2 hoki, ka hōhonu ake ngā wai i te takiwā o te *whare-tūpuna* me te *wharekai* e tū ana ki te puku o te marae. Nā konei e kore e kore ka kino ake te tūponotanga kei raru te marae i ngā waipuke e ai ki ngā tūāhua e rua nei, nā runga i ngā matapae ka teitei ake ngā taumata waipuke, ka kaha ake anō pea te rere o ngā wai.

Mā te whakakotahi i ēnei kitenga, he mārama te kite ake, ko te āhuarangi tētahi noa o ngā āhuatanga e whai pānga ana ki te whakaraeraetanga me te aumangea o te 'hapori' i Mitimiti kia tū pakari tonu, kia aro hoki ki ngā wero me ngā pēhitanga āhuarangi. E ai ki tēnei tirohanga, ehara i te mea he mea hua poka noa te mōreareatanga, te whakaraeraetanga me te aumangea ki ngā rerekētanga āhuarangi, engari kē, he take ēnei e whai pānga nui ana ki te whakawhanaketanga whai oranga tonutanga, ngā ohu tōrangapū, me te taha whakahaere i ngā mōreareatanga taiao. He kaupapa whai mana nui tēnei ki ngā rangatira *ā-hapū/ā-iwi*

me te hunga whakarite whakatau huri noa i ngā momo ohu/rōpū, ahakoa iti, ahakoa rahi, ā, tae atu hoki ki te *ahi-kā*, inā rā, ko te āhua o tā tātou whakawhiti kōrero mō tētahi take, me te āhua o tā tātou whai whakaaro ki taua take, ka noho hei tūāpapa mō te whakamahere, te whakarite kaupapa here, otirā, ngā mahi me ngā whanonga ka hua ake. Ehara hoki i te mea ohorere, he nui ngā kaikōrero i whakaae me whakapakari ake ngā āheinga ā-pāpori, ā-ahurea, ā-ōhanga hoki o ngā *whānau* i te hapori hei āwhina i te taha arotake, whakamahere, aro hoki ki ngā wero tōtika, autaki hoki, ka hua ake i ngā rerekētanga āhuarangi.

I kitea hoki, ko ngā here me ngā pakaritanga i tohua ake i tēnei rangahau hei pito tīmata mō ētahi whakamaheretanga, whakaritenga kaupapa here rautaki hoki, ā-hapori, *ā-hapū/ā-iwi*, ā-kāwanatanga anō, hei whakangāwari (hei whakakore atu rānei) i ngā whakaraeraetanga o te wā, hei whakapakari hoki (hei whakahōu anō) i ngā āheitanga kia tū pakari tonu, kia takatū anō. Pēnei tonu i tērā i kōrerotia i runga ake nei, ko aua pito tīmata e whai hononga nui ana ki ngā āhuatanga pāpori-ōhanga-tōrangapū me ngā āhuatanga taiao anō o te wā: nā konā ko te āhua o tā te hapori āhei ki te tū pakari tonu, ahakoa ngā mōreareatanga āhuarangi o anamata, e hāngai nui ana ki te aronga atu ki ngā take o te wā nei, pēnei i ngā momo hanganga me te whai rauemi, te whai wāhi ki ngā kaupapa tōrangapū, ngā whakahaerenga ā-hapori, te oranga o te *whānau* me te whai mātauranga, ngā rawa ahurea, me te āta whakahaere i ngā mōreareatanga ka tūpono hua ake i te taiao. Arā tonu he uauatanga matatini maha me ētahi āhuatanga tē taea te matapae, ka whai pānga ki ngā whakahaerenga mō ngā mōreareatanga āhuarangi o anamata ka pā ki te hapori - tae atu ki te āheinga (me te hiahia) ki te whakarite tikanga whakahaere, tūāpapa mana whakahaere hoki, e āhei ana ki te noho takatū atu ki ngā mōreareatanga e rerekē haere ana i roto i ngā tau.

Ko tā ngā wheako i hua ake i tēnei mahi he tohu, ko te arotake ahotini i te taiao me te whakawhanaketanga o te tangata tētahi o ngā raru "pūnaha" matua, uaua rawa atu anō, e pā ana ki te iwi whānui. Me whai he ahunga e whai hua ana i ngā momo rāngai rerekē me ētahi āhuatanga tātari hōhonu ake, kia pai ake ai te whakakotahitanga ahotini o ngā momo mōhiotanga o ngā kaipūtaiao, ngā kaiarotake kaupapa here, me te hunga whakarite whakatau i ngā ao taketake me ngā ao taketake-kore anō. Mā konei e whai kiko nui ake ai ngā kitenga ki tēnei wāhi popoke, matatini anō, mā konei hoki e āwhinatia ai te whakaritenga o ētahi mahere me ētahi mahi e aro ana ki ngā whakaraeraetanga o te wā, e tautoko hoki ana i ētahi ara hei takatū atu. Me haere tonu hoki ngā arotakenga whakataurite i ngā momo mōreareatanga rerekētanga āhuarangi e pā ana ki ngā momo hapori Māori rerekē, kia kitea ai te tika me te pono e ai ki ia hapori mō ngā pānga, ngā whakaraeraetanga me ngā āheinga kia takatū atu. Me whai whakaaro hoki ki ētahi take whāiti, pēnei i te kimi ara hei whakawhanaunga atu ki ngā rōpū whakaraerae rawa o te hapori, te whakaū i ngā tikanga tuku iho, me te whakapiki i te āheinga ki te whakamahi i ngā mātauranga pūtaiao kia māmā ake ai te noho takatū. Nā runga i te mōhio, ka whai pānga nui te āhua o tā te hapori titiro ki ngā mōreareatanga ki te āhua o ngā mahi a te hapori, ka whai hua nui te whakahāngai i ngā mōhiotanga ki te hapori tonu, me te tohu hoki i ngā 'tāngata tōtika' hei tuku atu i ēnā mōhiotanga.

Ehara i te mea ka hua ake i ngā rerekētanga āhuarangi he mōreareatanga hōu, heoi, ka auau ake pea, ka kino ake pea ngā mōreareatanga o te wā nei, me te aha, ka hua ake pea he rerekētanga ahunga-roa ki te āhua o te āhuarangi huri noa i Aotearoa. Mō hapori Māori kē atu e hiahia ana ki te arotake i ō rātou ake uauatanga ka hua i ngā rerekētanga

āhuarangi, me whakataukī ake, ehara i te mea me whakawhanake te pūtaiao “matapae” āhuarangi, ehara hoki i te mea me mātua whai mōhioranga āhuarangi motuhake ki te takiwā, pēnei i te momo i kōrerohia i tēnei pūrongo. Ko te mea kē, he māmā noa te kimi haere i ngā momo matapae rerekētanga āhuarangi pae-tahi me ngā whakamāramatanga e hāngai ana ki ngā pikinga taumata moana, ā, mā konei e whai māramatanga ai te tangata ki ngā momo pānga me ngā mōreareatanga e hāngai ana, ka tūpono hua ake. Hei take whai mana nui ake, ka taea tonutia te whakarite rautaki hei kaupare i ngā whakaraeraetanga, hei whakapakari hoki i ngā āheinga kia noho takatū atu ki ngā rerekētanga āhuarangi o anamata, ahakoa ngā āhuatanga kāore e mōhiotia ana i tēnei wā, inā hoki, ko te nuinga o ngā āhuatanga me ngā tukanga e here ana i ngā kōwhiringa me ngā mahi, ka whai pānga ki ngā take oranga pāpori-kaiao me te whakawhanaketanga o ngā *whānau/hapū/iwi* e hāngai ana.

1 Introduction and background

Few studies with specific populations and communities in Aotearoa/New Zealand (A/NZ) have been carried out to better appreciate the conditions that shape and determine community vulnerability and resilience (endurance) to climate risks and change. In response, NIWA is undertaking a series of placed based studies with Māori communities investigating 'community' vulnerability, adaptation and resilience to climate variability and change. This report documents a participatory-based research study involving community members from the *hapū* of Te Tao Mauī from Mitimiti settlement in the northern Hokianga of Northland, and NIWA's Māori Environmental Research and National Climate Centres. The information and learning derived from this work is expected to assist not only the *hapū* at Mitimiti but also provide relevant information to assist adaptation planning by other Māori communities as well as central and local government to the direct and indirect impacts of climate change (and on-going climate variability) at the coast.

The following sub-sections in this chapter set the context for this place-based study and provide information relevant to the work conducted throughout. An overview of the latest science on climate change is provided first, followed by a brief review of what is currently known about the differentiated nature of expected climate change impacts and risk for Māori communities. Thereafter key global change terms and concepts used within this study are presented and defined. Finally, before outlining the key objectives of this specific study, a summary of formerly published climate adaptation research conducted to date with, and on behalf of, indigenous peoples with similar historical and socio-political landscapes to Māori, is presented.

1.1 Climate change science

Scientific evidence about global climate change continues to accumulate and therein affirm the links between human activities, increasing greenhouse gas (GHG) emissions, and rising global surface temperatures (among other climate-environment related changes). In spite of evidence for human-induced climate change, determining how different groups across society are likely to be impacted, including the contextual factors that drive their relative vulnerabilities and resilience, is an extremely difficult task. Yet it is one that is vitally important for identifying risks and making actual decisions about appropriate response and adaptation strategies.

Before recapping the limited work conducted to date on Māori climate change issues, a summary of the physical science is provided below as a basis for understanding the 'projected' and 'downscaled' assessments of change given later in this report. More detailed information on climate change projections is available through the latest Inter-governmental Panel on Climate Change (IPCC)[1] series of reports[2] and for the A/NZ context through the Ministry for the Environment (MfE) funded guidance manuals: 'Climate change effects and

[1] The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 by the World Meteorological Organisation (WMO) and the United Nations Environment Programme (UNEP) to collate assessments of scientific publications and technical reports on climate change (IPCC, 1990; IPCC, 1995; IPCC, 2001; IPCC, 2007). Work conducted by the IPCC culminates in a series of reports every 5-6 years for the entire planet (IPCC, 1990; IPCC, 1995; IPCC, 2001; IPCC, 2007), with the latest round of reports to be released in 2013 and 2014. It is also worthy of note that the IPCC has almost no employees and disbands after the reports are published (i.e. voluntary service). The latest series of reports are based on the work of 500 authors and 5,000 reviewers.

[2] The projections reported in this document are based on the fourth assessment report (otherwise referred to as the AR4). However, please note that the AR5 Summary for Policymakers from Working Group 1 was released at the same time as this report.

impacts assessment: A guidance manual for local government in New Zealand' (MfE, 2008a) and 'Coastal Hazards and Climate Change: A guidance manual for local government in New Zealand' (MfE, 2008b).

The AR4 Working Group 1 report produced by the IPCC in 2007 concluded that warming of the climate system is now "unequivocal" and that most of the observed increase in global average temperatures since the mid-20th century is "very likely" due to the observed increase in anthropogenic [human] GHG concentrations (IPCC, 2007). At the crux of this issue (from an atmospheric science perspective), human activities such as fossil fuel burning and land use change have been increasing the natural levels of greenhouse gases (e.g. carbon dioxide - CO_2, methane - CH_4 and nitrogen dioxide - N_2O, among others) in the atmosphere, causing heat from the sun to be trapped in the atmosphere instead of being radiated back into space and therein the Earth to warm and the climate, by consequence, to change. Over the last century alone, atmospheric concentrations of carbon dioxide increased from a pre-industrial[3] value of 278 parts per million to 379 parts per million in 2005, and the average global temperature rose by 0.74° C (IPCC, 2007), with 16 of the 18 warmest years on record (over the past 132 years) having all occurred between 1995 and 2012 (Hansen *et al.,* 2013).

Scientists have designed climate models (based on the physical laws of how the atmosphere behaves) that evaluate the role of increasing GHGs on our climate. Using mathematical representations of the atmosphere, land and oceans, scientists have shown that natural effects such as solar variability do not fully explain the increases in temperatures that are observed in the instrumental record – particularly over the latter part of the twentieth century. In contrast, when GHGs are included in these simulations, the observed warming is more closely followed – indicating that the warming observed over the past 100 years is unlikely to have been caused by natural factors alone. Figure 1 shows the influence in modelled output when GHGs are excluded and included in globally modelled temperature (IPCC, 2007).

In conjunction with these assessments, detailed climate projections for the 21st century (which simulate the effect on the atmosphere and oceans of different possible future scenarios of GHG emissions) show that anthropogenic climate change will most likely continue and may even accelerate with unexpected surprises (IPCC, 2007). While there are still many uncertainties associated with predicting future climatic changes, the climate projections summarised by the IPCC AR4[4] include:

- An increase in globally averaged surface temperatures of between 1.1ºC and 6.4ºC by 2100 AD, and a 'very likely'[5] increase in the frequency of hot extremes and heat waves.
- Both increased and decreased average annual rainfall - depending on location - of between 5-20% at regional scales during the 21st century.
- A likely increase in the frequency of heavy precipitation (rainfall) events.
- Continued widespread retreat of glaciers throughout the 21st century.

[3] Typically refers to the period prior to 1750 AD.
[4] These projections are for the so-called SRES (Special Report on Emission Scenarios), and were developed for a range of possible future economic, development and social scenarios. The scenarios do not include climate-policy initiatives to reduce greenhouse gas emissions (IPCC, 2007).
[5] The language of 'likelihood' helps to describe quantified uncertainty (IPCC, 2007). Very likely equates with a 90-100% probability while likely equates to a 66-100% probability of the outcome occurring.

- A basic rise in global mean sea-level of between 0.18 to 0.59 m with an additional contribution[6] of up to 0.2 m by the 2090's relative to the 1980-1999 average.

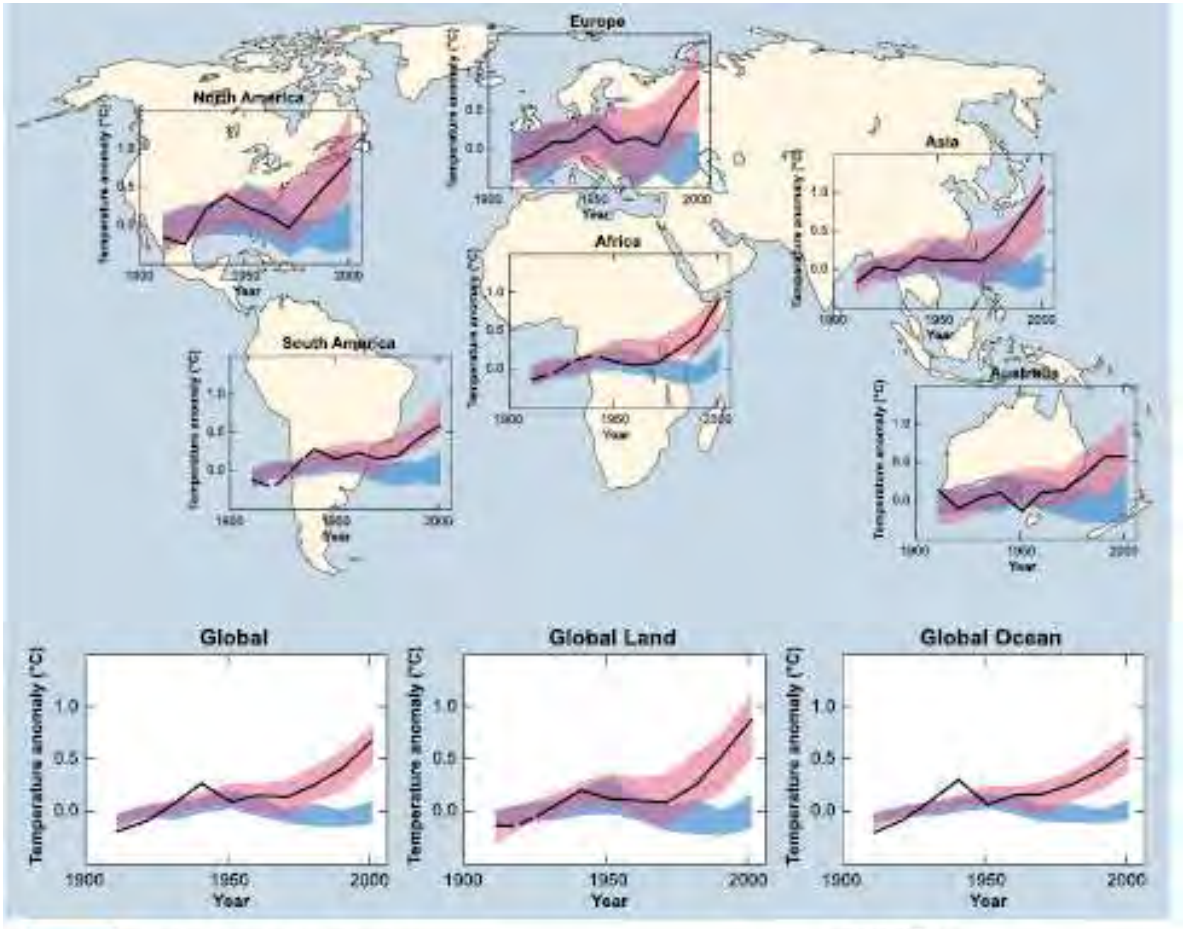

Figure 1: The figure shows the influence in modelled output when GHG's are excluded and included in globally and regionally modelled temperature. The black line indicates the observed increases in temperature over the years. In the blue band modeled average temperature takes into account solar, volcanic effects, and observations. In the red band GHG's and aerosols are included (IPCC, 2007).

Importantly, these global averages do not necessarily reflect the complex range of outcomes that will occur across national and regional scales. Recent studies already have shown larger biological impacts in equatorial regions and these are understood to be related to the change in temperature relative to what the biological systems have become adapted to, rather than the absolute magnitude of temperature change (Dillon *et al*., 2010). Notwithstanding the importance therefore of remaining cautious when interpreting these global projections, the information needs to be 'down-scaled' to be meaningful at the national or regional level. Full details of available national and regional 'down-scaled' predictions for A/NZ, in the context of Local Government, is summarised in the guidance manual referred to above (MfE, 2008a).

[6] These projections do not include contributions due to changes in the dynamics of ice-sheet discharge, which is less well understood and likely to be an increasing factor, particularly if greenhouse gas emissions are not reduced. Instead IPCC provided an estimated rise in the upper ranges of the emission scenario projections that would be expected with "scaled-up ice sheet discharge" if contributions to sea-level rise were to grow linearly with global temperature change for each emission scenario. This was estimated within the IPCC AR4 as varying between an additional 0.09 m to 0.17 m (depending on emission scenario) but was rounded up in the IPCC (2007) Synthesis Report to an additional 0.1 to 0.2 m rise. It was also clearly stated that larger contributions from the Greenland and West Antarctic ice sheets over this century could not be ruled out (IPCC, 2007).

Broad patterns of change over A/NZ for the next 50-100 years are expected to consist of:

- Rising temperature of ~1ºC by 2050 and 2°C by 2100 - with greater increases in the winter season, and in the north of A/NZ
- Decreased frost risk but increased risk of very high temperatures
- Enhancement of westerly winds
- Stronger west-east rainfall gradient (wetter in the west and drier in the east)
- Increased frequency of extreme (heavy) daily rainfalls resulting in floods
- Large areas of the east are likely to face increased soil moisture deficits
- Snow line rise and glacier shrinkage
- Continued sea-level rise (SLR), possibly of the order of 0.5 to 0.8 m by the 2090s but rises of 1 m or more cannot be ruled out[7].

Note that a range of emissions scenarios is typically used in projecting future climate conditions as we do not know exactly how human-induced GHGs will vary over the century, and therefore cannot define exactly how the emissions will translate into climate changes and SLR. Consequently, future changes in climate are typically presented as ranges, rather than a single value. In spite of the uncertainties, confidence in estimates of future changes in climate-related risks is increasing. This is due to the consistency in model-based projections of the likelihood of changes in key climate variables, as well as increased consistency between these projections and the observed changes in these likelihoods over recent decades. More specific information on climate change scenarios is presented in Section 5 of this report.

A final point to emphasise here is that there is considerable natural variability in climate which can deviate from long-term averages. Subsequently, human-induced long-term trends will be superimposed on these natural variations, and it is this combination with weather events that will provide the future climate extremes to which societies and the varied groups within them will be exposed.

1.2 Climate change policy and planning

Mounting scientific evidence on climate change indicates that avoiding the worst impacts of climate change would require policy interventions that severely moderate (and / or transform) development paths across international, regional and local levels (MfE, 1990; IPCC, 2007). Accordingly, this section offers a brief review of climate change policy and planning in A/NZ, with the principal objective of logging progress through a summary of key international and domestic drivers and developments.

Formal acceptance of climate change as a national issue arguably began in June 1992 when the New Zealand Government signed the United Nations Framework Convention on Climate

[7] SLR projections for A/NZ are currently based on global model output with regional departures from the global mean projections likely to be for a modest additional component (Ackerley et al., 2013). There remains considerable uncertainty over how much SLR will occur globally however, and therefore little guidance about a possible upper limit for A/NZ (MfE, 2008b; RSNZ, 2010).

Change (UNFCCC) at the 'Earth Summit' held in Rio de Janeiro, Brazil[8]. The UNFCCC treaty recognised that addressing climate change would require collective international action and thereby signatories effectively committed themselves to supporting the stabilisation of GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. However, the treaty set no mandatory limits on GHG emissions for individual countries and contained no enforcement mechanisms. Rather, it provided for updates (called "protocols") that would eventually set mandatory emission limits to stabilise net GHG emissions (MfE, 1994)[9]. Importantly, these international developments strongly influenced the direction of New Zealand's climate change policy with an emphasis placed upon the mitigation of GHG emissions. Central government agencies therein invested heavily in creating GHG inventories to estimate and monitor emissions as well as resourcing practices for valuing, buying and selling of greenhouse gas emission allowances in an attempt to reduce the country's net emissions tally.

The next notable domestic policy development for New Zealand occurred in 1993 when the Ministry for the Environment (MfE) published the booklet: "Information for the Guidance of Local Authorities in Addressing Climate Change" (MfE, 1993). This booklet aimed to raise climate change awareness among local government elected representatives, resource managers, policy advisers and planners (as well as the general public). It also represented the first significant effort by central government to directly engage local government in actions to address both the impacts of climate change and to limit GHG emissions. Local government were advised that it had an important role in supporting central government (as noted in Resource Management Act[10], 1991), but no guidance on firm actions were provided at that time.

Meanwhile, in order for New Zealand to meet its international climate change policy obligations, policies were explored that could return New Zealand's GHG emissions back to 1990 levels. Therefore to match the Kyoto Protocol[11] with domestic legislation, and to reduce the rate of GHG emission growth, the New Zealand government proposed its first broad climate change policy package in October 2002. On the one hand, the package was presented as a broad attempt to reduce emissions that could move to an emissions trading system over time[12]. On the other, the package gave the first explicit direction from central government to local government on climate change action as it indicated upcoming changes

[8] International action on climate change had its origins in the joint meeting of the United Nations Environment Programme (UNEP), the World Meteorological Organisation (WMO), and the International Council for Science Conference (ICSU) in Villach, Austria in 1985 (WMO, 1986). Scientists from 29 countries gathered at this inaugural meeting to assess the role of increased GHGs and aerosols on climate change as well as the potential impacts of such forcing on the climate system; and, subsequently concluded that it is both a matter of urgency to refine estimates of future climate conditions to improve decision-making, and that the rate and degree of future warming could be profoundly affected by governmental policies on energy conservation, use of fossil fuels, and the emission of some greenhouse gases.

[9] It would take 5 further years before a legally binding international agreement was established at Kyoto, Japan (more commonly known as the 'Kyoto Protocol') - whereby all participating nations agreed to an average GHG emission reduction target of 5% from 1990 levels by 2012. Countries were given the option of either achieving their targets by producing less GHG emissions, or by taking responsibility by buying emission allowances from countries with excess emissions credits (UNFCCC, 2007).

[10] The RMA (1991) is A/NZ's primary local government regulatory tool for environmental management.

[11] The Kyoto Protocol was signed in May 1998 by the New Zealand Government and ratified in late 2002, thereby committing the country to stabilising the average of its 2008-2012 GHG emissions to 1990 levels.

[12] In support of this package, the government proposed introducing an agricultural emissions research levy (2003) - commonly described as the 'flatulence' or 'fart tax'. The levy was in fact not a tax based on emission levels rather a levy at a level considered necessary to address how to reduce ruminant methane from farm animals and nitrous oxide emissions at the farm level. However, the proposed levy was aggressively opposed and thereafter discontinued as a potential policy.

to the Resource Management Act - 1991 (RMA) and stated that central government would likely pursue formal partnership with local government in the form of an NZ-specific 'Cities for Climate Protection' (later renamed 'Communities for Climate Protection' in New Zealand) programme (DPMC, 2002).

Following up on these proposed measures, the New Zealand cabinet amended the RMA in 2004 by inserting three new matters into Section 7 of Part II of the Act. The Resource Management (Energy and Climate Change) Amendment Bill 2004 created provisions for 'all persons exercising functions and powers under the principal Act to have particular regard to:

i. the efficiency of the end use of energy
ii. the effects of climate change
iii. the benefits to be derived from the use and development of renewable energy' (P. II);

Local authorities were explicitly mandated:

i. 'to plan for the effects of climate change, but
ii. not to consider the effects on climate change of discharges into air of GHG' (P. II).

In brief, the passing of this Amendment removed the authority of regional councils to control emissions of GHGs for climate change (whether or not they had been doing so specifically for climate change or other regulatory monitoring reasons). In doing so, it recognised the Government's preference for national instruments to reduce GHG emissions through mechanisms such as a carbon tax. Furthermore, it heralded a significant shift in approaches for governing responses to climate change, separating the responsibility for managing climate change – whereby central government would manage mitigation[13], and regional government would be responsible for strategies and decision-making surrounding adaptation (Greenaway and Carswell, 2009).

In the succeeding years, the RMA 2004 Amendment has led to a more explicit and comprehensive focus on the potential effects of climate change in the development of regional policies and planning provisions (Reisinger *et al.,* 2011). Numerous scientific reports have been commissioned by local authorities that evaluate the risks of climate change impacts (e.g. Bell *et al*., 2006) and intensive effort has been devoted by central government agencies to the production and dissemination of suitable guidance material for local government to ensure that climate change considerations become a regular component of relevant council functions and are recognised by staff, elected representatives, and regional industry and community groups (MfE, 2008a, 2008b). However, there is as yet insufficient evidence as to whether any improvements in local government policy and practice on climate change can be attributed to this legislative mechanism or more simply greater community awareness and general acceptance of climate change (Reisinger *et al.,* 2011).

Reisinger *et al.,* (2011) also point out that the amended RMA (2004) has effectively led to a greater burden being placed on local authorities who face a number of obstacles in wishing

[13] After the September 2005 general election, the government announced that it would not be proceeding with its proposed carbon tax and would instead consider other ways to manage A/NZ's GHG emissions. Subsequently, a revised climate change policy package was issued in 2007. The primary mechanism from this package was the New Zealand Emissions Trading Scheme (ETS) which was legislated in September 2008 and amended in November 2009. In short, the ETS puts obligations on certain sectors of the economy to account for the GHG emissions that result from their activities. At the time of writing this report, some Māori groups are raising concerns about issues including the monitoring of GHG emissions, the allocation of emissions units, and the entry time of different sectors of the economy into the ETS. For a review of the likely impacts of the ETS on Māori see Insley and Meade (2008).

to impose controls on activities that may be unsustainable in the face of climate change. Some of the obstacles include the limited availability of baseline data (in particular short time records for rainfall and flood risk, and limited understanding of coastal dynamics), the large range of local-scale projections from different climate models[14], the limited availability of probabilistic climate change projections to support quantitative risk assessments and the perception in some councils (and sections of the community) that climate change science is contentious and speculative. In addition, practitioner knowledge at national and local levels continues to be challenged by a rapidly advancing field of research and development, and there are many existing day to day pressures for councils to address. Reisinger *et al.,* (2011) suggest that there is a need for more detailed and prescriptive central government guidance that would help balance long-term community perspectives against powerful special interests - but the value and specific form of such additional guidance continues to be debated.

In spite of these challenges, there is a growing recognition of the linkages between climate change and sustainable development, and the need for adaptation strategies that are integrated across water, energy and land use policies at national, regional and local levels. Some regional authorities have acknowledged using the Local Government Act 2002 as a reference point for linking climate change to existing land, water and energy management strategies (Greenaway and Carswell, 2009; Reisinger *et al.,* 2011). Further, responsibilities under the Civil Defence Emergency Management Act (2002) and the New Zealand Coastal Policy Statement (2010) have also seen these legislation used to consider and prepare for hazards and risks associated with climate change. Given this feedback from council planners and recent reviews of regional policy documents (Willis, 2007), there does appear to be improving integration of climate change decisions into wider non-climate contexts, however much more remains to be done.

1.3 Māori communities and climate change

To date, only a handful of studies have considered how Māori society is likely to be affected by climate change – and these studies have tended to be either very sector specific in their analyses (e.g. Harmsworth, 2003; Funk and Kerr, 2007; Insley and Meade, 2008; Insley, 2010; King et al., 2012a, 2012b) or more general in scope inferring risk and vulnerability based on exploratory engagements with varied stakeholders and existing social-economic-political and ecological conditions (e.g. Packman *et al*., 2001; Cottrell *et al*., 2004; King and Penny, 2006; Hennessy *et al*., 2007; MfE, 2007; King *et al*., 2010). Aside from the need for more detailed information across all the different sectors, systems and groups that make up Māori society, it is generally recognised that Māori society is climate sensitive due to the strong links that exist between Māori economic, social and cultural systems and the natural environment (NZIER, 2003). Added to this, it is also recognised that the projected impacts of a changing climate on Māori will be differentiated depending on social, political, economic and environmental circumstances (Figure 2).

The vulnerability and resilience of Māori will also vary between Māori living in small rural settlements to Māori in regional centres and larger municipal areas. But, in what ways do they vary? How might specific groups reduce their vulnerability and manage risk? Do Māori governance structures (including policy makers and local authorities) have adequate information and tools to respond to the pressures that Māori face? And, how should priorities

[14] Some councils have requested that guidance on scenarios and methods for climate risk assessment be nationally binding and include specific figures especially for SLR, to help avoid delays, costs and uncertainties resulting from challenges against the choices that councils otherwise have to make.

for adaptation action and planning in communities and settlements be decided? All of these questions are important when considering the distinctive character of, and challenges already facing, Māori society. Although it is well known that Māori are experienced in dealing with climate variability, new and untried strategies may be needed to ensure the long-term sustainability of climate sensitive communities and activities in the context of a changing climate (King *et al*., 2010). However, it is also important to recognise, that for some Māori communities, businesses and groups, climate change will create opportunities via an untold number of interacting drivers of change including new technologies, advanced business networks, diversification of industrial practices, settled Treaty of Waitangi claims[15], cultural capital and creativity.

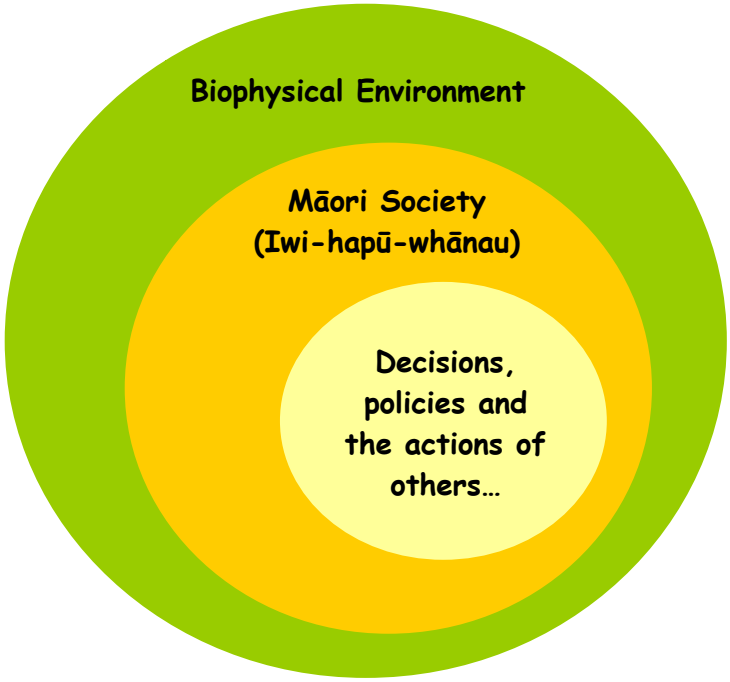

Figure 2: The key spheres of influence that complicate the climate change issue for Māori society. (Source: King *et al*., 2010).

Making decisions about what to do about climate change is complicated due to the uncertainty about the magnitude and distribution of possible impacts, and the risks attached to making poor decisions or no decisions at all. Important questions are therefore being asked about whether all groups are likely to face the same challenges and/or a combination of pressures that put some groups more at risk than others. In particular, Māori coastal communities and associated infrastructure have been identified as being highly vulnerable to SLR and extreme events such as storms and high waves (Hennessy *et al*., 2007). Currently many of these coastal areas and values are being compromised by environmental changes (including coastal erosion, floods and catchment runoff, among others), increased pressure

[15] Treaty of Waitangi claims and settlements have been a significant feature of A/NZ society since 1975. The Waitangi Tribunal was established by the Treaty of Waitangi Act 1975. This permanent commission of inquiry is charged with making recommendations on claims brought by Māori relating to actions or omissions of the Crown that breach the promises made in the Treaty of Waitangi - 6 February, 1840 (Orange; 1989; Durie, 1998; Walker, 2004.

on resources and widespread coastal development – in both urban and rural areas (Penny *et al*., 2007a, 2007b).

A further challenge in understanding the dynamics of these drivers across Māori communities relates to the diversity of community types themselves and the various realities that underlie all social-cultural groups. From a planning perspective, one of the tasks policy-makers face in responding to the vulnerability of different groups in society is designing policies that target the causal factors responsible for vulnerability (see the following section for discussion of this term). Given the complexity of factors involved, and because policy initiatives to address the issue are likely to be incremental and constrained by resources and budgets, policy makers have the difficulty of deciding on where, and at what scale(s), to direct their efforts. Reliable and evidence-based information is therefore required to better understand the vulnerability and adaptive capacity of *whānau/hapū/iwi* [extended family/sub-tribal kin group/tribal kin group] and Māori businesses. This needs to include the inter-linkages and dependencies between people and the physical environment (across space and over time). Such information will help to understand what makes some stakeholders more resilient than others, while at the same time assist in identifying vulnerable systems and groups where failure is likely to carry the most significant consequences.

1.4 Concepts of community, risk, vulnerability, adaption and resilience

Due to the contestable (and sometimes confusing) use of key concepts and terminology in global environmental change studies, we provide below a brief overview of our assumptions and interpretations. This exercise highlights some of the nuances of these terms including our own interpretations and applications.

Community

The concept of ‘community’ is often central to any research which calls for an examination of social, political, economic, or environmental realities. While some researchers and research funding agencies recognise (and sometimes acknowledge) the reality and challenge of oversimplified conceptions of community, it is also apparent that how this influences and shapes research and policy is often overlooked – whether conveniently or simply unknowingly (Agrawal and Gibson, 1999). Added to this dilemma, research objectives and strategies surrounding ‘communities’ often demand results and/or outcomes that can be treated as universal and implemented locally, regionally and nationally (i.e. ‘transferable’ across different groups in society). In our case, the ability of the research team to consider and appreciate the “context-specific vulnerability and adaptation options facing rural and urban Māori communities” heavily relies on how the term ‘community’ is identified, explored and eventually defined.

Our consideration of social theory on this topic (Cohen, 1985; Walmsley and Lewis, 1993; Jewkes and Murcott, 1996; Agrawal and Gibson, 1999; Anderson *et al*., 1999; Jorgensen and Stedman, 2001; Panelli and Welch, 2005) confirms that ‘communities’ more than ever before involve complex social realities and diverse configurations – that evolve and transform through time. It is no longer viable or realistic therefore to assume that a social group or ‘community’ (including the people within it) will fit ‘neatly’ or exclusively into a single category. Subsequently we agree with arguments that advise against using universalist notions of community that ignore the complex internal and external realities (i.e. critical interests and processes within communities as well as between communities and other social actors) that

underlie contemporary living arrangements – be it urban, rural or otherwise. Note this acknowledgement is crucial for not only avoiding the oversimplification of dynamic social and physical realities, landscapes and structures at the beginning of the twenty-first century for Māori, but also because oversimplified notions can contribute to misaligned social plans and policy that lead onto unsuccessful social and environmental outcomes (Agrawal and Gibson, 1999).

In the work described here, we presuppose that Māori 'communities' are a social group defined first and foremost by *whakapapa* [ancestral and kinship linkages to people and place, genealogy, literally means 'to place in layers'] and thereafter characterised by complex internal and external relationships which are underpinned by a high degree of personal intimacy, emotional depth, moral commitment, social cohesion and continuity through time linked to place (Wellman and Leighton, 1979). And, although Māori society remains essentially a 'tribal' (putting debates about the historical basis and cultural specificity of the term aside) it is obviously not exclusively tribal. That is, in addition to the historical formations of *whānau*, *hapū* and *iwi*, Māori society also needs to be understood as consisting of individuals, groups, pan-Māori collectives, business enterprises and sectors – all of which include an assortment of perceptions, values, beliefs, professions and expectations that can result in equally diverse social, political and economic realities (Maaka, 2003). Furthermore, it is the inter-relationships between groups and individuals that make the varied dimensions of communities operate. To consider anything otherwise is a precariously narrow and limiting view of Māori social organisation today.

Risk

One of the problems with defining risk is that it has been developed and applied across a range of disciplines and activities leading to varied conceptual definitions and meanings. In spite of this, most definitions of risk involve probabilities, relating mostly to (i) the probability of occurrence of a hazard[16] that acts to trigger a disaster or series of events with an undesirable outcome, and (ii) the probability of a disaster or outcome, which combines the probability of the hazard event with a consideration of the likely consequences of the hazard (Brooks, 2003). In this report, the concept of 'risk' is expressed more explicitly with reference to climate change and understood to mean "the chance (i.e. probability) of an 'event' being induced or significantly exacerbated by climate change, with that event having an impact on something of value to the present and/or future community. Risk is measured in terms of *consequence* and *likelihood*. It also has an element of *choice* by humans" (MfE, 2008a:100; MfE, 2008b:92). Importantly, in using this definition it is also recognised that the probability of loss, injury or harm caused by a given hazard, is influenced by the vulnerability of a specific sector, system or group; and, that risks can be avoided or mitigated by modifying any of the elements of vulnerability (Crichton, 1999).

In the context of climate change, assessment of risk typically involves the identification of specific climate hazards and the appraisal of the adverse effects (in some cases these will be beneficial and/ create opportunities) in terms of magnitude, spatial scale, time-frame, duration and intensity for different systems, sectors or groups across society (MfE, 2008a; MfE, 2008b; NRC, 2010). Once these characteristics of the physical hazard have been identified, the potential severity of loss (consequence) and the probability of occurrence (likelihood) are thereafter typically assessed. This can be relatively simple to establish, such as the likelihood of a flood event, or or such as the valuation of direct and indirect impacts

[16] The term 'hazard' is commonly used to mean something that could cause harm.

and losses arising from a flood, or impossible to know in the case of the precise probability of an extreme or unlikely event occurring. Moreover, this will sometimes require groups or individuals to estimate as best as possible to properly prioritize the implementation of risk management decisions. Importantly, when the risks cannot be assessed with sufficient confidence to inform decision-making but there nonetheless is good reason to believe that harmful effects may occur to human or bio-physical systems, regulatory bodies or other decision-making organisations may either ignore the unknown risk or invoke the 'precautionary principle' (MfE, 2008a; MfE, 2008b; Brooks, 2010).

Managing climate change induced risks is about drawing upon the best available information to determine the likelihood of climate impacts, and the secondary or flow-on effects of their consequences (MfE, 2008a; MfE, 2008b). Such information can thereafter be used to select and implement response options that will reduce the risk and associated potential harm or loss. In this way, climate adaptation is basically a risk-management strategy to reduce the imapcts from the rising likelihood of weather and climate-driven hazards (MfE, 2008a; MfE, 2008b). Techniques to manage risk typically fall into four major categories: avoid the risk, reduce the negative effect of the risk, transfer the risk to another party, and/or accept some or all of the consequences of a particular risk (Dorfman, 2007). Further, given the dynamic nature of climate and our expectations for projected impacts and possible response options to change through time, the management of risk under such uncertainty can also be improved through "adaptive management" approaches (MfE, 2008b; Britton *et al*., 2012). That is, iterative processes that recognise changing environmental conditions, and the need to monitor progress in real time and to learn through such processes, can help to deal with the numerous complexities and uncertainties that affect the management of risk[17]. Risks can never be fully avoided or mitigated however, because of financial and practical limitations. Consequently, all organizations and/or groups have to accept some level of residual (remaining) risks (MfE, 2008b; NRC, 2010; Brooks, 2010).

Vulnerability

Definitions of vulnerability to environmental stress and susceptibility vary widely across the different domains of social research (e.g. natural hazards, engineering, development, food security, climate and global change sciences, among others). And subsequently, numerous frameworks, conceptual models, and vulnerability assessment techniques have been developed to advance the theoretical underpinnings and practical applications of vulnerability (Kelly and Adger, 2000; Adger, 2006; Smit and Wandel, 2006). Notwithstanding this scholarship, there are two dominant ways used to explore or 'frame' climate change vulnerability (Kelly and Adger, 2000; O'Brien *et al*., 2007). The first is the 'end-point' approach (also referred to as 'outcome vulnerability'), which considers the projected impacts of climate change on a particular exposure unit (can be either biophysical or social) and the modifying role of adaptation measures to determine the vulnerability. The second is the 'starting-point' approach (sometimes referred to as 'contextual vulnerability') whereby a multidimensional view of climate–society interactions is taken. Typically, attention is given in starting-point studies to the socio-economic and political context within which climate impacts and linked processes take place; and therein a broader scope of possible policy interventions is identified. Noteworthy, O'Brien *et al*., (2007) argue that because each 'framing' or 'discourse' prioritises the production of different types of knowledge, as well as emphasises different types of policy responses to climate change, it is crucial that vulnerability studies be

[17] More simply, this is about learning from experience and mistakes to improve decisions about risk over time.

explicit about the kind of vulnerability actually being explored. In recognition of these differences, our research team combined these approaches to explore present and future community vulnerability at Mitimiti.

Overall, the analysis of vulnerability to climate variability and change helps provide a place to begin to inform decision-making about actions that will limit and/or avoid impacts by supporting coping and adaptive strategies (Kelly and Adger, 2000; Smit and Wandel, 2006). Importantly, this also involves identifying the constraints and barriers that stand in the way of developing and implementing practical and achievable coping and adaptive strategies. In the research documented here, we adopt a definition of vulnerability that is closely aligned with the work of the IPCC, which defines vulnerability as "the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. It is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC, 2007: 883)". A key premise for this work is that ***vulnerability*** in the context of climate change is a function of the ***exposure*** and ***sensitivity*** of a system to climatic risks and the ***adaptive capacity*** of the system to deal with those risks (Figure 3). Furthermore, these "determinants are dynamic (they vary over time), they vary by type, they vary from stimulus to stimulus, and they are place- and system-specific" (Smit and Wandel, 2006: 286).

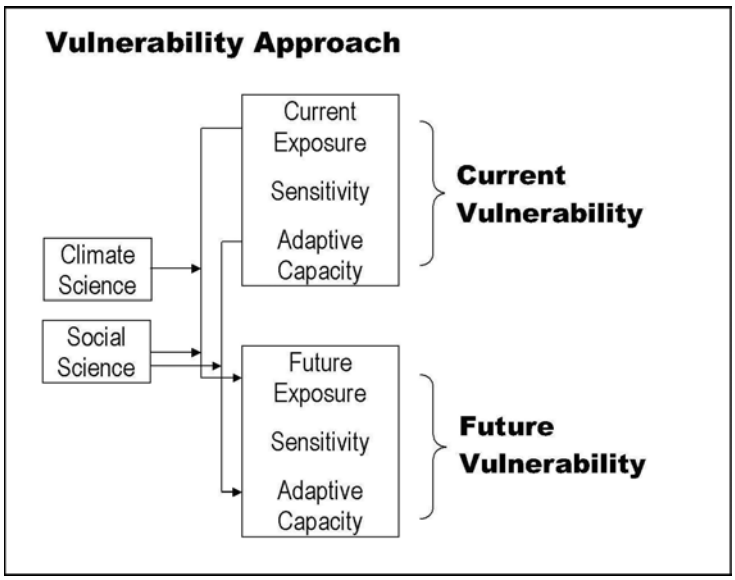

Figure 3: Analytical framework for vulnerability.

Exposure generally refers to the state and change in external stresses that a system is exposed to. In the context of climate change, these are normally specific climate and other biophysical variables (including their variability and frequency of extremes) (IPCC, 2007). The main characteristics of these stresses include their magnitude, frequency, duration and areal extent of the hazard (Burton *et al*., 1993). For the purposes of this study, we classify physical determinants as exposure.

Sensitivity refers to the factors that contribute or influence the degree to which people (or a system) are directly and/or indirectly affected, either adversely or beneficially, by climate variability or climate change (IPCC, 2007). Typically, sensitivity (as well as adaptive capacity) in community-based vulnerability studies emphasizes the importance of non-climatic factors such as age, income levels, economic resources, housing type and construction, living

arrangements, infrastructure, technology, information and skills, institutions, and equity in amplifying or attenuating vulnerability alongside the nature of the climatic stress (i.e. exposure) (Kelly and Adger, 2000; Smit and Wandel, 2006; Ford *et al*., 2010). In line with these previous studies, our work also interprets sensitivity within the socio-political and economic context that particular climate stresses and/or impacts take place. Acknowledgement of antecedent conditions is also crucial, which highlights place-specific and multi-scale processes that occur within and between social-ecological systems (Cutter *et al*., 2008). As Kelly and Adger (2000: 329) point out, this "…may well determine vulnerability not only to climate stress but also to other forms of environmental and societal pressures".

Adaptive capacity describes the ability of a system to adapt to climate change to moderate potential damages, make use of opportunities, or cope with adverse impacts (IPCC, 2007). This definition covers two distinct aspects: one is coping or tactical capacity (i.e. the actions performed in response to immediate climate stresses), and the other may be regarded as an ability to adapt (i.e. the capacity to change system exposure or sensitivity to reduce future impacts) (Eriksen and Kelly, 2007). Some communities may have high coping capacity but possess low adaptive capacity due to resourcing. Both coping capacity and the ability to adapt can change over time because of social and economic changes. However, coping capacity usually implies a return to a previous state, while the ability to adapt does not assume that an original state should or can be maintained, but rather it is a more future oriented and long-term process. Determinants of adaptive capacity typically include financial, human and technological resources, knowledge, education and health status, social networks, governance structures, and existence of natural and man-made assets (Adger *et al*., 2007). Importantly, high adaptive capacity does not guarantee that adaptation will in fact occur because numerous barriers can limit its practical implementation, and further there are some fundamental questions about absolute limits to adaptation (depending on the magnitude and rate of change) (Adger *et al*., 2005). Hurricane Katrina and its impacts on New Orleans in the USA are a well-known example of a region with high adaptive capacity (as measured by most criteria) but failure to implement effective and long term adaptation measures to hurricane flood risk.

Resilience

The emergence of the concept of resilience has its roots in interpreting ecosystems. Holling (1973: 14) is widely recognised for his early use of the term to describe the ''measure of the persistence of ecosystems and their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables". More recently the global environmental change community has been active in conceptualising resilience in terms of socio-ecological systems (or human-environment interactions) (Janssen *et al*., 2006). Consequently, resilience has now come to be most frequently defined as "the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organisation, and the capacity to adapt to stress and change" (IPCC, 2007: 880). This definition includes not only a system's capacity to return to the state (or multiple states) that existed before the disturbance, but also to advance the state through learning and adaptation (Adger *et al*., 2004; Klein *et al*., 2003; Folke, 2006). One might therefore say that a socially resilient system is a system that has minimised its vulnerability through successful application of adaptive capacity.

Important to the work carried out in this place-based study, a major criticism of resilience as a concept is that it tends to downplay or ignore higher-level systemic and structural issues

that may be the root causes of vulnerability (Kirmayer *et al*., 2009). More recent approaches therefore tend to emphasise the global, cultural and other contextual factors that impact on indigenous resilience (Ungar, 2008), and the importance of multiple elements, ranging from spiritual factors, collective strengths, access to resources, governance and risk prevention, among others (Durie, 2005[18]; Te Puni Kookiri, 2009). However, class, power, gender and ethnicity are often ignored in resilience framings that assume people are able to be reflexive and make rational choices around risk (Lupton, 1999)[19]. Moewaka-Barnes (2010) therefore poses the question: what types of challenges are acceptable and what happens when challenges are inequitable and on-going? Remaining mindful of these qualifications and questions, given that we are concerned with matters such as the ability of communities and associated institutions to go on flexibly adapting behaviours and rules over time, then the concept of indigenous resilience nested within (and alongside) an overall vulnerability systems structure still seems potentially valuable[20].

Adaptation

In the research here, we adopt a definition of adaptation that is closely aligned with the work of the IPCC (2007: 881): that is, adaptation to climate change is defined as "an adjustment in ecological, social or economic systems in response to observed or expected changes in climatic stimuli and their effects and impacts in order to alleviate adverse impacts of change or take advantage of new opportunities". This definition includes the notion that adaptation can be indirect and not necessarily a conscious response to observed climate changes and/or their effects, as well as anticipatory, planned or proactive (i.e. as a result of deliberate policy decisions in anticipation of future changes and effects). A common analytical approach towards facilitating climate change adaptation typically focusses on: (i) reducing the sensitivity of the system, (ii) altering the exposure of the system, and (iii) increasing the resilience of the system (social and ecological) to cope with changes (Adger *et al*., 2004).

Importantly, adaptation varies "not only with respect to climatic stimuli but also with respect to other, non-climatic conditions, sometimes called intervening conditions which serve to influence the sensitivity of systems and the nature of their adjustments" (Smit *et al*., 2000: 235). Smit *et al*., (2000) provide a useful example of a drought that produced similar crop yields in two different regions, but quite distinct impacts on people within these two areas because of differing economic and institutional arrangements as well as different adaptive responses over different time frames. Adger *et al*., (2004: 78) similarly argue that "adaptations are not isolated from other decisions, but occur in the context of demographic, cultural and economic change as well as transformations in information technologies, global governance, social conventions and the globalising flows of capital and labour - it can therefore be difficult to separate climate change adaptation decisions or actions from actions triggered by other social or economic events". In short, it is unlikely that adaptation decisions and actions by communities will be taken in light of climate change alone. Rather, there is mounting evidence that climate change adaptation initiatives and opportunities will be

[18] According to the Durie (2005: 235) endurance "represents the outcome of innate strengths, resilience, the availability and utilisation of resources, environmental synergies, and the impacts of societal and global change. It is a dynamic journey that extends over time, interacting with spiritual, physical, and social systems, and encountering barriers as well as opportunities… it is a product of vision, innovation, and wise leadership, and it is served by a determination not simply to survive but to live productive, meaningful, and rewarding lives without being subjected to hostile environments, oppressive forces, or an impoverishment of resources".

[19] A growing scholarship shows that indigenous resilience generally has roots in a history of colonisation (Te Puni Kōkiri, 2009).

[20] Note the concept of sustainability is also central to studies of resilience because the resilience of communities is inextricably linked to the condition of the environment and the treatment of its resources.

integrated with other programs and strategies (e.g. natural hazards management, land-use planning and infrastructure replacement, among many others) (Smit and Wandel, 2006; Moser and Ekstrom, 2010).

1.5 Previous climate adaptation research with Indigenous peoples

A review of published studies on indigenous adaptation to climate change reveals that the experience of the Inuit in northern Canada has attracted more climate change related research than any other indigenous group (possibly even more than for all other indigenous groups put together). Some of the earliest research to focus on indigenous communities and climate in the Canadian Arctic recognised from the start that indigenous groups have throughout time demonstrated adaptability and resilience in the face of changing conditions (Sabo, 1991; Cruikshank, 2001; Berkes and Jolly, 2001), as well as faced limits to coping and adapting to climate changes, variations and extremes (Brody, 1987; Krupnik, 2000; Berkes and Jolly, 2001). These research contributions have more recently been added to by a rapidly expanding library of local studies on climate change vulnerability, adaptation, and resilience with 'northern' indigenous peoples. A few place-based studies relevant to this project include the work of Ford *et al*., (2006a), Wenzel (2009), Pearce *et al*., (2010), and Ford *et al*., (2010).

Ford *et al*., (2006a) developed a vulnerability-based approach to characterize the human implications of climate change in Arctic Bay, Canada. These authors concluded that Inuit in Arctic Bay possess significant adaptive capacity in the face of changing climate-related exposures. This adaptive capacity includes mechanisms such as traditional Inuit knowledge, strong social networks, flexibility in seasonal hunting cycles, some modern technologies, and economic support. However, changing Inuit livelihoods have also undermined certain aspects of adaptive capacity, and have resulted in emerging vulnerabilities in certain sections of the community. Meanwhile, in the paper: "If the climate changes, must the Inuit?" Wenzel (2009) attempted to get to the heart of the cultural question of climate change in the Arctic. While the author largely skirted around this core question, it nonetheless raised some valid issues – namely that biophysical change alone is not an insurmountable threat; rather the greatest threat comes from the politics of climate change. In particular, the paper argues that resource substitution and mobility, used by Inuit ancestors during periods of climate extremes in the past, are now severely constrained by outside actors and the move to permanent settlements. While the paper largely fails to answer the question it poses itself in its title, it does stress that in order for Inuit subsistence culture to survive it needs to be defended in light of outside environmental pressures that may seek to constrain its potential for adaptation.

More recently still, Pearce *et al*. (2010) presented an easy to follow assessment of climate related vulnerability facing the community of Ulukhaktok in the Northwest Territories of Canada. This study was predicated upon the rationale that limited work had been undertaken regarding the implications of climate change for indigenous people and their livelihoods, and their capacity to deal with and adapt to changing conditions. These authors concluded that "Inuit in Ulukhaktok are coping with climate change related changes by taking extra precautions when travelling, shifting modes of transportation, travel routes and hunting areas to deal with changing trail conditions, switching species harvested, and supplementing their diet with store-bought foods" (Pearce *et al*., 2010: 157). However, limited access to capital resources, changing levels of traditional knowledge and land skills, and substance abuse were identified as key constraints to adaptation. And further, Ford *et al*. (2010) examined

how policy intervention can assist Inuit communities to adapt to climate change. The authors make clear that opportunities for adaptation are available through the considerable adaptive capacity that Inuit possess on the one hand and through policy interventions on the other hand. These interventions include: (i) teaching and transmission of environmental knowledge and land skills, (ii) enhancing and reviewing of emergency management capability, (iii) supporting flexible resource management regimes, (iv) providing economic assistance to support adaptation among households with limited income, (v) increasing research efforts to help improve understanding of short-term and long-term risk factors and the diverse options for different places, (vi) protecting key infrastructure, and (vii) promoting of awareness about climate change impacts and adaption among policy makers.

A selection of other notable publications related to indigenous vulnerability and adaptation to climate change from the Canadian Arctic include: Berkes *et al*., (2003); Ford and Smit (2004); Smit and Wandel (2006); Furgal and Seguin (2006); Ford *et al*., (2006b), Ford *et al*., (2007); Ford *et al*., (2008); Ford (2009); Ford and Furgal (2009); and Laidler *et al*., (2009). In spite of an increasing indigenous voice concerned about climate change impacts in the neighbouring U.S.A., there has been very limited climate change adaptation research produced for, or by, Native American peoples to date[21]. Some of the exceptions include the work of Houser *et al*., (2001), which is part of the foundation report completed by the National Assessment Synthesis Team (NAST) for the U.S Global Change Research Program. These authors provide a broad overview of the potential environmental, social and ecological impacts of climate change on Native American peoples and their homelands throughout the U.S.A. In turn, they discuss impediments to climate resilience, many of which exist for reasons other than climate exposure. For example, some native communities are restricted by reservation boundaries, and thus, have limited relocation options available to them if their homeland is compromised by climate related impacts. Subsequently, the authors identify three principal strategies for coping and adapting to future climate change impacts, including; (i) enhance education and access to information and technology, (ii) promote local land-use and natural resource planning, and (iii) participate in regional and national discussions and decision-making. In a follow-up report, the NAST (2009) produced an updated account of climate related vulnerabilities facing the U.S.A., including some reference to the unique vulnerabilities which affect Native American communities. The U.S. Army Corps of Engineers most recently directed vulnerability assessments for coastal flooding and erosion for six native Alaskan communities – leading to a proposal to relocate these communities inland at an estimated cost US$30-50 million per community (NRC, 2010). Note the reasons for the limited research conducted to date in this space have been attributed to other priorities dominating the focus of both governmental agencies and local peoples themselves – most importantly poverty, unemployment and dislocation, among other ‘everyday’ social-ecological challenges (Finan *et al*., 2002).

With respect to Scandinavia, investigations into the impacts of climate change on the indigenous Saami people, and their adaptive capacity, are negligible (at least those in published in English), and appear to be largely through the lens of its effects on reindeer husbandry (Weladji and Holand 2003; Weladji and Holand 2006; Tyler *et al*., 2007; Rees *et al*., 2008). More recently, Keskitalo and Kulyasova (2009) investigated the adaptive capacity of two small-scale coastal fishing communities in Finnmark, northern Norway. Saami peoples of the area were identified as “Sea Saami”. The study found that adaptation for indigenous

[21] Considerable grey literature exists on this rapidly emerging topic; however, the boundaries of this review prevent this material being included.

and non-indigenous coastal fishing groups is highly dependent on regulation, legislation and market mechanisms including: increased competition; changes in the economic and employment structure of the region; and access to quota - circumstances which sit beyond the control of the local community. Keskitalo (2009) also examined the complexity of climate change vulnerability for renewable-resource sectors such as forestry, fishing and (mainly indigenous) reindeer herding in northern Norway, Sweden and Finland. These authors concluded that there are a number of international and regional levels of influence which shape the adaptive capacity of communities as they struggle to comprehend (and respond to) globalising factors, such as internationalisation of economies and the changing role of the state. In addition, this study found that stakeholders with limited economies and political capabilities were most vulnerable to climate change, as successful adaptation, even at the local level, often required access to considerable resources and ability to influence international decision-making processes and complex governance networks.

What little published research on Pacific Island communities exists tends to either view their experience as a microcosm of the wider changes and adaptive responses required for all people to cope with the predicted impacts of climate change (Mimura *et al*., 2007) or enter into discussions and debates about migration as a coping and adaptation strategy (Barnett and Adger, 2003; Barnett, 2005; Mortreux and Barnett, 2009; Boncour and Burson, 2009). Barnett and Adger (2003) contend that overstating the dangers of climate change may lead investors and aid donors to reconsider the worth of financial support. Further, if internalised by local people, this overstatement may even lead to practices of unsustainable development, such that the impacts of climate change materialise more through the idea of climate change rather than through actual changes driven by climatic processes. Similarly, Barnett (2005: 328) suggests that encouraging migration as a solution to climate change detracts from the need for adaptation policies to allow people to ''lead the kind of lives they value in the places where they belong''. Mortreux and Barnett (2009) presented evidence collected from Funafuti – the main island of Tuvalu – to challenge the widely held assumption that climate change will, or should result in large-scale migration from Tuvalu. Their work shows that for most people climate change is not a reason for concern, let alone a reason to migrate, and that would-be migrants do not cite climate change as a reason to leave. People in Funafuti wish to remain living in Funafuti for reasons of lifestyle, culture and identity. Somewhat differently, Boncour and Burson (2009) examined (from a distance) climate change and migration in the Pacific, and pointed out that while migration may be a climate change adaptation strategy, it could well run into conflict with border security. A lack of data and understanding on how people will respond to the impacts of climate change, however, makes any predictions about migratory behaviour difficult to assess. The paper nonetheless stresses that migration should be given weight as a useful adaptive response.

In spite of these analyses there remains a dearth of studies that have considered the capacity of social (and ecological) systems to adapt, and the constraints and limits to adaptation for Pacific Island peoples (Barnett and Adger, 2003). Some exceptions include Barnett (2001); Sutherland *et al*., (2005); Hay and Mimura (2006); Bridges and McClatchey (2009); and Rasmussen *et al.,* (2009), among others. Although theoretical in approach, Barnett (2001) investigated the problem of scientific uncertainty and the way it impedes planning for climate change and accelerated SLR in Pacific Island countries. Shortly thereafter, Sutherland *et al*. (2005) reviewed a community based vulnerability assessment to climate change in Samoa. This involved exploring future changes in climate-related community exposure and associated challenges in terms of future adaptive capacity. These

authors concluded that enhancing adaptive capacity will only be successful when it is integrated with other policies such as disaster preparedness, land-use planning, environmental conservation, coastal planning, and national plans for sustainable development. Meanwhile, Hay and Mimura (2006) examined the linkages between climate and sustainability in the context of local level climate risks and adaptation responses for the wider Asia-Pacific region. In their analysis of a series of regional and local case studies, climate change is viewed as both an impediment to increasing sustainability and as an opportunity, though in most cases the former far outweighs the latter. Assessments of climate change vulnerability and risk are shown to be of critical importance because they inform decisions as to where resources for adaptation are best invested. Thereafter, Bridges and McClatchey (2009) attempted to understand general resilience and vulnerability to climate change through the experience of villagers living on low-lying atolls in the Marshall Islands. These authors concluded that atoll life forces recognition of the 'boundedness' of small ecosystems, and as such has resulted in social systems that utilize a parallel sort of logic in order to further support continued existence in marginal environments. However, successful adaptation by island dwellers in the past is no guarantee of success in the future. Rather, greater flexibility in resource management may be required to cope with predicted changes resulting from climate change. Further still, Rasmussen *et al*., (2009) examined, among other questions, to what extent the traditional Polynesian social structure reduces vulnerability and enhances adaptive capacity. These authors concluded that the Polynesian value system helps to reduce vulnerability because people feel a responsibility to look after their wider family, clan members and neighbours. Similarly the traditional system of redistributing food resources is also considered critical tool for increasing resilience.

Finally, there is a growing, yet comparatively smaller quantity of research available on indigenous adaptation to climate change in Australia (Hennessey *et al*., 2007). Initial research contributions were largely concerned with the potential impacts of climate change on the health and culture of Indigenous Australians (Braaf, 1998; Green, 2006; Altman and Jordan, 2008; Green, 2009; Green *et al*., 2009). For example, Green *et al*. (2009) examined the potential impacts of climate change on indigenous people across tropical Northern Australia. Focussing on biodiversity, health, infrastructure, education and livelihood opportunities, the scoping study concluded that there can be no one-size-fits-all approach to producing adaptation strategies and that collaboration and partnerships will be key to the development of future adaptation strategies. Most recently these efforts have been added to by the place-based adaptation-focussed research of Petheram *et al*. (2010) and Green *et al.* (2010). Interestingly, Petheram *et al*. (2010) conducted workshops and in-depth interviews in two 'communities' to develop insight into Yolngu peoples' observations and perspectives on climate change in North East Arnhem Land (Australia), and their ideas and preferences for adaptation. Among other valuable insights, the respondents concluding strongly that climate change adaptation policies would need to address current non-climate issues too – because they were so interconnected and overwhelming in comparison to climate change. Respondents' preferences included greater self-sufficiency, independence, empowerment, resilience and close contact with the natural environment. The results suggest that strategies and policies are needed to strengthen adaptive capacity of communities to mitigate existing poverty and well-being issues, which will in turn assist with responding to changes in climate.

1.6 Research objectives

This work seeks to understand the contextual conditions and/or drivers of Māori 'community' vulnerability, adaptation and resilience to climate variability and change in a coastal-river

reach environment. A step guide to conduct such work involves (i) assessing the present exposure, sensitivity and adaptive capacity of the community to climate related coastal hazards, (ii) exploring future scenarios of climate-induced coastal impacts to consider future risks, constraints, capacities and opportunities. We do not seek to presume any of these community variables, but rather to identify these empirically through open conversations with *te hau kāinga* [home-people] from Mitimiti. Through this work it is expected that grounded information will be generated to assist the community at Mitimiti to identify community relevant options for adaptation action and planning to cope, and contend with, future climate conditions and challenges at the coast. It is also expected that this work will contribute broader lessons to assist adaptation planning by other communities as well as central and local governments to the direct and indirect impacts of climate change.

Specifically the objectives of this project are:

- To examine the processes that contribute to 'community' vulnerability as well as those processes that lead to adaptation – paying close attention to the impediments and strengths that facilitate or constrain adaptations.
- To explore selected future scenarios of climate-induced coastal change and consider how the potential impacts and risks facing the 'community' at Mitimiti might change under altered environmental conditions.
- To identify coping practices and adaptation strategies that assist in reducing vulnerability (and building adaptive capacity) appropriate to the community at Mitimiti.

In order to realise these objectives the study comprises the following ten key phases:

Phase I: Review previous work and research

Phase II: Establish conceptual framework, research approaches and methods

Phase III: Examine current climate-induced coastal hazards

Phase IV: Explore community vulnerability to climate-induced coastal hazards

Phase V: Model projected SLR and coastal river-reach flooding scenarios

Phase VI: Consider climate-induced coastal changes and future community risks

Phase VII: Discuss community constraints, capacities and opportunities

Phase VIII: Identify options for managing future vulnerability, endurance and adaptation

Phase IX: Summarise results

Phase X: Reflect on the study outcomes

2 Mitimiti - North Hokianga

This section provides background information on the people and landscapes within and surrounding the settlement of Mitimiti. It also provides a brief overview of previous coastal change and process studies conducted in and around the area. Note there may be other 'grey' reports or studies conducted in and around this catchment area; however any such written sources of information were unavailable for this review.

2.1 Mitimiti settlement

Mitimiti settlement in the northern Hokianga of Northland consists of approximately 50 full-time residents, all of whom hold *whakapapa* links to the area. Residents principally trace their decent through the the *hapū [sub-tribal kin group]* of Te Tao Mauī, who hold *mana whenua* [territorial rights] in this *rohe* [area, boundary, district, region]. Mitimiti is one of a number of small *whānau* [extended family] and *hapū* based settlements in the North Hokianga area that link to the northern *iwi* confederation of Te Rarawa. Mātihetihe[22] Marae [meeting house and surrounding area] is the focal point of the community at Mitimiti (Figure 7), and is one of 23 marae that elect a delegate to sit as a Trustee for the board which governs the legal entity of Te Rūnanga o Te Rarawa (Mātihetihe Marae: Hapū Plan, 2011).

Figure 7: Mātihetihe Marae, Mitimiti – North Hokianga.
Source: D-N. King (2011).

Archaeological sites around Mitimiti, including several historical *pā* [village, settlement] and terraces, are evidence of the long-standing connection that Te Tao Mauī have with this

[22] The name Mātihetihe refers to the coastal native tumbleweed or tihetihe that once grew abundantly along the sand dunes. The tihetihe plays a vital role in the life cycle of the toheroa (*Paphies ventricosa*) - a large bivalve mollusc which is a taonga species of Te Tao Mauī. The toheroa spat would be distributed along the coast latching onto the tihetihe plant (Mātihetihe Marae: Hapū Plan, 2011).

coastline and its resources (Grouden, 1992; Mātihetihe Marae: Hapū Plan, 2011). Early Māori occupation caused some disturbance to the landscape surrounding Mitimiti, but these impacts were largely localised, dominated by the clearance of land for settlement and gardens for food provision (Willetts, 1985). The commencement of Eurpoean arrival in the 19th century and the associated trading and exploitation of natural resources is understood to have had considerable impact upon the biophysical and social environment at Mitimiti. For example, a flax mill was set up by two European entrepreneurs during the early 1870s in the valley surrounding the Moetangi Stream. The reasons for choosing this site were made clear in Alfred Yarborough's description of his first visit to the area in August 1972… "…we came to Moetangi, the proposed site of the Flax Mill. We cantered, up a stream through the sandhills, upon a beautiful valley with flax growing tall enough to hide a horse and man, reaching up to the top of the hill all around, lots of water and plenty of firewood" (Grouden, 1992: 44). However, in spite of the large quantities of flax harvested the mill was in operation for only two years before it was closed down in 1874 due to a fall in external demand.

Throughout the first half of 20th century, small cattle and sheep farms dominated the rural economy of the Mitimiti coast and large *whānau* gardens were commonplace. However, like many other rural Māori communities in A/NZ, many of the residents of Mitimiti left during the 1940s, 50s, and 60s in search of secure employment in nearby towns and cities. Many of the descendants of these individuals and families live in the wider Northland region, and in cities (most commonly Auckland) and to a lesser extent overseas – in particular Australia. In spite of this, many of the *whānau* who migrated to cities retain strong connections to Mitimiti; even those generations who have never been full-time residents identify Mitimiti as their *tūrangawaewae* [a place to stand, home grounds through rights of kinship and *whakapapa*], retaining their physical, social and cultural relationship with the *rohe*. This means that resident numbers can swell during *hui* [assemble, meeting, gathering], *tangi* [funeral, grieve, cry], *hura kōhatu* [unveiling – a ceremony at the graveside to unveil the headstone], birthdays, weddings, and during holiday periods, especially in the summer months (Mātihetihe Marae: Hapū Plan, 2011). For the *ahi-kā* [home-people] employment opportunities remain scarce, with considerable dependence placed upon the forestry industry[23]. To a lesser extent, some residents are involved in public sector employment through education, health and conservation of the Warawara native forest.

The present settlement at Mitimiti is supported by Mātihetihe marae, Mātihetihe School and the Catholic Church. Mātihetihe marae is nestled behind sand dunes and comprises a *wharenui* [main meeting house at a marae], *wharekai* [dining room at a marae], ablution block, a church, and elevated above the *marae* complex atop a small hill sits the *urupā* [cemetary] – Maunga Hione. It is the only *marae* that sits on the stretch of coastline between the Hokianga and Whangapē harbours on the edge of Te Moana Tapokopoko-ā-Tawhaki (Tasman Sea)[24]. The *wharenui* was originally built facing seaward as most *manuhiri* [guests, visitors] arrived by boat, but when it was destroyed in a storm and re-built in the early 1950s it was named Tumoana and faced inland to accommodate the majority of manuhiri who had begun arriving via the new West Coast Rd (Mātihetihe Marae: Hapū Plan, 2011). Mātihetihe

[23] Exotic forestry began to boom in the Northland region in the 1970's leading to the development of a *Pinus radiata* plantation owned by the Japanese company Juken Nissho Ltd less than 1 km from Mātihetihe Marae (Thode, 1983). According to Collins and Kearns (1999) the West Coast Road (the main road into Mitimiti) now carries the most logging traffic in the Hokianga region.

[24] When reciting their *pepeha* [tribal saying] Te Tao Mauī refer to this shoreline as Te Akau. Te Akau is the shore where "the sea meets the land and the land meets the sea", in reference to the northward journey being made by spirits to Te Rerenga Wairua (Mātihetihe Marae: Hapū Plan, 2011).

School is located some 200m north of the marae offering co-educational teaching for student years 1-8. The school was founded in 1890, and was initially a part-time Native School. Secondary school education is provided at the neigbouring settlement of Panguru, although many *whānau* also send their children to boarding schools in Kaikohe, Whangarei and Auckland.

Like many rural communities in A/NZ, residents travel to neighbouring townships for vital services and provisions (e.g. Panguru is 20 km from Mitimiti and provides access to a health clinic and small store), although household food supplies are frequently supplemented by gardens and traditional *kai* [food, to eat, consume] through hunting, fishing and diving. Notwithstanding these diverse living arrangements and the socio-economic differences between *whānau*, the people of Mitimiti remain independent in many respects and take strength through strong internal relationships and connections to ancestral *whenua [land]*.

2.2 Physiography

Mitimiti is located 36 km due south of Kaitaia on the west coast of the North Island of A/NZ (Figure 4). The Hokianga Harbour is some 10 km to the south and the Whangape Harbour is a similar distance to the north. Bounded by the steep and densely vegetated Warawara Ranges to the east, the Mitimiti coastal strip is characterised by wide sweeping sandy beaches separated by low rocky headlands and seven principal streams (1-6 km stream length) which discharge into the Tasman Sea. From north to south the streams include: Waitaha, Ngatuna, Waikare, Taikarawa, Mitimiti, Moetangi, and Mātihetihe. The beach is a high-energy dissipative system and is fronted by narrow belts of Pleistocene and Holocene dunes (Brook, 1996). Waves often reach heights in excess of 2 metres. The sands are primarily derived from harbours and rivers to the south of Mitimiti (e.g. Hokianga and Kaipara Harbours, and to a lesser extent the Waikato River) and are transported along the coast by south-west swells, longshore drift, semi-permanent rip systems, and locally produced waves. During periods of high wave energy, the surf zone at Mitimiti can extend hundreds of metres offshore, allowing sand to bypass the headlands at the northern end of Mitimiti[25].

To the east of the study area, the Warawara Ranges rise to a peak of 496 m above sea level (Mt Umawera) and comprise well drained Te Kai steep-land soils and strongly leached Tutamoe friable clay. The Tangihua volcanic complex forms the underlying geology of the catchment (Cretaceous to Eocene), which comprises deeply weathered tholeiitic basalt, dolerite, gabbro, and breccia (Christie and Barker, 2007). Streams that descend the ranges are characterised by sequences of steps and waterfalls (Willetts, 1985), which transform into meandering waterways as they flow through the lower-sloped valleys towards the coast. Despite the very steep terrain, there is little sign of hill-slope erosion (Willetts, 1985). The hill country remains covered with original and regenerating podocarp-broadleaf native forest, including the largest stand of high-altitude *kauri* [native coniferous tree] in New Zealand (Conning, 1998). At lower elevations, coastal flora assemblages give way to pastured land that extends up many of the river valleys where floodplains are present. A number of studies have explored the biophysical attributes of the forest (e.g. vegetation structure, geology), as well as the history of human and animal influence on the forest in the Warawara Forest

[25] Note that NIWA explored the potential impact of sand extraction from the beach at Mitimiti in 1998. The final report concluded that the beach at Mitimiti is part of a highly active sand system, and as such a small amount of sand extraction would be unlikely to have a major impact on the coastal geomorphology of the area (Jeffs, 1998). Notwithstanding this, the author noted that there were concerns that the back shore and dunes may be subject to coastal erosion and consequent loss of property if sand extraction were to be take place at Mitimiti.

Sanctuary (Hutchins, 1918; Davidson, 1948; Rawlings, 1969; Willetts, 1985; Geringer, 1992; Conning, 1998).

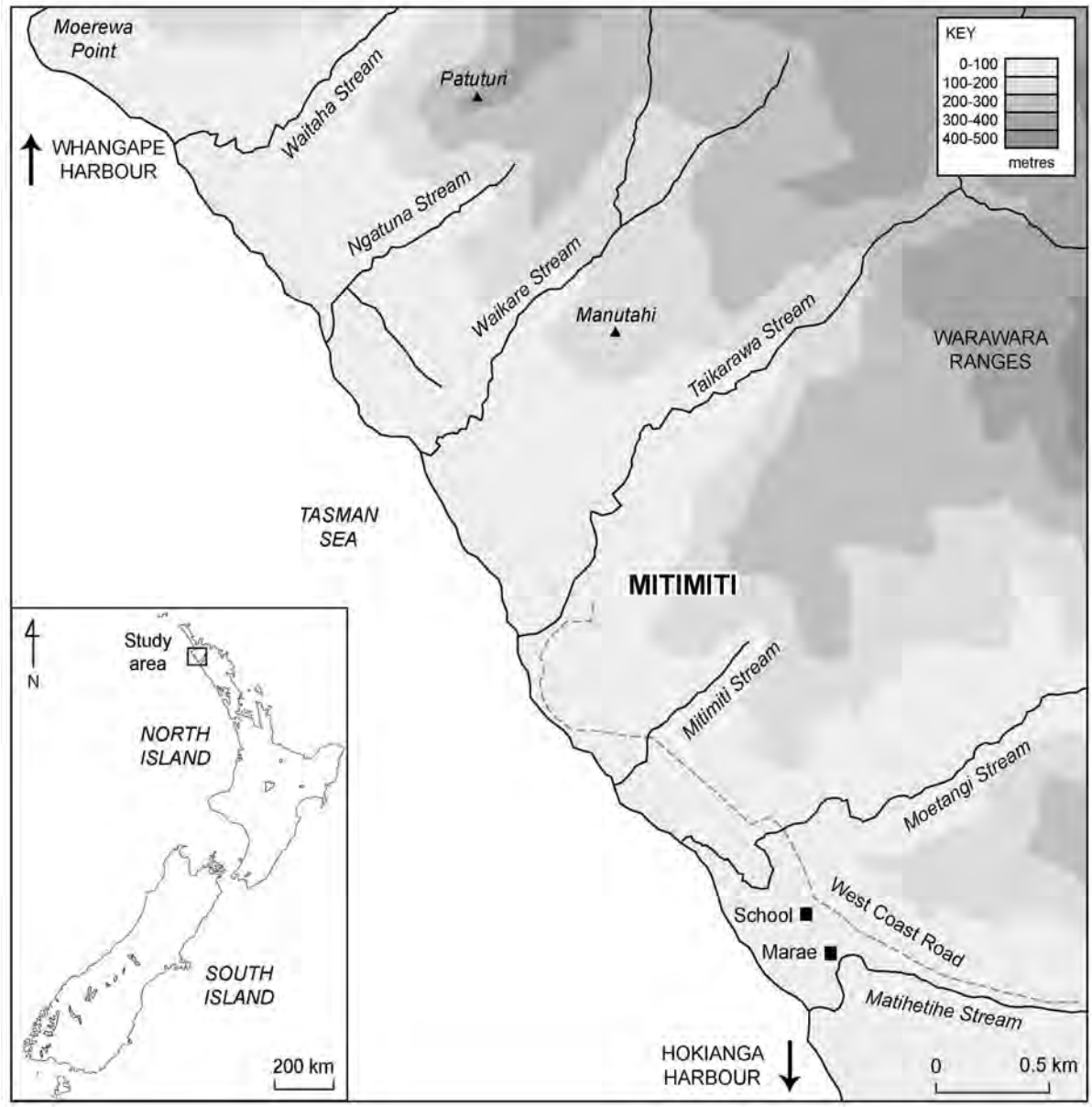

Figure 4: Mitimiti - North Hokianga, Northland.

Due to its northern latitude and close proximity to the sea, Mitimiti has a mild, humid, and relatively windy climate (Moir *et al.,* 1986). Based on meteorological observations from Kaitaia Observatory (the nearest climate station to Mitimiti), the average daily maximum temperature for the area ranges from approximately 24°C in February (the warmest month) to 15°C in July (the coolest month). The average daily range is around 8.0°C. Ground frosts are rare, occurring on average only 1.7 times per year at Kaitaia airport (Moir et al., 1986). Total annual rainfall averages around 1350 mm, with a seasonal pattern showing higher rainfall in the winter months (June-August) (Figure 5). Significant rainfall events may also occur during the summer months due to tropically-derived storms or decayed tropical cyclones. These extreme weather systems occur on average once or twice per year and typically bring heavy rain and strong easterly winds to the Northland region (Moir et al.,

1986). The rainfall distribution patterns in the Mitimiti area are directly related to local orography and hence higher elevations within the Warawara Ranges receive greater rainfall than at the coast.

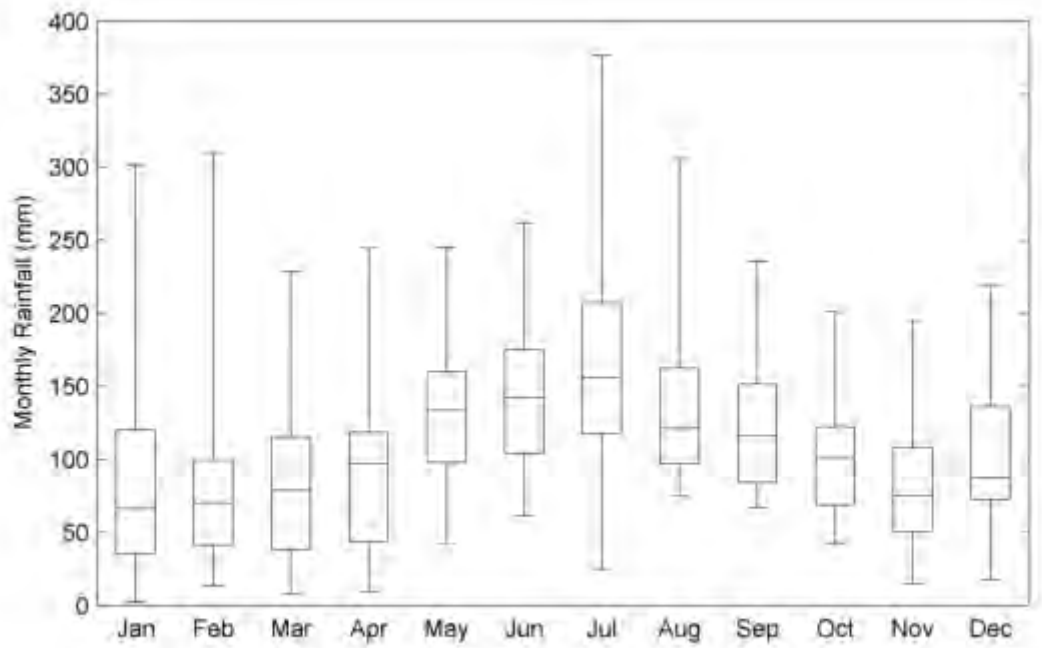

Figure 5: Monthly rainfall for Kaitaia Observatory (1985-2012). The box-plots show the maximum and minimum for each month as well as the values exceeded in 75%, 50% and 25% of years. Source: NIWA Cliflo database (www.cliflo.niwa.co.nz).

The wind climate at Mitimiti is dominated by southwest, west and easterly flows, with mean wind speeds frequently exceeding 20 km/h (Figure 6). Seasonal and diurnal wind variations are also notable, with southwest winds dominant during winter months and the calm days most likely to occur during summer and autumn (Moir *et al.,* 1986). Diurnal variation in wind speed is well marked with the greatest speeds occurring in the early part of the afternoon (Moir *et al.,* 1986).

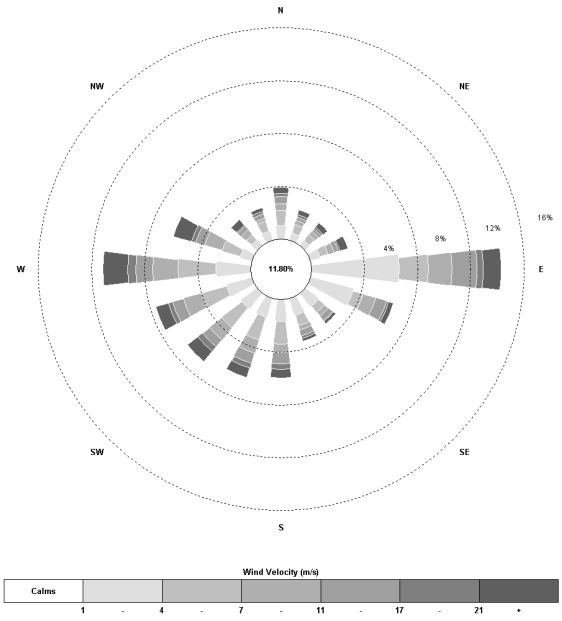

Figure 6: Kaitaia mean hourly wind data: Jan 1986 – Jan 2010

3 Human-environment research approaches

This section summarises **Complex Systems Theory** (also referred to as Complex Systems Science) as a theoretical framework to understand and appreciate the complex interactions and feedbacks that are part of human-environment systems. The framework can be thought of as a set of presuppositions that help to understand inherent system dynamics as well as the issues to be addressed. Nested within this framework, an inductive-based methodological approach commonly referred to as **Grounded Theory** was applied in constructing and completing this project. Deliberately the research team and community partners also formally incorporated a **Community-Based Participatory Research** approach which was informed by Māori-centred research principles. Commentary on the assumptions underpinning the theoretical framework and these reinforcing research approaches, as well as the approval of human ethical standards in working alongside the community at Mitimiti, are described below.

Note the use of qualitative and quantitative research methods for this study are covered in Chapters 4 and 5 and 6.

3.1 Complex systems theory

A common dilemma in environmental change studies centres on the issue of integrating complex processes and feedbacks across different temporal and spatial scales to understand earth as well as human-based systems[26] (Hanson, 1958; Engelhardt and Zimmermann, 1988; Rees, 2010). Complexity of course is inherent within earth (hereafter ecological) systems (e.g. the ocean, the atmosphere, the climate systems, etc.), and is equally a defining characteristic of human (hereafter social) systems which are dependent on different scales and differentially affected by linear and non-liner system outcomes. More broadly still, complexity typifies the interactions and responses between ecological and social systems which also do not necessarily respond in linear, predictable, or controllable ways (Laerhoven and Ostrom, 2007). For example, physical processes within and across hydrological and coastal systems typically operate across different temporal and spatial scales, while simultaneously these processes can be modified by (as well as modify) human-based systems and interactions.

Uncertainty is a central feature of the complexity of social-ecological systems and typically refers to the unpredictability of outcomes of complex systems, particularly non-linear causal relations. For example, if a complex system is influenced by a relatively persistent and increasing forcing function such as SLR, there is no actual guarantee that the response will be straightforward or predictable (Cowell and Thom, 1997). Uncertainty also characterises social systems since “institutional arrangements leave open wide avenues for choice, and each individual’s outcome is dependent upon the action of others” (Ostrom, 2005: 48-49). Further, uncertainty is commonly used to refer to the unknown outcomes of complex interactions between social and ecological systems. This is particularly significant when human interventions have been found to drive social and ecological systems in directions contrary to those intended (Folke *et al*., 2002). Gregory (1994) argues that the selection of a theoretical framework should therefore offer explanations relating to the construction and

[26] The concept of ‘system’ is an organising concept to simplify complex structures and relationships between institutions, economy, society and environment.

conceptualisation of reality and the interplay of different factors in society such as the role of the individual and the role of politics and of meaning.

Complex systems theory has therein evolved as a response to the challenge posed by complexity, uncertainty and unpredictability (as well as risk) in social-ecological systems. It is particularly suited for empirical research concerned with processes of vulnerability and adaptation in such systems (Krupnik *et al*., 2010). Increases and shifts in scientific understanding have also pointed out the limitation of reductionist science, and highlighted the need for researchers to recognise that 'everything is connected to everything else'. Rather than thinking of social-ecological systems and processes as somehow separate and independent, complex systems theory submits that such systems are coupled, integrated and complex in their nature (Holling *et al*., 2002); and that people are embedded within ecological systems (Folke *et al*., 2002). This view is internally consistent with traditional Māori views of the universe and the 'interconnected' nature of all things expressed through elemental concepts such as '*whakapapa*' (Marsden, 2003; Roberts, 2010).

Our understanding of social-ecological processes in this research study is therefore based on a complex systems position that recognises (i) social-ecological systems are a product of complex processes that are space and time-integrated, and (ii) there are limitations to addressing and reasoning complex problems. Our theoretical framework therefore requires that attention be paid to interdependent environmental, economic, social and institutional factors. Practicality of course urges us to integrate and communicate (as best we can) our scientific understanding of complex social-ecological systems and processes.

3.2 Grounded theory

Grounded theory is a methodological approach which denotes the practice of generating theory from research which is 'grounded' in empirical data (qualitative and/or quantitative). The theory was developed in 1967 by Glaser and Strauss in their seminal work the *'Discovery of Grounded Theory'* and later applied in their own sociological studies. Since this time, other disciplines have engaged and applied this theory which is now well established in geography, anthropology and psychology, among other disciplines (Glaser and Strauss, 1967). The emergence of grounded theory was in large part a response to more traditional research approaches where theory was first generated and thereafter tested or validated through empirical field studies. In contrast, the grounded theory approach guides the researcher through the building of theories rather than the testing of theories (Bailey *et al*., 1999). Glaser and Strauss (1967: vii) hoped this new approach might close "the embarrassing gap between theory and empirical research". For further information on the emergence of Grounded Theory please refer to: Glaser and Strauss (1967), Strauss and Corbin (1990), and Pidgeon (1996).

In practical terms, grounded theory is a dynamic and process-orientated approach whereby data is collected and analysed simultaneously, allowing both processes to inform and focus the other throughout the entire research exercise, and thereafter for 'theory' to be discovered. In other words, theory is inductively generated from observations in the field and/or in the recurrent themes or issues in the data collected. As such, Glaser and Strauss (1967: 3) explain that grounded theory will: "…fit the situation being researched and work when put into use. By fit we mean that the categories must be readily (not forcibly) applicable to and indicated by the data under study; by work, we mean that they must be meaningful, relevant and be able to explain the behaviour under study. Grounded theory also places great emphasis on interview participants' own accounts of social and psychological events

and on their associated local phenomenal and social worlds (Pidgeon, 1996). Further, grounded theory emphasises the importance of the relationship between the researcher and interview participant; and therein the need to be aware of ethical considerations, based on obligations to those researched, obligations to society and obligations of relevance (Strauss and Corbin, 1994). Together, these features of the grounded theory approach have a track record of being particularly suited to the study of local interactions and meanings as related to the social context in which they actually occur (Pidgeon, 1996).

For this study, grounded theory was selected to ensure that those involved in the research would remain open to issues which might otherwise have been obscured by a narrow focus on more conventional approaches. It was also expected that this approach would help to untangle the complex nature of factors that make-up Māori community vulnerability (and resilience) to climate variability and change and therein allow the truth to emerge through the voices of those involved - reflecting varied meanings, values, goals and purposes. The grounded theory approach was also expected to assist the interrogation and analysis of the relationships and inter-relationships involved, and to more fully contextualise complex processes of change. Research for this study therefore relies on detailed field enquiry designed to reflect the lived experiences of those who are directly involved in, and/or are influenced by processes of change - historically, socially and politically. Both quantitative and qualitative research methods were used (See: Section 4 and 5 and 6) to ensure that the research recognises the unique physical, social, cultural and other characteristics of the study area and explicitly recognises the complexities of everyday life.

3.3 Community-based participatory research

A community-based participatory research (CBPR) approach was used to complement the application of grounded theory. CBPR is an approach that aims to establish productive working and social relationships between previously unacquainted groups (i.e. the research team (and institute in this instance) and the community). Implicit in this approach is a commitment towards (and encouragement of) sharing of new information, resources and opportunities, and for learning, responsibility, action and shared decision-making concerning the project activities and goals. The willingness of interviewees to participate in the research, and the validity and depth of the material gathered were, to a large extent, based on trust and co-operation developed between the researchers and the interviewees.

Typically, CBPR involves community members in all stages of the research, from project design to interpretation, review and the dissemination of results (Wallerstein and Duran, 2003). Crucially important to the overall process and success of the project was the role of the Mitimiti based project manager, who seamlessly organised project meetings and *whānau* involvement. While climate change was not regarded as the top research priority for the community at Mitimiti the idea of investing ‘community’ time in such a project was recognised as a way to create some initial space to plan, to strategize and to take greater control of climate-induced changes on the coastal environment. Some of the other benefits to be gained from participation in this project include:

- Identifying present and future climate change impacts, risks, adaptive strategies and opportunities facing the community at Mitimiti.
- Prioritising local values and vulnerability affected by existing climate and coastal processes and those likely to be affected by climate change.
- Raising the profile of key climate change issues facing the community at Mitimiti.

- Improving the capacity of the community at Mitimiti to speak the language of climate change and adaptation with local and central governments.
- Incorporating Māori vulnerability and adaptation options/responses into iwi management documents, local planning arrangements and regional plans.
- Recovering local stories and experience of climate and coastal changes from *whānau*, *hapū* and *iwi* history.

Human ethics approval was sought and granted through the social research team at AgResearch Ltd (29/09/2010). In association with this application the following ethical responsibilities were communicated through a work-plan to the community at Mitimiti and applied throughout the project:

- **Honest and clear purpose**: The purpose of the research must be communicated honestly and clearly to an interviewee/s as well as provide an opportunity to clarify any questions s/he may have.
- **Confidentiality**: The information provided by an interviewee is private and confidential, and will only be used for the objective outlined in the purpose of the research. If the information shared is to be included in reports and/or publications this must be made clear.
- **Consent**: Once informed of the purpose the interviewee must agree (give consent) to participate in the research. Typically signed consent forms are used BUT verbal consent is acceptable.
- **Right of withdraw**: The interviewee may withdraw information at any time up to <a given date> without providing a reason.

Importantly, the work undertaken in this place-based study followed an additional set of ethical principles that underpinned the relationship between NIWA, and Mitimiti community members. These principles were applied through an observance of *tikanga* Māori and recognition of the rights, interests and values of *whānau* involved in the research (Smith, 1990; Te Awekotuku, 1991; Durie, 1996; Smith, 1999; Pihama *et al*., 2002, Mead, 2003). The core principles include: *aroha* [sincerity, mutual-respect, love]; *kanohi kitea* [seen face, in person, literally means 'face to face']; *mana* [dignity, authority, control, prestige, power]; *manākitanga* [to support, take care of, give hospitality to visitors, protect, look out for]; *whakapiki tangata* [empowerment]; *māhaki* [humility]; *whakatuia* [integration]; *tūpatotanga* [caution]; and *whakawhanaungatanga* [kinship, process of strengthening relationships].

Finally, this study was expected to generate data, research analyses and knowledge of benefit to the wider community from Mitimiti settlement. Maximising the benefits of this work therefore required agreement between parties to make this information available to a diverse range of interested stakeholders at the conclusion of the project (e.g. Māori authorities and local government). It was therefore agreed that public release of any collaboratively produced research findings would require the approval of both parties. Furthermore, it was agreed that any intellectual property developed jointly with Te Tao Mauī or other providers will in principle be shared, and will be subject to a separate agreement between the parties, as necessary. All matters relevant to the project were subsequently agreed upon via a formal contract for services between NIWA and the Mātihetihe Marae Committee in September 2011.

4 Physical research methods

This section outlines the physical research methods used to generate information about climate-induced SLR along the greater Mitimiti coastline and more detailed analysis of coupled coastal-river reach flooding around Mātihetihe Marae under two climate change scenarios for 2040 and 2090 AD. The principal steps comprised: (i) the examination of first-order changes in Mean High Water Spring (MHWS) extent due to SLR along the greater Mitimiti coastline for 2040 and 2090 AD, (ii) the development of a hydrodynamic model for the simulation of an extreme flood event that occurred in January 1986 at Mātihetihe Marae (Mitimiti), and (iii) the estimation of future inundation extents and depths at Mātihetihe Marae based on the analogue 1986 flood event characteristics under two climate change scenarios, taking into account geomorphological adjustment of the coastal-river reach system and base-level estimates of SLR for 2040 and 2090 AD (MfE, 2008b), respectively. These specific climate-induced coastal hazards were selected for analysis based on existing community knowledge and concerns about present and future climate-induced risks and conditions across Mitimiti. Further, past extreme events are recognised as useful indicators of future vulnerabilities and are therefore invaluable for assessing how climate change might affect river flows and coupled sea-level rise (MfE, 2010). Before outlining these procedures in more detail, background information is provided on the selection of climate change scenarios which are commonly used to explore possible future climates and related outcomes.

4.1 Climate change scenarios

Climate change scenarios, tied to a timeframe, are commonly used to explore possible future climates and related outcomes. The need for scenarios is due to the uncertainty over future emissions of greenhouse gases and aerosols which themselves depend on changes (and uncertainties) in population, economic growth, technology, fossil fuel use and national and international policies, among other factors (IPCC, 2007). Future climate changes generated from such scientific analyses and computer models are therefore called projections, not predictions.

IPCC emission scenarios

In its Fourth Assessment Report, the IPCC presented projections from six emissions scenarios that covered a wide range of possible future economic, political and social developments during the 21st century. These scenarios are known as the “SRES scenarios” after the name of the report, the *IPCC Special Report on Emissions Scenarios* (Nakicenovic and Swart, 2000). Climatologists use model-based ‘scenarios’ to provide plausible descriptions of how the future might unfold when evaluating uncertainty about the effects of human actions on climate. The SRES scenarios are divided into four families, or storylines, that describe distinctly different future developments of economic growth, global population, and technological change. These four families are known as A1, A2, B1, and B2. The A1 family is further subdivided into three groups (A1FI, A1T and A1B), resulting in 6 scenario groups, for which emissions scenarios were developed by the IPCC Working Group III in 2000. The storylines behind the emission scenarios are described in more detail in Box 1. Note the IPCC does not promote any one SRES scenario as being more likely than any other.

All scenarios describe futures that are generally more affluent than today, and in many of the scenarios a narrowing of income differences between world regions is assumed. In most scenarios, global forest cover continues to decrease for some decades, primarily because of

population and income growth. This trend is eventually reversed, with the greatest increase in forest area by 2100 occurring in the B1 and B2 scenarios. Behind these scenarios are assumptions about how demographics, energy use and technology might change. The scenarios do not describe how the particular emissions track might be achieved and, indeed, New Zealand is too small a geographic region to be considered explicitly. Furthermore, as required in the IPCC's Terms of Reference, the scenarios do not allow specifically for political climate initiatives to reduce GHG emissions, such as implementation of the UNFCCC or meeting the emissions targets of the Kyoto Protocol (IPCC, 2007).

Box 1: SRES Storylines

A1: This scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. A major underlying theme is convergence among regions of the globe, with a substantial reduction over time in regional differences in *per capita* income. The A1 family is split into three groups that describe alternative directions of technological change in the energy system: fossil intensive (A1FI), non-fossil energy sources (A1T), or a balance across all sources (A1B).

B1: This scenario family describes a convergent world with the same population trajectory as in the A1 storyline, but with rapid changes towards a service and information economy, with reductions in material intensity, and the introduction of clean and resource-efficient technologies.

A2: This scenario family describes a very heterogeneous world, with the underlying theme of self-reliance and preservation of local identities. Global population increases continuously, economic development is regionally oriented, and *per capita* economic growth and technological change are more fragmented and slower than in the other storylines.

B2: This scenario family describes a world that emphasises local solutions to economic, social and environmental sustainability (i.e., a heterogeneous world as in A2). Global population increases continuously at a rate slower than A2, with intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines.

Source: IPCC, 2007

Global model simulations and down-scaling

For the IPCC Fourth Assessment process, a set of standard experiments was run by science institutions that operated global climate models (GCMs) (IPCC, 2007). A control simulation was made of what was called the 20th century climate, although runs actually started as early as 1860 for some models. The 20th century model simulations used 'observed changes' in solar radiation and volcanic aerosols, in addition to the observed greenhouse gas increases. From the year 2000 onwards, the models were forced by the SRES scenarios. Owing to computing and data storage constraints, only three of the SRES scenarios were studied in detail: all models (a total of 24) examined the A1B mid-range scenario, and most models also completed B1 (low emissions) and A2 (high emissions) simulations.

The output of a global climate model is generally too coarse in terms of spatial resolution to be directly applied within New Zealand. Consequently, NIWA validated the performance of

the GCMs in simulating 20th century climate in the New Zealand-South Pacific region, and selected 12 of the models for 'downscaling' over New Zealand (MfE, 2008a). Downscaling is a technique for building in local scale detail that is consistent with the global model output at a much larger spatial scale[27]. The methodology for downscaling temperature and precipitation is described in MfE (2008a), and the scientific details are provided in Mullan *et al*. (2001). Note that in the MfE guidance manual (2008a), downscaled projections of temperature and precipitation were derived only for the 12 A1B simulations. Since that time, the same downscaling has been applied to GCM output from the B1 (low) and A2 (high) scenarios[28]. All 12 models have been shown to perform adequately in simulating the twentieth century climate of New Zealand and the South Pacific – although the downscaled global model results can differ significantly from one another (See: MfE, 2008a).

Two emission scenarios were adopted for this study (A2 and B2) based on the downscaling results from the 12 most appropriate models (MfE, 2008a), with attention given to the 12-model maximum, average and minimum for '2040' (actually 2030–2049 time period) and for '2090' (actually 2080-2099 time period). This approach is consistent with "The *Climate Change Effects"* manual which suggests choosing a mid-low and a mid-high scenario to help span future possibilities (MfE, 2008a).

4.2 Sea-level rise

The first-order impact of climate-induced SLR for two areas along the Mitimiti coastline was explored for 2040 and 2090 AD using mean SLR projections of 0.4 m and 0.8 m, respectively (MfE, 2008b) (Figure 8). The Mean High Water Spring (MHWS) level exceeded by 10% of all high tides (MHWS-10) was used as the baseline for this analysis. This regular 'twice-monthly' spring tide level at Mitimiti is governed largely by a combination of the twice-daily lunar tide (M_2), the effect of the Moon in its perigee (N_2) as it travels in an elliptical orbit around the Earth each month[29], and the twice-daily solar tide (S_2).

On-shore topography data was collected over 3 days in June 2012 with a real-time kinematic GPS (RTK GPS) survey and was used to map the locations of the MHWS contour line under the two SLR scenarios. This approach for representing SLR is commonly referred to as 'bath-tub' inundation technique as the level of the sea is simply raised up to a specified level to inundate all low-lying land areas below this level. The approach offers a useful first-order approximation of change but more detailed modelling that simulates the combined influence of sea-level, wave run-up, stream-flows and adjustments in stream-bed morphology would produce more realistic scenarios of changing inundation risk through time.

[27] The downscaling procedure uses historical monthly data anomalies to develop regression equations for precipitation and mean temperature, and is applied to a NIWA gridded data set that covers all of A/NZ with 0.05° latitude-longitude (approximately 5 km) boxes. This is more commonly known as the Virtual Climate Station (VCS) network (Tait *et al*., 2006). There are approximately 11,500 grid-points over the A/NZ land mass. For each climate element, the grid-point anomaly is related to three predictors: the large-scale zonally-averaged anomaly over 160–190°E at the same latitude as the grid-point, and the anomalous components of two wind indices known as the Trenberth Z1 and M1 indices (Trenberth, 1976). If there is very low explained variance in the regression at some location, the climate change at that point will effectively be the same as the latitude-average evaluated at the model grid scale. In applying the regression to the future projections, the changes in circulation (Z1, M1 indices derived from model pressure field) and in latitude-average climate (from model precipitation or temperature field), relative to the base period of 1980-1999, replace the observed monthly anomalies.

[28] Note that while the A2 scenario is regarded as 'high' it is not the most extreme SRES.

[29] Eliiptic orbit takes 27.55 days.

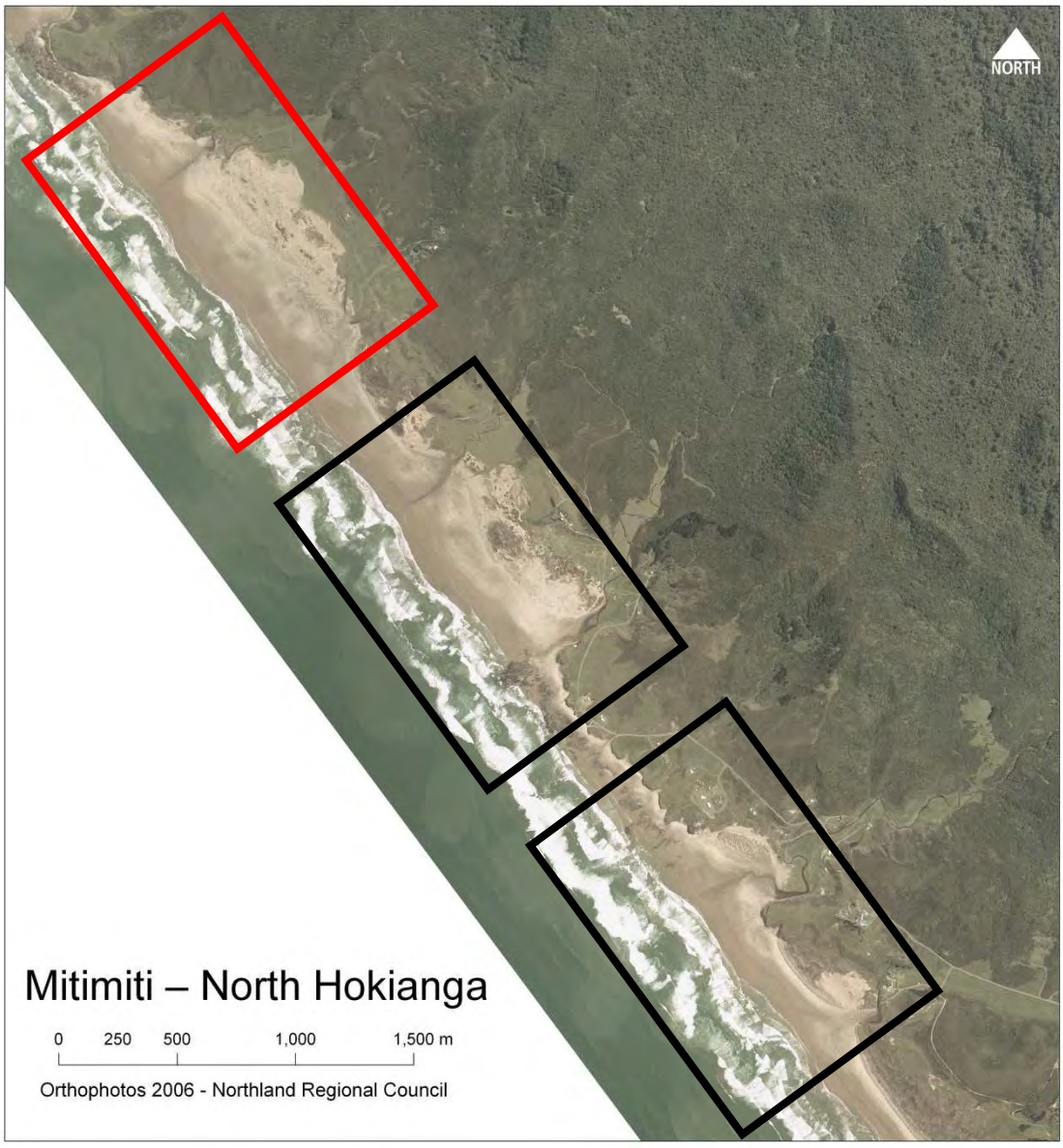

Figure 8: First-order domains for analysis of sea-level rise for 2040 and 2090 AD at Mitimiti. Inundation modelling was not undertaken in the red-box due to insufficient surface data.

Sea-levels for the Mitimiti coast were calculatedfrom Anawhata sea-level data relative to the Auckland Vertical Datum-1946 [AVD–46][30], by assuming that the Mean Level Of Sea (MLOS)[31] at Anawhata 1998-2006 approximately equals the MLOS at Onehunga 2001-2011. Thus sea-level at Anawhata was referenced to AVD-46 by adding +0.22 m relative to MLOS measured at Anawhata to an assumed datum. The MHWS-10 tide level for Mitimiti based on astronomical tides for current sea-level is 1.61 m AVD-46 (Table 1), and using this baseline resulted in future sea-levels of 2.01 m by 2040 AD and 2.41 m by 2090 AD above AVD-46.

[30] Auckland Vertical Datum 1946 (AVD-46) was established as the mean sea-level (MSL) datum at Port of Auckland from 7 years of sea-level measurements collected in 1909, 1917–1919 and 1921–1923. AVD-46 is +1.743 m relative to tide gauge zero at Port of Auckland, which equals chart datum on the east coast, or +2.201 m to chart datum at the Port of Onehunga. Sea level has risen since the AVD-46 datum was established, at a long-term rate of 1.5 mm/yr at Auckland relative to the land (Hannah et al., 2010; Hannah and Bell, 2012).

[31] MLOS is the actual Mean Level Of Sea averaged over a period of at least one calendar year. MLOS is a varying level that includes the effects of long period (>1 year) fluctuations in sea level. These can include the 2–4 year El Niño-Southern Oscillation (ENSO) cycle, the longer 20–30 year Interdecadal Pacific Oscillation (IPO) effect and long-term SLR. It varies, but can be converted to a fixed Local Vertical Datum (i.e AVD-46).

This method is consistent with the risk-based approach described by the Ministry for the Environment in their 'Guide for Local Government: Preparing for coastal change' (MfE, 2008b)[32].

Table 1: High-water tide levels for Anawhata. HAT = highest astronomical tide; MHWPS = mean high water perigean spring (M2 + S2 + N2); MHWS-1 = level exceeded by 1% of all high tides. MHWS-10 = "pragmatic" mean high water spring height exceeded by 10% of all tides; MHWSn = mean high water spring nautical (M2 + S2); MHWNn = mean high water neap nautical (M2 – S2); MHWAN = mean apogee neap (M2 – S2 – N2); Min HW = minimum high water; MLOS – mean level of the sea.

Tide	Relative to MLOS (m)	Relative to AVD-46 (m)
HAT	1.75	1.97
MHWPS	1.53	1.75
MHWS-1	1.61	1.83
MHWS-10	1.39	1.61
MHWSn	1.33	1.55
MHWNn	0.77	0.99
MHWAN	0.57	0.79
Min HW	0.34	0.56

Note that while SLR scenarios above 1 m are generally considered as having lower probability during the 21st century, they cannot be ruled out based on current scientific understanding (RSNZ, 2010).

4.3 Flood simulation modelling

Before incorporating the impact of future SLR and coupled estimates of extreme rainfall and associated flood flows on the Mātihetihe Stream due to climate change, a peak flow estimation model for the Mitimiti catchment was developed based on an extreme rainfall event that occurred on the 4-5 January, 1986[33]. The development of the flood hydrograph for the Mitimiti catchment was limited by the lack of measured flow data in this catchment; consequently, a catchment of similar size, topography, bedrock, vegetation, land cover and soil characteristics, and one preferably located within the same geographical region was sought. Following discussions with a senior hydrologist from the Northland Regional Council (Hansen, 2013: personal communication) and appraisal of the NZ Land Inventory published

[32] The MfE guidance recommends for planning and decision timeframes out to the 2090s (2090–2099): (i) a base value SLR of 0.5 m relative to the 1980–1999 average should be used, along with (ii) an assessment of the potential consequences from a range of possible higher sea-level rises (particularly where impacts are likely to have high consequence or where additional future adaptation options are limited). At the very least, all assessments should consider the consequences of a mean SLR of at least 0.8 m relative to the 1980–1999 average. For planning and decision timeframes beyond the end of this century, an additional allowance of 10 millimetres per year is recommended.

[33] During the night and early morning of the 4th and 5th January 1986, a high intensity rainstorm hit the Whangape Harbour area in north-west Northland causing serious erosion and flooding. The greatest impact of the storm was felt over an area some 16 kilometres long, from Mitimiti in the south to Herekino in the north and from the west coast inland some 5 kilometres (Northland Regional Council, 1986).

by Landcare Research[34], the Mangamuka catchment, located to the north-northeast of Mitimiti, was identified as meeting most of those criteria. Note the Mangamuka catchment (21.75 km^2) is an order of magnitude larger than Mitimiti catchment (1.75 km^2), but has similar geological, land cover, topographical and soil characteristics.

Continuous flow records are available from the Mangamuka Gorge site for 1976 to 1993. From these records, the mean annual flood (MAF) flow was estimated (66.2 m^3s^{-1}), and a total of seven flow events closely matching the MAF were identified between 1976 and 1993. These seven flow events were analysed in detail to derive the times to peak (flow), and a median time to peak (171 minutes) was determined. A design hydrograph for the Mitimiti catchment was also derived for this median flow event (Figure 9). To transfer this median time to peak from Mangamuka to Mitimiti, it was multiplied by the ratio of the longest flow paths in the two catchments. Longest flow path was defined as the farthest point within the catchment to the catchment outlet. It was thereafter assumed that for catchments with similar hydrologic, geological, soil, land cover, topographic and meteorological conditions, the longest flow path would capture the differences in times to peak. The longest flow path for Mangamuka is 8,410 m, and for Mitimiti is 2,518 m. This resulted in a time to peak of 53 minutes for the Mitimiti catchment. Accordingly, a 60-minute (53 minute time to peak approximated to the nearest hour) duration, 100-year return period rainfall event was selected to simulate a flood hydrograph in the Mitimiti catchment.

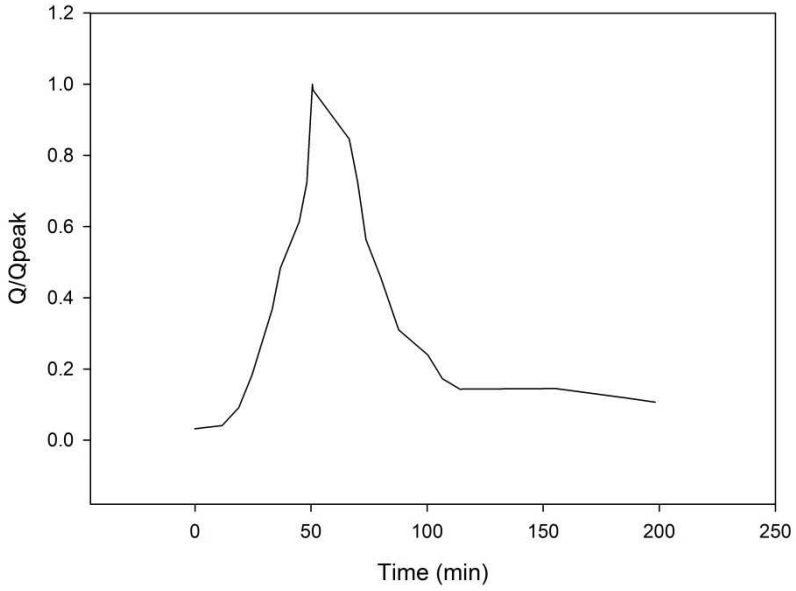

Figure 9: Mitimiti catchment design hydrograph based on the Mangamuka mean annual flood flow hydrograph. Note that 'Time' is the product of time-to-peak for the selected event from the Mangamuka catchment and the ratio of longest flow paths of Mitimiti andf Mangamuka catchments.

NIWA's High-Intensity-Rainfall-Design System, (HIRDS version 3, http://hirds.niwa.co.nz/), was used to derive a 60-minute 100-year return period rainfall event in the Mitimiti catchment. A check on the source data indicated that rainfall data from Herekino, Opanoni and Rotokakahi were used in HIRDS to develop the rainfall predictions for this region. Following further discussions with the Northland Regional Council (Hansen, 2013: personal communication), it was concluded that HIRDS v3 sufficiently represents the region, and hence can be used in this study. For the Mitimiti region, HIRDS predicted that a 60-minute

[34] http://www.mwpress.co.nz/store/viewItem.asp?idProduct=543

duration, 100-year return period rainfall would amount to 52.4 mm. Peak flow for the selected rainfall event was estimated using the rational method as described in Griffiths and McKerchar (2012). Using the design hydrograph from Mangamuka catchment, transferred time to peak and estimated peak flow, a flood hydrograph for the selected rainfall event was computed (Figure 10). This hydrograph was subsequently used within the hydrodynamic model to simulate flood inundation.

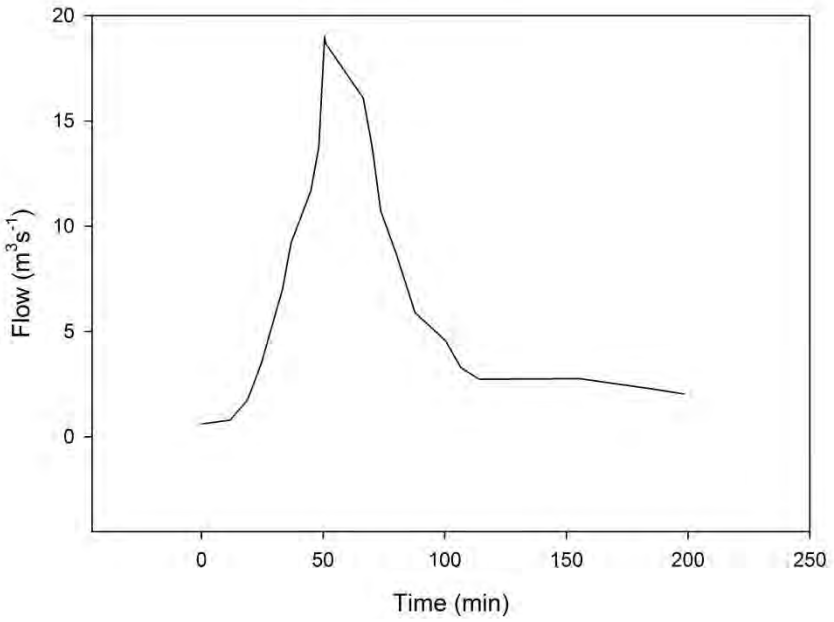

Figure 10: Simulated flood hydrograph for the Mitimiti catchment for a 60-minute duration 100-year return period rainfall event of 52.4 mm per hour. Temporal distribution of flows was derived from the Mitimiti design hydrograph and peak flows estimated using the rational method.

4.4 Flood inundation mapping

The 2-D hydrodynamic model "Hydro2de" (Beffa and Connell, 2001; Beffa, 1996) was used to simulate inundation across the coastal-river reach surrounding Mātihetihe Marae at Mitimiti for 4-5th January, 1986[35]. The channel and floodplain topography data input to the Hydro2de model was based upon a digital elevation model (DEM) that was constructed in this study using real-time-kinematic (RTK) GPS data captured by NIWA surveyors in December 2012. These data have a horizontal accuracy of 0.02 m and a vertical accuracy of 0.03 m. The domain of interest for the Hydro2de flood inundation model is shown in Figure 11. Note that the RTK-GPS data did not cover the domain entirely and hence the missing edge pieces were filled in with data from the NZMG 1:50,000 series maps. These areas had no material effect on the modelled flooding and have been trimmed from some figures. The RTK GPS data were referenced to ellipsoidal heights, converted into elevations in reference to the New Zealand Vertical Datum 2009 (NZVD09) geoid model and then converted to AVD-46 by applying a local geoid offset of 0.34 m after calibration to local survey control.

[35] The Hydro2de model solves the depth-averaged shallow-water equations for a grid using finite volume schemes where the flow variables are located at the cell centre. A notable feature of the model is that it is numerically stable in the presence of hydraulic jumps in braided rivers and flood plains. It has been used effectively in a number of previous flood application studies (Duncan and Carter, 1997; Duncan and Hicks, 2001; Duncan and Shankar, 2004; Duncan and Bind, 2008; King *et al.,* 2012a, 2012b).

Since no bathymetric data were collected for Mātihetihe Stream, interpolated minimum water surface elevations were used instead of actual bed elevations. This assumption was deemed appropriate, given the shallowness of the stream and the large floods that were modelled where an extremely small proportion of the flow is actually contained in the active flow channel.

Figure 11: The red box shows the approximate extent of the flood model domain surrounding Mātihetihe Marae.

Hydraulic resistance assessment

Hydro2de requires an estimate of hydraulic resistance for each model cell (1 m x 1 m). For river beds, this is often based on an estimate of the dominant grain size of the surface bed material. The model offers a choice of several flow resistance parameters. In this study a hydraulic resistance parameter, z0, was used following the work of Smart *et al*. (2002) and Smart (2004)[36]. The land cover in the domain was categorized with the z0 values assigned based on experience with other inundation 2D models (Duncan and Hicks, 2001; Duncan and Shankar, 2004; Duncan and Bind, 2008). The boundaries between significant areas of each land cover type were digitized and appropriate z0 values were assigned to the cells in each cover type polygon.

[36] An advantage of using z0 is that it is a parameter of the velocity distribution rather than a description of the boundary material. Hence, z0 gives hydraulic roughness, as seen by the flow, rather than relying on a boundary resistance characteristic such as bed material grain size. A further advantage is that it changes less with flow depth than some other flow resistance parameters.

Incorporating baseline sea-level

As outline in Section 4.2, the Mean High Water Spring (MHWS) level exceeded by 10% of all high tides (MHWS-10) was used as a baseline to determine the downstream water levels at the coastal-river reach boundary of Mātihetihe Stream in January 1986.

Model calibration

The inundation model developed for this study was calibrated to the 4-5th January 1986 flood, using observations of flood extent and flood depth provided by local residents who were present during the event. These observation points were identified on the DEM and the water depths at those locations were confirmed in the model. The authors are therefore confident of the extent of inundation for this stream because the point of inundation extent was easily identified in the field and on aerial photographs. While there are some differences between the observed and modelled depths at a few locations, the modelled extent and depths are mostly similar to the observations. The hydrodynamic model calibration is therefore as good as can be achieved given the uncertainty in the peak flood flows and rainfall event characteristics (i.e. size, duration), and the observed flood levels[37].

Inundation model uncertainty

Explanations for some of the departures between the modelled and observed flood levels as well as more general uncertainties associated with the coastal-river reach inundation modelling are offered below:

(i) Uncertainty as to the size of the flood in the Mātihetihe Stream and in the smaller tributary channels. There is also uncertainty about the modelled hydrograph shape as it is based on a constant rainfall intensity falling uniformly over the whole catchment and for the time of concentration. This assumed behaviour is unlikely to occur in nature, but as there were no measurements available, these assumptions were necessary.

(ii) Uncertainty in the DEM. The DEM for the modelling domain was derived from RTK-GPS surveying which has a horizontal and vertical accuracy of 0.02 m and 0.03 m, respectively. No RTK-GPS measurements were made in the active stream channel however so there is some uncertainty about the stream bed levels. Notwithstanding this, given the large size of the flood any errors in river bed levels are not likely to materially affect flooding extent.

(iii) Uncertainty in the hydraulic roughness values chosen for the various land cover types. Some polygons may not be homogeneous – that is, a single bush in a paddock will represent highly localized increased roughness. Further, there were no measurements of the size of surface bed material in the stream on which to base hydraulic roughness estimates and therefore a uniform size of bed material for the entire stream was assumed. In reality, bed material size would decrease between the outlet from the hills and the estuary.

[37] True verification requires either knowledge of a different flood (including hydrograph shape and measurements of flood extents and/or depths), or an independent set of measurements of the extent of the calibrated event. Verifying the hydrodynamic model performance by comparing simulated with observed inundation extent poses problems where landscape is relatively steep, since it is possible to model the extent of inundation reasonably well, but to have the water level outside acceptable model uncertainty.

(iv) Uncertainty about the ground surface cover at the time of the January 1986 flood as the land cover was assessed from recent aerial photographs. This could affect the hydraulic roughness of the flood plain through hump and hollow terrain modifications as well as a change in the extent of vegetation adjacent to the river fairway and the width of the fairway.

(v) Uncertainty of the tide level for the model. While the astronomical tide in the open ocean near the Mātihetihe Stream can be accurately modelled and storm surge can be assessed from synoptic weather maps, there is some uncertainly in the amount of wind setup that can contribute to higher or lower water levels, especially where the water is shallow as it is in the Mātihetihe Stream.

4.5 Estimating climate change induced coastal flooding

Downscaled climate projections for New Zealand indicate that extreme rainfalls[38] are likely to increase for different regions of the country (especially in places where the mean rainfall increases) and that these changes will almost certainly impact upon the occurrence of flooding (MfE, 2010). Any estimation of future flood flows must therefore consider new estimates of extreme rainfall under changing climate conditions. In addition, SLR is expected to increase base levels for coastal river reaches, and so, such a factor also needs to be considered when estimating flooding due to climate change. In this study, a procedure outlined in the Ministry for the Environment's *Tools for Estimating the Effects of Climate Change on Flood Flow* manual (MfE, 2010)[39] was followed. This involved: (i) estimating increases in extreme rainfall due to projected changes in mean annual temperature, (ii) estimating changes in flood flows from the new estimates of rainfall that incorporate climate change impacts, and (iii) estimating changes in flood inundation due to climate change impacts on rainfall, river-flow and sea-level[40].

Estimating future changes in temperature, rainfall and peak-flood flows

Projected increases in annual maximum, mean and minimum surface temperatures for the Northland region were obtained for 2040 and 2090 AD, for the respective A2 and B2 climate change scenarios (See: Table 2 - MfE, 2010). These temperature changes were then used to derive new climate change induced extreme rainfall estimates based on a maximum 8% change in extreme precipitation for each 1 degree Celsius of temperature change (MfE, 2008a; Carey-Smith *et al*., 2010)[41]. By applying these temperature and precipitation changes, revised 60-minute duration 100-year return-period rainfall events were determined under each climate change scenario for 2040 and 2090 AD conditions. Table 2 shows the maximum, mean and minimum percentage changes in temperature (T) and rainfall (R) due to climate change for the Mitimiti catchment as well as the resulting peak inflows (P) for Mātihetihe stream for the A2 and B2 emission scenarios for 2040 and 2090 AD. The new

[38] Extreme rainfall is often defined as a rare event that generates an unusually high amount of rainfall (e.g. 95th or 99th percentile rainfall).

[39] The manual provides best practice information and guidance for integrating climate change into flow estimations for each region of A/NZ.

[40] More advanced methods may produce more certain predictions, but this increase in certainty requires increased resources (in terms of expertise, person time and data input requirements) (MfE, 2010).

[41] The current standard guidance for councils and engineers in A/NZ who are planning for extreme rainfall changes under future climate is available in MfE (2008a). This study indicated a maximum increase of 8% per degree of warming for all return periods and rainfall durations – a number derived principally from the Clausius-Clapeyron constraint. Further to this, the full RCM domain covering A/NZ and the surrounding ocean was examined by Carey-Smith *et al*., (2010), and these authors estimated the maximum expected change in extreme precipitation as a function of regional warming to be between 7 and 9% per degree of warming.

estimates of rainfall due to climate change range from an increase of 2.4% to 40% and the future peak flood flows for the Mitimiti catchment range from a corresponding minimum to maximum increase of 2.4% to 40% (refer Table 2). New hydrographs depicting future peak flood flows (i.e. the amount of water flowing in the stream) for the Mitimiti catchment under the two climate change scenarios are shown in Appendix B and C.

Table 2: Climate change induced 60-minute duration 100-year return period rainfall and peak flow statistics for Mitimiti – North Hokianga for 2040 and 2090 AD. Min=Minimum. Max=Maximum. ↑=Increase.

Scenario	**Temperature (°C) ↑**	**Rainfall (mm/ hr^{-1}) 60-min**	**Rainfall (%) ↑**	**Peak flow (m^3s^{-1})**	**Peak flow (%) ↑**
Current climate		52.4		19.01	
A2 Min - 2040	0.4	54.1	3.2	19.62	3.2
A2 Max - 2040	2.2	61.6	17.6	22.36	17.6
A2 Mean - 2040	1.1	57.01	8.8	20.68	8.8
B2 Min - 2040	0.3	53.66	2.4	19.47	2.4
B2 Max - 2040	1.5	58.69	12.0	21.29	12.0
B2 Mean - 2040	0.8	55.75	6.4	20.23	6.4
A2 Min - 2090	1.1	57.01	8.8	20.68	8.8
A2 Max - 2090	5.0	73.36	40	26.61	40
A2 Mean - 2090	2.5	62.88	20	22.81	20
B2 Min - 2090	0.7	55.33	5.6	20.07	5.6
B2 Max - 2090	3.5	67.07	28.0	24.33	28.0
B2 Mean - 2090	1.7	59.53	13.6	21.60	13.6

Incorporating sea level rise projections

The influence of climate induced SLR on peak flood levels and flood extents across the Mitimiti catchment were incorporated for 2040 and 2090 AD using the mean SLR projections of 0.4 m and 0.8 m, respectively (MfE, 2008b). Again, using MHWS-10 at 1.61 m as the baseline this resulted in future sea-levels of 2.01 m by 2040 and 2.41 m by 2090 AD, above AVD-46 (Figure 12).

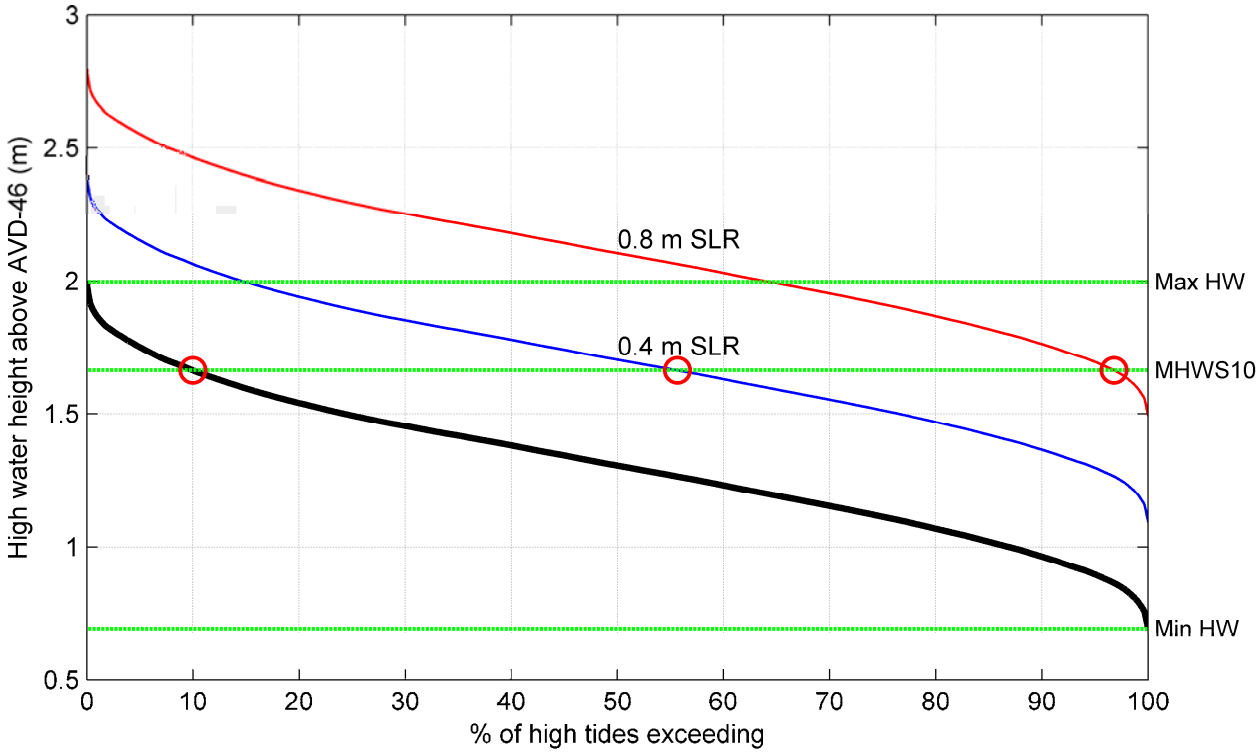

Figure 12: Cumulative high-tide exceedance plot for the nearest tidal recorder at Anawhata. The lower curve is for present-day sea levels and the upper curves are for SLR of 0.4 m and 0.8 m respectively. The curves are based on predicted astronomical high-tide levels and exclude non-tidal components such as storm surge, wave set-up and run-up with the relevant SLR added. High-water heights are relative to a mean level of the sea (MLOS) of zero.

Estimating future adjustments in coastal geomorphology

An additional influence of SLR is that it will raise the level of the small pocket beach at the outlet of Mātihetihe Stream, and to some extent also the level of the stream bed immediately upstream from the beach (Ranasinghe et al., 2012). Both of these morphological responses will affect flood levels.

Currently, the stream exits to the ocean across a small backshore tidal sand flat and then over/through a beach berm. The form and height of the beach berm and the channel across it varies often, depending on the recent coastal conditions (tides, waves, sand exchanges with offshore) and also stream flows and their phasing with respect to the tide. This beach berm is potentially important for flooding in the lower reach of Mātihetihe Stream because its elevation imposes a hydraulic control on flood outflows. If this berm rises, then the floodwaters will back-up (i) until they attain sufficient 'head' to pass over the berm and then (ii) until enough time elapses for the flood flows to cut a channel through the berm. A conservative assumption is to consider that the worst flooding will occur before any significant beach berm erosion occurs. In the context of this study, a reasonable assumption is that the average height of the beach berm will rise to match SLR, since (i) the berm is constructed by waves riding in on the ambient sea level and (ii) the pocket-beach location at Mātihetihe Stream will always be a sand trap, which will ensure an adequate supply of sand to lift the beach profile in equilibrium with sea level.

Apart from this stream-mouth bar effect, another expectation is that as sea-level rises, the bed of the sand flat and then stream behind the beach will also rise, since its base level is

provided by mean sea level. The distance upstream that the change in base level will influence will depend on the character of the stream. Potentially, if it had a sandy, alluvial bed for some distance up the valley, then the whole length of valley bed would eventually lift in response to the increase in base level. The rate that this would occur would depend on the supply of bed-material sediment from the catchment, and it may not be enough to match the rate of SLR. However, the Mātihetihe Stream bed appears not to be fully alluvial except very close to the beach, and the road culvert appears to provide a hydraulic and morphological control so this is likely to limit the upstream extent of influence of a sea level rise on bed levels. For this study, based on field inspection and floodplain profile data, we estimated that the effect of a rise in sea level on stream bed levels would taper upstream only as far as this culvert. The main sand source for the channel behind the beach is likely to be wind-blown beach sand rather than fluvial sand from upstream, thus with this ready supply of sand we expect that the profile of the stream bed will rise, on average, in equilibrium with SLR.

On this basis, we adjusted the hydraulic model topography by raising the level of the beach berm (as surveyed) by the extent of SLR (i.e., 0.4 and 0.8 m) and we also raised the level of the stream bed, linearly tapering the extent of rise upstream to zero at the road culvert. Only levels in the active bed were adjusted, while the surrounding land remained unchanged. At a broader scale, we expect that the Mitimiti coast will have a relatively simple response to SLR. For the most part, the coastline is cut into raised marine terraces but with small embayments at stream mouths (such as Mātihetihe Stream). Sand generally only collects above sea level in any quantity (forming beaches) in the embayments, since these are zones of relatively lower wave energy. Sand will drift in and out of the embayments as coastal storms come and go. A rise in sea-level will simply mean that the water will be deeper in front of the rocky segments offshore, while sand will continue to be trapped in the embayments.

5 Projected sea-level rise and coupled stream flooding

This section presents the mapping results from our assessment of (i) projected SLR impacts along the Mitimiti coastline for 2040 and 2090 AD, and (ii) climate-induced coastal flooding due to extreme rainfall under different climate change scenarios and projected higher sea-levels for 2040 and 2090 AD. Cautionary remarks and clarifications which explain the uncertainties inherent in presenting future climate projections are also provided.

5.1 Sea-level rise

Coastal inundation depths and extents for the Mitimiti coastline under current high tide levels (defined as the level exceeded by 10% of all high tides: MHWS-10) as well as the corresponding sea-levels for 2040 AD and 2090 AD with an assumed 0.4 m and 0.8 m SLR respectively, are shown in “time-lapse” format in Figure 13 and 14. As detailed in Section 4.2, these scenarios represent the first-order impact of climate induced SLR as the MHWS-10 high-tide level only has been used for this analysis. More extreme high-tide scenarios based on the MHWS-1 (only exceeded by 1% of all high tides) for the central and southern areas of the Mitimiti Coast are contained in Appendix C and D, respectively.

Under current MHWS-10 conditions, the high-tide in the central and southern areas of Mitimiti Beach covers the majority of the onshore beach system exposed at low tide. Expanses of tidal water also reach considerable distances landward into local depressions and existing stream channels such as the Taikarawa, Moetangi and Mātihetihe Streams. Notwithstanding this, pockets of sand between resilient outcrops remain dry under current MHWS-10 conditions including more extensive fields of hummocky (and partially vegetated) dune sands extending inland across low-lying coastal terrain.

It is evident that an increase in base sea-levels of 0.4 m by 2040 AD would result in broader areas of coastal land being inundated by the ocean more frequently (i.e. the present MHWS-10 level of 1.61 m which is exceeded by 10% of all high tides will by 2040 AD be exceeded by 45% of all high tides - Figure 12). The most pronounced changes show extensive inundation of stream discharge zones such as low-lying farm-land surrounding the Moetangi Stream and Taikarawa Stream. Slightly higher spring high-tide extents between current conditions and 2040 AD are also evident along the base of raised coastal terraces and extensive frontal dunes that extend north and south of the domain areas considered. Many of these frontal dunes are already showing signs of erosion and retreat.

An increase in base sea-levels of 0.8 m by 2090 AD shows even more extensive areas of coastline being inundated by the sea more frequently (i.e. the present MHWS-10 level will be exceeded by 90% of all high tides, notwithstanding any long-term morphological change - Figure 12). Present low-lying farm-land and dune-fields surrounding the streams at Moetangi and Taikarawa are in the future tidal zone. Such changes indicate the formation of a tidal embayment around Moetangi Stream. Greater inundation by the tide is also evident around Mātihetihe Stream where increasing water extent and depth are indicated as far the Mātihetihe Marae complex. Further, by 2090 AD the future MHWS-10 is likely to reach the base of raised coastal terraces on a near daily basis.

Importantly, this future MHWS-10 tide scenario for 2090 AD (which will occur regularly on average a few days a month during spring tides) does not include the effect of stream-flows, higher tide levels due to storm-tide conditions (i.e. the combined effect of storm surge coinciding with a high astronomical tide), wave set-up and/or on-going coastal erosion or

sedimentation on tidal extents or water depths, and therefore greater inundation extents and depths than those shown are possible. The interplay of these drivers of coastal change are examined in further detail in the following section.

5.2 Extreme flooding

Inspection of the modelled flood conditions for the Mātihetihe coastal-stream reach domain (which incorporates the projected rises of mean sea-level presented in Section 5.1) for the 2040s and 2090's under maximum, average and minimum A2 (mid-high) and B2 (mid-low) climate change scenarios revealed minimal differences in projected flood extents and water depths when compared to the inundation from the January 1986 reference flood event. Given the overall similarity of these results across the full range of scenarios considered, the following analysis and interpretations are based on our modelling of the average A2 and B2 climate change scenarios only. Extreme coastal-river-reach flood extents and depths for January 1986 and corresponding extreme flood conditions for the 2040s and 2090s under everage B2 and A2 climate change scenarios for the Mitimiti coastal-river reach are presented in Figures 15 and 16, respectively. Additional figures of projected extreme inundation under the minimum and maximum B2 and A2 climate change scenarios for 2040 and 2090 AD are provided in Appendices E and F. Please note that while the results between the B2 and A2 scenarios indicate minimal projected differences in extreme flood extents and depths in this instance, the authors nonetheless maintain that exploring different scenarios that span different future possibilities is a valuable exercise that might result in different outcomes at different locations.

The mean B2 and A2 scenario results both show that the projected inundation extents around the Mātihetihe Marae complex for 2040 and 2090 AD are unlikely to differ markedly from the inundation extents experienced during the extreme flood event that occurred across the Hokianga in 1986. In spite of this outcome and the resulting flood extents depicted in Figures 15 and 16, the estimated future peak flood flows for the Mātihetihe Stream under the mean B2 and A2 climate change scenarios for 2090 AD were approximately 20% and 30% greater than the flows used to simulate the 1986 flood event. These somewhat unexpected results are mostly due to the relatively steep land around the edges of the flooded area where the water level can change without much corresponding change in the extent of flooding[42].

Notwithstanding these qualifications, the most notable change from this modelling exercise is the gradual and on-going encroachment of water at the seaward end of the model domain. Relatively large differences in flood extent and water depth are also evident between the dune-field and the marae complex from 2040 and 2090 AD. This is likely to exacerbate existing erosion problems and increase the risk of damage to waste-water infrastructure at the back of the marae complex. An increase in inundation extent is also depicted across the areas currently used for car-parking on the southern side of the marae complex. Beyond these new flood extents, the modelling for both 2040 and 2090 AD under the mean B2 and A2 climate change scenarios indicates increasing water depth around the *whare-tūpuna* and *wharekai* located centrally within the marae complex. This is likely to increase the risk of direct flood damage under both scenarios given the expectations for slightly higher peak flood levels and possibly increased flow rates. These heightened risks also extend to *whānau* and *manuwhiri* either using and/or trying to gain access to the marae. Conversely, Mitimiti

[42] In other words, where the terrain is steeper the changes in extent are likely to be negligible.

Church remains free from inundation for an event equivalent to the January 1986 flood under both of the climate change scenarios assessed.

Finally, while the future frequency of extreme flood events under future climate change scenarios was not determined in this study, it is projected that heavy rainfall events will become more frequent in many parts of New Zealand, especially where mean rainfall increase is predicted (MfE, 2008a). Further work would be required to translate changing rainfall frequencies into future flood frequencies.

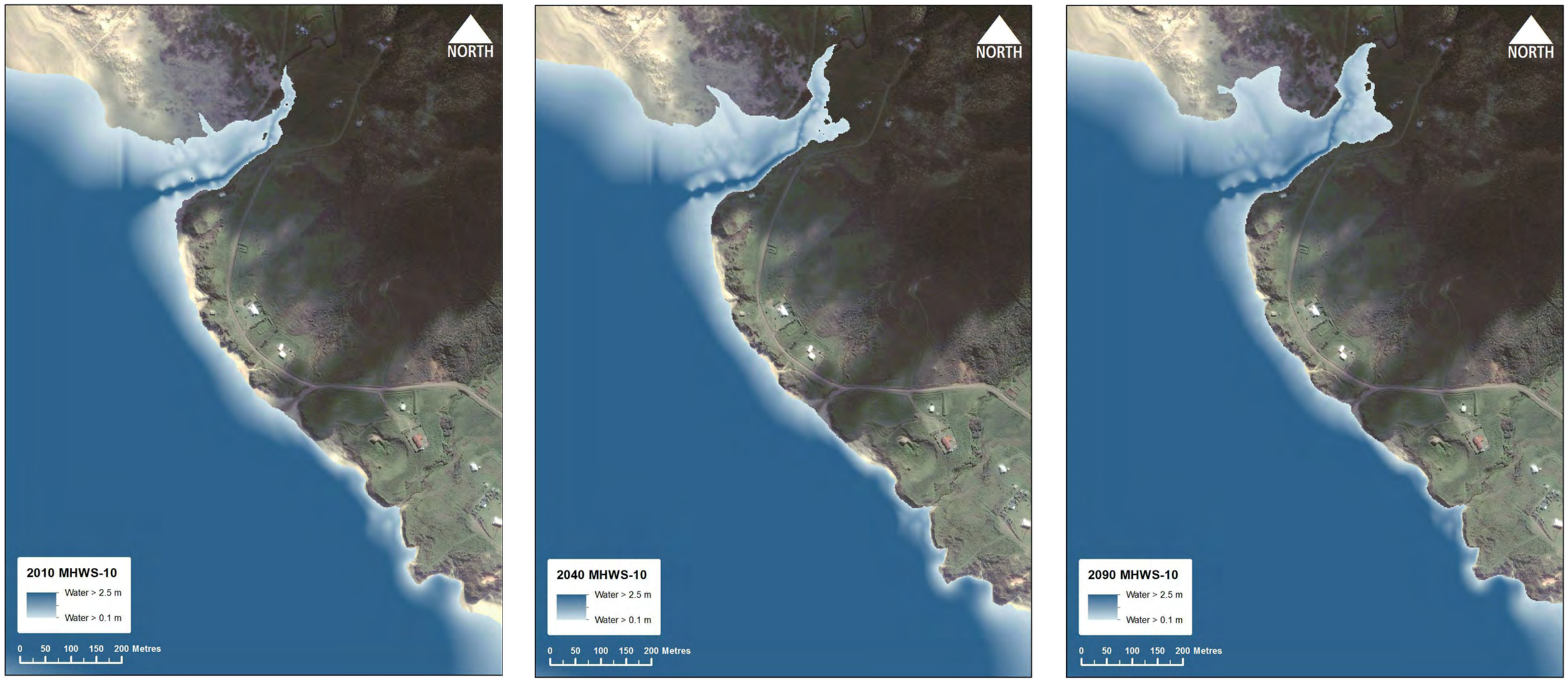

Figure 13: Mapping sea-level rise at central Mitimiti – Hokianga, Aotearoa/New Zealand. Changes in coastal inundation depth and extent are shown for current (present-day) conditions for the projected higher sea-level scenarios for 2040 and 2090 AD described in the text.

Figure 14: Mapping sea-level rise for southern Mitimiti – Hokianga, Aotearoa/New Zealand. Changes in coastal inundation depth and extent are shown for current (present-day) conditions for the projected higher sea-level scenarios for 2040 and 2090 AD described in the text.

Figure 15: Modelling climate change induced coastal-stream reach flooding for 2040 and 2090 AD around the Mātihetihe Marae compex under the B2 ‘mean’ climate change scenario and sea-level rise scenarios as described in the text.

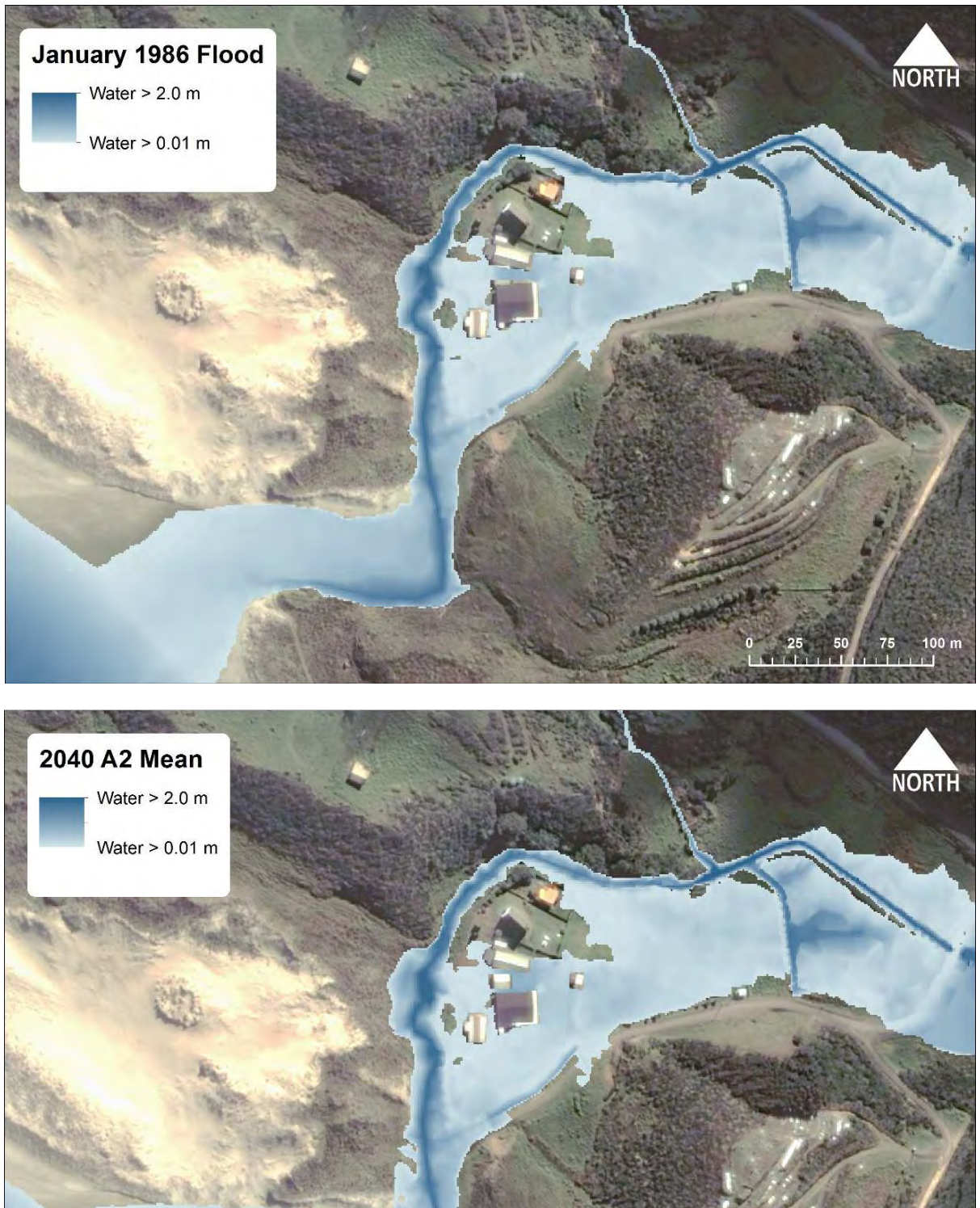

Figure 16: Modelling climate change induced coastal- stream reach flooding for 2040 and 2090 AD around the Mātihetihe Marae complex under the A2 ‘mean’ climate change scenario and sea-level rise scenarios as described in the text.

6 Social research methods

This section provides details of the range of social research methods used to gather information about the contemporary social and environmental conditions at Mitimiti. The main methods included: (i) semi-structured and open-ended group interviews with a broad cross-section of the community, (ii) semi-structured and open-ended interviews with key informants, and (iii) land trips and personal observation. These different consultation methods were planned to ensure that a range of views and perspectives were considered. The resulting information not only tells us about the community and its social-ecological context, but also feeds into the project's decision making processes for next actions. Importantly, all aspects of this 'knowledge exchange' were underpinned by an observance of *tikanga* [conventions, culture, custom, correct procedure, lore] with many interviewees preferring to speak in *te reo* Māori (See: Section 3.3).

Note that a lot of informal engagement underpins participatory involvement (whether engaging with an individual or a group) which is often not taken into account.

6.1 Group-based interviews

The first round of open and semi-structured group interviews was conducted within the *wharenui* [main meeting house at the marae], the *marae ātea* [open area in front of the *wharenui*] at Mitimiti and within the NIWA Auckland office between the 27th November – 9th December 2011. A total of sixteeen home-people were interviewed over three group sessions (with five to six interviewees per group). The interviewees were selected by the Te Tao Mauī project manager, and largely comprised *kaumātua* [elders – not gender specific] and Mātihetihe Marae Trustees[43]. These sessions lasted between 2-3 hours and were attended by two or three NIWA facilitators and the Te Tao Mauī project manager from Mitimiti.

All group interviews began with a *mihi whakatau* [formal welcome speech – this included a restating of the project objective] followed by a *whakawhanaungatanga* exercise to enable time for introductions and the establishment of *whānau* and community relationships. The interviews were guided by a broad set of pre-determined vulnerability and adaptation-based questions which were designed to explore people's attitudes, beliefs and experiences with the direct and indirect impacts of climate and coastal processes. These questions were in turn supported by participatory mapping[44] and themed prioritisation exercises. At the end of each session informants were invited to identify any absent *whānau* members who they believed should be asked to participate in the project. All interviews were electronically recorded and transcribed. The semi-structured in-depth approach ensured some element of structure for key areas of interest while also allowing sufficient flexibility (in line with grounded theory methodology) to explore new areas and avenues of interest.

It is important to acknowledge that group interviews are useful for involving many sectors of the community – particularly from the point of view of sharing experience and hearing a variety of thoughts and statements where participants can react to ideas and build-off of each

[43] One of the major benefits of working with pre-existing groups of people (as opposed to a randomly selected group) is that they provide one of the social contexts within which ideas are formed and decisions are made (Lewis, 1992).

[44] Participants were encouraged to annotate the large aerial maps by identifying significant sites and places of change. This proved to be an effective technique to share experience and understanding due to the location-specific nature of much of the conversations/discussions.

other's comments (Lewis, 1992). Safety in numbers may also make some people more likely to consent to participate in the research in the first place. However, group dialogues such as these can be also impacted by personalities that dominate the discussion and/or group dynamics that discourage more reserved members to join in (Lewis, 1992). Further, this can lead to people censoring their ideas in the presence of people who differ greatly from them in power, status, education, and other personal characteristics. To supplement this research method, the research team additionally sought to interact with key community members or residents representing different perspectives on an individual basis (see Section 4.2)[45].

Finally, the group interviews were augmented by many instances of informal discussion, as is the case in most qualitative research. For example, it was *tikanga* that the workshop sessions and meetings finished with *kai* for the group and researchers to share together[46]. Both group interview phases of research were wrapped-up with a *poroporoaki* [farewell speech] and *karakia* [prayer, incantation] – this included acknowledging interviewees for their support and restating the next steps ahead in the project.

6.2 Individual (and paired) interviews

The first round of open and semi-structured individual (and paired) interviews was again conducted within the *wharenui* at Mitimiti as well as within the private homes of some informant's during the 27th November – 2nd December 2011. A total of eleven home-people (including one participant from a group session) were interviewed. These participants comprised *kaumātua, pākeke* [adults] and *rangatahi* [younger generation, youth] and were selected by the Te Tao Mauī project manager based on inter-generational experiences and relationships with Mitimiti. Note most of these informants were unavailable for the group discussions and thereby made themselves available at the later dates.

All individual interviews followed a similar format to the group interviews (as described above), and were guided by the same set of vulnerability-based questions. Again, these interviews were used to examine in more depth people's personal attitudes, beliefs and experiences with the direct and indirect impacts of climate and coastal related changes on the environment and community. Each session lasted between 1-2 hours, and was attended by one or two NIWA facilitators and the Te Tao Mauī project manager. All interviews were electronically recorded and transcribed. Note that implementation of this method of data collection resulted in a considerable quantity of raw data being gathered.

A second round of semi-structured individual and paired interviews was conducted within the private homes of interview participants on the 11-12th June 2013. A total of fifteeen home-people were interviewed, ten of whom were involved in the first round of interviews. These participants comprised *kaumātua* and *pākeke* who were purposefully identified by the Te Tao Mauī project manager and the NIWA research leader. The principal criteria for participant selection related to the need to follow-up on specific comments made by key participants during the first round of interviews as well as new questions that emerged following the analysis of specific interview transcripts. This process also permitted the research team to ensure that our interpretations had accurately captured the expressed insights and concerns

[45] Note that individual responses are not independent of one another and the results are never guaranteed to be representative of the general population – rather, ultimately they represent the view and experiences of those people who have been engaged only.

[46] In debriefing sessions amongst the researchers, these additional comments and observations were discussed and noted.

of participants during the first round of interviews – otherwise adjustments were made. Furthermore, it provided an invaluable opportunity to deepen our understanding of community realities, aspirations, attitudes and perceptions, that otherwise cannot be observed. Interviews lasted between 1-2 hours, and were complemented by on-land visits. The second formal visit to Mitimiti also provided an opportunity to present maps which illustrated future climate projections and possible impacts of SLR in and around the Mitimiti coast. This afforded an opportunity to explore how perceptions of risk changed when presented with new information.

Overall, these interviews provided comprehensive information from individuals that resulted in an in-depth, if not sometimes isolated, view of the subject. That is, just as there are potential limitations with group settings, individual interviews have potential for undue emphasis to be placed on issues specific to the individual. Recognition of such strengths and limitations underpinned the decision to use multiple methods for information-gathering.

6.3 On-land walks and observations

On-land walks and observations were made on successive visits to Mitimiti – and these opportunities were taken to discuss in greater depth and view first-hand some of the many places and phenomena highlighted during the group and individual interviews. Moreover, a specific walk of the land occurred on 15th May, 2013 during which three *whānau* shared their direct experiences of the January 1986 flood event. The information gained through this action was supplemented by field notes and photos. A photo gallery is provided in Appendix G.

6.4 Analysis of information

The analysis of the data collected through group, paired and individual interviews was open-ended, inductive and consisted of 'content analysis' where ideas or words were identified along with the frequency of their use and 'thematic analysis' whereby the principal themes emerging from the data were examined (King *et al*., 2008; King *et al.,* 2012a, 2012b). Identifying the principal themes involved sorting, coding and categorising data directly from the interview transcripts. The themes that emerged provided sufficient information to understand the contemporary exposure and sensitivity of the community to variations in climate and coastal processes, as well as the adaptive capacity of the community to deal with the impacts of social and environmental changes. Secondary sources provided further context to the interview data and offered additional information which enriched our understanding of the present human and biophysical landscape at Mitimiti.

The transcribed interviews were examined thoroughly, and divided into stand-alone pieces of information, which were then sorted into categories. As each piece of information was categorised, it was compared to other entries within that category which enabled the identification of similarities, discrepancies, and dissenting opinions. As the research progressed, categories (identified from both the written and interview data) emerged, merged, and disappeared, until a set of principal themes were distilled, and confirmed through previous studies and follow-up interviewees. Quantitative research results and the latest information from other scientists, policy analysts and decision-makers were then integrated into the analysis to identify potential future exposures and sensitivities (what conditions or risks the community may be facing) and future adaptive capacity (in what ways

the community may potentially plan for or respond to these conditions) to determine whether the community's present coping strategies were capable of dealing with these future risks.

Finally, by way of disclosure, it should be noted that the authors are not entirely dispassionate observers and thereby the extent to which their involvement with *whānau* from across the community may bias the views contained in this work is left for the reader to determine.

7 Climate risks, vulnerability and endurance

This section comprises the results derived from the analysis of individual, paired- and group interviews with community members from Mitimiti settlement. Current (and past) exposures to environmental hazards and change (with a specific focus on the coastal hazards) were identified based on participant observation and collective experience (assisted through a participatory mapping exercise) and information derived from the review of secondary sources. Connected with this phase of interviewing, the role of coping and adaptive strategies was also explored, which necessarily involved consideration of the social, economic and cultural factors that influence the sensitivity of the community to coastal hazards and change. Again, the aim here is to develop an understanding of how people interact with the environment and to characterize the role played by biophysical and human processes. The aim here was to better understand the nature of the physical environment to which the community is exposed, the likelihood or frequency of occurrence of hazard events, what interests, values and aspects of people's lives are at risk, and what are the contextual factors that cause, or contribute to, such risks? Finally, the implications of different climate change scenarios, projected impacts and future risks are presented. These results are based on direct feedback from community members given during the final round of interviews in May 2013.

7.1 Exposure to climate-induced coastal hazards and change

During discussions with community members, extreme storm events and linked flooding were identified as the most common types of climate-induced hazards at Mitimiti. Related hazards ranging from storm surge, high winds, landslides and erosion were similarly identified as well as acknowledgment of the hazards associated with continually changing coastal processes such as tides, rips, erosion and shoreline change. To a slightly lesser extent, less predictable and changing climate conditions were identified by interviewees with narratives most commonly covering warming temperatures, higher winds, more frequent and heavy rainfall events, and periods of low rainfall (i.e. drought). Contextual details are provided in the grouped narratives below.

Storms, floods and high-winds

Extreme storm events and associated flooding dominated all interview sessions. Most community members acknowledged the disruption caused by such events, as well as the potential harm to *whānau* and damage to community (and private) infrastructure. A number of community members also referred to high winds during storm events. These interviewees described damage to household roofing, decks and porches as well as corrosion of vehicles and machinery from the salt-laden air. Notwithstanding these narratives, most interviewees simultaneously acknowledged that the exposed nature of the coast to extreme weather conditions is simply part of living at Mitimiti. Some recollections from storm events are provided below:

> *"I can remember we had a flood here in the 90's. We were walking around the wharekai in our gumboots - the one that is standing now. And I was down there at a mate [funeral] at this time and the water was coming down the road, down the paddocks. You could hear it coming, it was coming, flat-tack and right through the marae… I can always remember that day." (12 July 2013)*

"Water almost came into the wharenui [ancestral house] that night. Water was rushing through the old toilets waist high. The old wharekai was flooded out, water was rushing in one door and out the other" (26 March 2013).

"I remember when it flooded through that building [the wharekai] and we were in there, and someone said if you want to get back on the road get going and the next minute it came through the door and in through the wharekai…" (12 July 2013).

"March 1995 was when the water came right through the marae. That was when all the kids had to stay at school and mums bach got flooded out completely with waist high water at Moetangi and the bridge support got pushed out too (26 March 2013).

"We were here for the 1999 flood and we had no bridge which meant that you couldn't go anywhere so there was no shopping no nothing… but we got used to that and that council put in a foot bridge and we had to walk across the other side and use the brother n laws vehicle and go to Kaitaia to get my shopping. I would leave my vehicle just pass Mingo's place and then I would lug it across the foot bridge, get in my car and bring it home. We did that for months and months." (12 July 2013)

"In the big flood in 1999 when the maunga came down…our bridge was washed away and all the people on this side were isolated…" (26 March 2013).

"When they had a big storm, that bridge at Moetangi got washed out, so everybody on that side had to walk across on planks to get their kai … to get their stuff or get a vehicle on the other side to drive off if they had appointments in town." (8 December, 2011)

"Oh my gosh. I think it happened 2:30 am. And the wind was so fierce that it was like…the roof was [going to go] and the balcony… So he [points to husband] got a thick rope and got me to hold on to it, and while I was holding on to it, it was lifting me up in the air off the floor. Man that was a nightmare for me." (28 November, 2011)

"Every time it rains - we stress. Are they [guests] going to get in, are they going to get out. People who have been before it is not a problem, but new people?" (12 July 2013)

"…the wind's probably the most hazardous thing… and also the salt laden air is really a problem because everything corrodes or rusts very quickly, so… you either live with it, or you have to keep addressing it. So things don't last forever, including vehicles. But that's part of just accepting nature here." (28 November, 2011)

"I've been in my house going on 30 years, and I've changed my roof three times in those years." (28 November, 2011)

"There are some unreal winds that come. But they're not here for too long thankfully. They pass very quickly. But you just know that anything could happen. Those are the worst winds. And surprisingly, the worst winds are not off the sea. They're actually from across the hills. You can see what the bush is like here. It looks wind-blown." (28 November, 2011).

"Weather events have affected people here a lot over the years. There's no doubt about it, Mitimiti is exposed, really exposed. The elements are always [going to] be right on your doorstep." (28 November, 2011)

Some community members identified a number of influences that exacerbated the likelihood of flood occurrence (and subsequent risks). The impact of land use change from native forest to dairy and pine plantation forest was often cited, followed by discussion of the resulting increase in hill-slope erosion, landslides and the delivery of sediment and fallen vegetation into local streams causing stream blockages during heavy rainfall events. Direct modification of stream channels through gravel extraction and road construction was also identified as contributing to flood risk. In some cases, these changes were considered to have exacerbated existing risks as well as introduced unforeseen impacts such as the obstruction of high stream flows by culverts. Linked conversations questioned the cumulative impacts of these changes on *mahinga kai* [food gathering, cultivation].

"…they just went in with axe and slash hook and chopped everything they ran into, to try and make dairy farms… maybe it looked good, and had dairy cows on [the land], and people made a living off it, but what they did was damage the whole bloody environment." (28 November, 2011)

"The debris creates blockages and moves the creek around … Because you've got so much bush up behind there… It all comes down in the creek." (28 November, 2011)

"Landslides also happen here. One time they had a big landslide just opposite the school up here. Yeah…I went to go in my truck to Kaitaia…oh well I'm off…and I didn't even get to the school, and I had to come home. God I can't get through that one…That was a huge one." (12 July 2013)

"That how I remember it. I was camping down at Moetangi and I got flooded out and went home. And there was a 21st the next day and I did all the cooking, the pavalova and chocolate logs, and walked up the road because there were slips all over the road. You couldn't drive…" (26 March 2013)

"…ever since they put that pine forest in, the toheroas [shell-fish] started disappearing, slowly, slowly, 'til there's nothing there now." (28 November, 2011)

"…you've got a little culvert, little hole, and then you've got this road which is higher than the creek. You block that hole up, and it just becomes a dam… I remember once as a kid, it getting right to the top and almost going over the top. And if it did that, it'd just wipe the whole thing out. We'd be gone. And that impacts on us [because] it's right on our [doorstep], and anyone who's down the beach." (8 December, 2011)

"Yeah that's like over here in Taikarawa as well. Our road that climbs up to the house, there's a culvert there, and a few times it's come over. That's how heavy it is. And over real bad." (8 December, 2011)

"I've always worried about this road here, and this creek, the Mitimiti creek. This acts like a dam right here and you've got a little culvert, little hole, and then you've got this road which is higher than the creek. You block that hole up, and it just becomes a dam. It's been, I remember once as a kid, it getting right to the top and almost going over the top. And if it did that, it'd just wipe the whole thing out. We'd be gone. And that impacts on us cos it's right on our, and anyone who's down the beach. Man if it went." (8 December, 2011)

Tides and currents

Many interviewees described the tides and to a lesser extent rips and currents as everyday hazards capable of endangering the safety of *whānau* and *manuhiri* to the area. There was also widespread agreement among many of those interviewed that the tides were now higher than in the past. This change was commonly seen as a threat to everyday activities that take place along the beach (e.g. food gathering, alternate road access and swimming) as well as Mātihetihe Marae, where tides and storm surge are now reaching further inland increasing the risks of damage to marae buildings and supporting infrastructure. For some *whānau* these concerns appear to have affected their social use of the beach, in that they now prefer to have social occasions elsewhere and discourage their children playing on the beach. Further still, some interviewees felt their warnings were not taken seriously and this was a source of anguish when lives were claimed by the sea.

"It's a real dangerous place when the tide's going out. When the tide's coming in, it's safe, but when it's going out… it just bottlenecks through there. And if you're standing in that area, kiss your ass goodbye." (28 November, 2011)

"I am exposed, because I am close to the sea." (12 July 2013)

"You've [got to] watch the children more down [at] the tides. You can't let them go off. As children our parents used to send us off with a horse, and we'd be down there… but now, you've actually [got to] go with the children down the beach. Whether they're fishing or just going into the rock pools." (8 December, 2011)

"You feel sick about it. It actually is not a nice feeling. I feel really pouri [sad, depressed], awangawanga [be uneasy in mind, disturbed, worried, anxious, distressed]. *It's not a very nice thing to know that somebody's just drowned below you. In fact I usually find it quite hard to deal with, definitely on the first night. (28 November, 2011)*

"Yeah, you just feel for the whānau, you can't help it. So part of it is it's important for us to have a little bit of a debrief as a whānau, and sometimes we do that. And to be a part of the things like putting rahui on and lifting it. It helps to alleviate some of that mamae [ache, pain, injury, wound]. *So you have an opportunity to grieve for them too, and to karakia for them. But it is, it's a horrible feeling. I hate it." (28 November, 2011)*

"The tides have gotten bigger… And like this year alone, the tides have been so big, they would come right up to the creek to about here. Flood a bit of our paddock there. And also below Fred's house, it used to only come up to about there, but it was actually coming up [further]." (29 November, 2011)

"It [the coastline] will encroach more on the marae in time. So the movement of sand I think is the concern for me … if [the dune] doesn't get planted up or grow … we're [going to] lose that, and the sea will encroach further. And already what I've noticed is that… [with] the king tides… the foam was actually right up at the back corner of the marae there. To me… it's something that I've only observed in more recent times… whether I've been more observant, or is it in fact a reality that it's a recent phenomenon?" (28 November, 2011)

"It's a worry because yeah, you can see there is a change, and I think the worry for me is the timeframe. Say for instance down here, even though we're up on a hill, the reality is, that tide could be just sitting below the house in we don't know how many years. So that's a concern. And just making sure we still have a community in the next 30 years' time, you know what I mean." (28 November, 2011)

"Last time we went home, we couldn't even go for a fish cos the tide was so far in." (9 December, 2011)

"I've noticed a lot of changes since I have been here. See where the sea is now – that was about high tide when I was a little fella…that would be about high tide [pointing to the line of the present low-tide) and now the tide comes right over the sand in front now… comes right over. …And the big tide will come right in down here [below the house] and will lay around there. You can look down there and see the froth...and it goes up the creek…and then out, and up she comes again." (12 July 2013)

"Half tide now would have been full tide in our day. That's how much the tide has changed." (12 July, 2013)

"It's getting impossible at the moment [to drive on the beach]. Forty or fifty years ago, high water we could still drive on the beach. We had an old 38 ex-school bus and you know you can still go netting at high tide. Now, half tide would be lucky to get up. It's dangerous. The sand is softer. You know, because it's washing the sand away." (12 July 2013)

"The big tides eh. The rising tides, for sure. That's gonna be a hazard, that's gonna impact us. Mind you, 22 odd years ago when we built these places around here, we were told then that we'd be under water in 20 years… Well I think even they knew things were changing. They must've seen physical [change], those people back then when we first moved back, those ones that had lived here a long time before then must've seen that things were changing even back then. So they were saying, well, the tide is rising, so you're gonna be under water, and we've always lived with that…" (28 November, 2011)

Sand movement and erosion

Changes at key locations along the beach were also widely referred to by interviewees. Some residents commented that large scale sand movement was resulting in pasture land being blanketed in sand while in other areas rock formations previously unseen on the beach were being uncovered. These changes were regarded as particularly problematic for safe vehicle access to remote homes along the beach. This is because a number of residents do not have road access to their properties, so the beach is used as the primary access-way. According to many interviewees, a further complication for these *whānau*, is the shifting character of local streams that issue across access-ways to the upper beach.

> *"See over here where all that sand is, and see that post on the corner there [points to southern head of the Moetangi Bay] there used to be grass all the way back to here [points towards the foundations of house]. There's no green grass anymore, the sand has come all the way up to here. …And, those rocks over there were never there" (12 July 2013).*

> *"Well, the dunes are moving all the time. Now down that way past the marae there, down towards Moetangi, you got a lot of sand washed off the banks and a lot of the rocks are starting to be exposed, and you can put it down to the weather patterns now. Bigger tides." (29 November, 2011)*

> *"You can't drive along now. You could drive along to the entrance to the harbour. Now you can't" (12 July 2013)*

> *"Flooding affects his access now - both the tide and the creeks. He can get cut right off and those kids cannot get to school because they are cut off. So they are affected very much." (12 July, 2013)*

> *"Yeah, so you have to be aware of it when you're crossing the creeks. Charlie and them have to, that's their way home. They're used to driving it at night too. I don't like going on the beach at night because things can change and you may not see. But they're used to it now. But sometimes that creek is really running high. Same with Moetangi. Everybody knows to avoid the creeks though when they're high." (28 November, 2011)*

> *"Yeah, the stream is actually coming up to that bend. So it's cutting into that bend there by that little bach you can see. So even Charlie's road, that road that's there now, it's no longer there, he has to cut across here now…. His road right by the creek, right by Taikarawa, he can't use it now cos the bank's gone." (8 December, 2011)*

Similarly, a reduction in the size and extent of sand dunes along the beach were identified. This change in dune morphology (often linked to changes in the position of streams across Mitimiti) concerned some interviewees - particularly in front of Mātihetihe Marae, where tides and storm surge are now reaching further inland increasing the risks of damage to marae buildings and supporting infrastructure. Explanations for these changes ranged from the loss of dune vegetation such as lupin and marram grass (which used to be harvested and sold by community members), to more extreme weather events and associated erosion from storm surge, flooded streams and higher tides linked to rising sea levels.

"We do still think they [the sand dunes] are retreating… I mean, you don't go out with a measuring tape, but you just think, gosh, those are moving back." (28 November, 2011)

"When I was a kid there was a big massive sandbank there [in front of the marae] and… we used to run down and jump off the top and you wouldn't catch the water. Now, if you jump off the top, well you're in the water. There is no bank, just a bed." (29 November, 2011)

"High tide don't stop anymore…So we need to relocate our marae and put it somewhere else." (12 July 2013)

"Moetangi here – just about every flood, things change. The flow of the stream changes. This last flood has also made a big change to areas around here – especially on the beach…" (12 July 2013)

"I think the hazard for me is that, if that doesn't get planted up or grow, that we're gonna lose that, and the sea will encroach further. And already what I've noticed is that… the foam was actually right up at the back corner of the marae there." (28 November, 2011)

"The biggest changes is with the reaction of the sea on the foreshore. A lot of our sand hills are disappearing. The tide seems to take more sand away now than ever before." (12 July 2013)

"I believe in time the sea will take what belongs to it. That might not be in my time, but it's coming. Those are the things I have seen in the past and think what is happening in the future there is nothing we can do about it. The thing is to move back and who knows in the next 80 years what the land will look like...the sea has a way of finding its way around. I have already told the kids... the sea is coming." (12 July 2013)

It is important to emphasise at this point that the movement of sand was not a concern for some interviewees, as these changes were seen as merely part of the coast's 'natural cycle'. Conversely, concerns were simultaneously raised about exposure of the community to future SLR, and the uncertainties related to this. Details about future coastal hazards and risk are considered in more detail in Section 7.3.

Weather-climate variability and change

Mitimiti community members have also observed increasing variability (and unpredictability) in climate patterns in recent years, particularly in relation to warming temperatures, higher winds, more heavy rainfall events, and extended periods of low rainfall (i.e. drought). In addition, noticeable shifts in the character of the seasons were described. The impacts and risks associated with these changes were of concern to many of those interviewed – ranging from adverse impacts on local ecosystems, to the availability of *kaimoana* and water for drinking and food production. The following comments provide a snapshot of recent observations and related concerns voiced during interviews:

"…the weather patterns seem to have changed for us… We've had these dry periods over the last couple of years, but also it seems to be warmer a lot later in the year… It's not as hot in December as it used to be…" (28 November, 2011)

"We're on the western side, so in the summer time it's very very hot when the sun comes out… It's very extreme. It's become much more extreme." (28 November, 2011)

"As soon as you get an easterly wind, the water [is] off the toheroas [a type of shellfish] for about 4 hours… where the tide's out during the day. And that sand just bakes with this hot sun we get now, it just bakes and cooks the toheroas. Just kills them off by the bloody thousands…" (28 November, 2011)

"The rain pattern now is more aggressive. It comes down quicker, and more, but it goes away quicker too, and it seems to drive a lot of things." (29 November, 2011)

"It's different now, to the past. I can remember going to school and all the pot holes had ice in them and we broke it….Not now though eh." (12 July 2013)

"…last summer we had a drought here, [and] what Mitimiti's always been special for is its fresh clean water, because we've got a lot of streams that come out of the Warawaras, so we've always had plenty of fresh water here for your garden, for drinking, and for your everyday use. But that could dry up. We could lose our valuable water resources." (28 November, 2011)

"The mussels are creeping up the rocks, the bull-kelp is moving." (12 July, 2013)

"Fifty years ago our garden were ready to be harvested. We had melons and corn ready for Christmas. They used to plant theme in July and August. The seasons have shifted." (12 July 2013)

"I think the climate is now more hit and miss. Nothing is the same anymore. The seasons have changed. Kumara is now being planted at Christmas time. It used to be planted in September-October." (12 July 2013)

Note that discussions also covered concerns about tsunamis affecting the Mitimiti area. These details are not provided however within this report.

7.2 Determinants of sensitivity and adaptive capacity

Four key determinants emerged from the analysis of community interviews which focussed on the 'things' that contribute or influence the degree to which people find themselves directly and/or indirectly affected by climate induced coastal hazards and change. These themes emerged through sentiments that appeared repeatedly in the interviews; and therein represent those matters or factors that people recognise as barriers, challenges and strengths. The matters discussed often intersect environmental, economic, social, political and cultural aspects of community life; and there is considerable over-lap between the themes, which reflects the interrelated nature of social and biophysical processes. Drawing lines between such themes was sometimes an exercise fraught with never-ending

exceptions. In spite of this, the authors have isolated the determinants in a way that helps to make sense of community sensitivities and adaptive capacities.

The key determinants considered in this section include:

- Social-cultural networks and community change
- Resourcing, self-reliance and innovation
- Knowledge, skills and expertise
- Community structures and decision-making

7.2.1 Social-cultural networks and community change

The importance of social-cultural networks along with rapid changes in the structure of the community at Mitimiti were the primary topics of discussion for many interviewees when questioned about how the community is affected by, and deals with, climate related hazards and change. These discussions most often surrounded the importance of internal community relationships for effectively managing climate related hazards and stresses, both between the *ahi-kā* [home-people] themselves and the *ahi-kā* and non- resident *whānau*,. Mutual support and collective action were regularly emphasised as too were the traditional values of *whanaungatanga* and more fundamentally *whakapapa* between people and place. Major changes in the composition of the community, in combination with low levels of economic development and opportunity and the appearance of new values and behaviours, were regularly identified however as a constraint to 'getting things done'. To a somewhat lesser extent, the importance of relationships with outsiders, local authorities and government agencies was also raised, particularly from the point of view of minimising the degree to which *whānau* (and the physical environment) are exposed to climate related hazards and stresses.

Internal *whakapapa* based relationships at the individual and *whānau* level were recognised by all interviewees as a critical feature of the Mitimiti community. Many of the interviewees spoke of the importance of *whakapapa* and the associated responsibilities community members shared through familial bonds. This internal dynamic plays a major role in shaping the way the community functions. The nature of these connections led many interviewees to describe their internal relationships as 'a strength' when considering responding to and/or recovering from adverse weather and climate episodes. Furthermore, a number of community members simply expressed a strong internal sense of responsibility to *tautoko* [support, prop up, verify, advocate, accept, agree] and *manāki* [take care of, support, give hospitality to, protect, look out for] *whānau* across the community in times of emergency or recovery. The extent to which *whakapapa* ties the community together and facilitates mutual support and collective action is illustrated in some of the following commentaries:

> *"I think from way back…You go to any of the families around here, like, all the Kendall's, they're descendants of Papa [Atama Paparang] here, he was a chief. And I descend off Moetara and also off Haretana, they were rangatira... And most of the families here, you got the Peita's, they all descend off Wharetohunga, and everybody that's around here, they're a descendant of someone that was pretty important, mai rā anō. And now, they carry on…it's a handed down tradition. It's*

just a handed down thing. And it's not forced on anyone, it's just there…" (28 November, 2011).

"People living here now are the descendants of whānau living here prior to the signing of the Treaty of Waitangi." (12 July 2013)

"…if any locals come unstuck somewhere along the line, you can guarantee that someone [will help them out]… cos we all know each other, we're all related somewhere along the line… and [if] someone's in trouble, always somebody comes along and says, "Hey, have you got something we can help with?" Everybody gets together and sooner or later it's all fixed up. That's how the people are around here. They're bloody good man, they're beautiful people around here. I wouldn't go anywhere else in the bloody world to live, because you know exactly what you've got with people here" (28 November, 2011).

"There is a history to this place and you feel it everywhere you go" (12 July 2013).

"…I learnt how to be Māori living there, and that was really, really important. And I've always had that appreciation. When I go back to Mitimiti… it gives me a spiritual dimension to my life. It re-charges the batteries; it just gives you that wairua. So for me, and I can't put my finger on it, it is my roots… because it enabled me to actually appreciate the essence of what, living [and] being in a Māori community is, appreciating the value system…appreciating what's real and what's not. Mitimiti taught me that. It's not somewhere you go [because] it's flash, but you learn the things that are important in life. You learn the essence of what is actually real, what is important. So for me it's more than just the land. There's a wairua about the place" (8 December, 2011).

"Yeah, it's the whanaungatanga eh. We pitch in and help [each other] you know. If Uncle rang him up to go and do something at his place…Yeah [we'll] go down and help the old fullas, you know." (29 November, 2011)

"There is strength in working together…" (12 July, 2013)

"If the phones went down we would just go out and check the neighbours...everyone has to be prepared to step up..." (12 July, 2013)

The concepts of *whakapapa* and *whanaungatanga* were also identified as crucially important for non-resident *whānau* – some of whom are actively involved in Mitimiti community affairs. Many of these non-resident *whānau* return to Mitimiti on a regular basis either for formal meetings on the marae or during holiday periods to visit *whānau*. All of the non-resident interviewees felt it was important that they (and their children) sustained their relationships with Mitimiti despite their physical absence.

"Yeah it's a real community. It's what the community's all about… giving the kids that sense of whanaungatanga is really important. Kotahitanga too is what it is… When they're away from that, they know that they've gotta look after each other." (8 December, 2011)

"I always felt we had a micro-culture within the Mitimiti area. We had something special. Again I can't put my finger on it, but I always felt it was really tight. Gosh, some of the things, you know my kids, when they say, what was it like when you grew up dad? Oh I had a horse. They go – "What!!!? You had a horse!!!?" Oh yeah, Uncle Harold gave me a horse. "What!!!? He just gave you a horse!!!?" [laughs]... Man you grow up and you think, I don't have the luxuries of life, but I have all I need." (8 December, 2011)

The importance of the relationship between the *ahi-kā* and non-resident *whānau* was also recognised by many of those interviewed, particularly in terms of meeting challenges on the one hand and realising *hapū* aspirations on the other. Most of those interviewed considered these connections as strengths and believed it broadened their sense of community and increased their ability to achieve collective goals and deal with challenges, climate-related or otherwise, should they arise. However, notwithstanding the high value placed on these internal relationships some interviewees also discussed the potential for conflict between the *ahi-kā* and non-resident *whānau.* Similarly, relationships between the *ahi-kā* themselves could sometimes be strained by internal disagreements; although, all interviewees were quick to qualify that *whakapapa* and *whanaungatanga* would surpass any disagreement if there was a threat of harm to anyone in the community.

"… if you bring too many ideas back, it does start to get some resistance, and I've learnt to just pull back, cos I was so enthusiastic, and you come back with a lot of passion, and you want to do things, but sometimes you have to be mindful. And I can be impatient, so I want to put things out [there]. And that can easily put people offside… but…there is an expectation that you will do something. That's your role is to help. So it's not that hard for them to accept that you want to help, but you often have to fit in on their terms, not yours. So you have to be prepared to just take orders for a little while. But having said that, the ones who are away, we need to find a way for them to feel linked up…they [will] never feel linked up if their ideas can't be put forward and heard." (28 November, 2011).

"At the moment we are getting too many families coming back trying to tell us what to do and they do not know the tikanga, the kawa that was left by our tūpuna. They can change the tikanga but they can't change the kawa" (12 July 2013).

"Aroha! Yeah. Whanaungatanga… It doesn't take much. You might have your worst enemy round the corner here, but a fulla says, "bro this house is getting bashed by the sea. We need the roof off – and it only takes a phone call" (29 November, 2011).

Major changes in livelihood and the changing make-up of the community were however regularly identified by interviewees as a constraint to working together and 'getting things done'. That is, low levels of economic development and employment opportunity have seen many *whānau* live away from their *tūrangawaewae* and as previously mentioned this has created tensions between the *ahi-kā* and non-resident *whānau,* as well as introduced new values and behaviours. The implications of these changes for community vulnerability and resilience to climate related hazards and stresses are wide ranging and complex – but most commonly, when reflecting on the things that either enable or make it difficult to deal with climate related hazards and stresses, interviewees touched upon the diminishing number of

whānau (and *kaumatua*) to help meet the various requirements and services provided by the marae. Notwithstanding these concerns, new opportunities have also emerged such as advances in technology which now play an increasing role in *whānau* connections. Broadband internet services are now available at Mitimiti, and thereby no matter where in the world *whānau* live, technology can now connect them in a matter of moments.

> *"I think the population is still declining and it is aging. So you are losing them at both ends." (12 July 2013)*
>
> *"How do you have a robust response when you just don't have the people on the ground?" (12 July 2013)*
>
> *"At one stage we had quite a shift back here…There was a lot of people who came back and built houses but the economy changes again and they couldn't stay here and then we ended up with all these budget houses that were built like 15-20 years ago and now they're empty and becoming dilapidated…" (12 July 2013)*
>
> *"The kids just grew up and it was automatic that the kids went to the cities to work. They didn't expect to hang around here because there was no dollars to be made." (12 July 2013)*
>
> *"When I was a teenager there were more people. It didn't matter. There were big families and all the kids come down. And there was plenty of labour. It's not like that now… most of the kids get to an age and they are gone. It's a big change." (12 July 2013)*
>
> *"Times have changed. You know, the internet, all kinds of distractions. All kinds of sorts of extra foods coming onto the shelves that kids like…" (12 July 2013)*
>
> *"Once upon time we used to do our own gardens and some of us still do. Our gardens were huge. Someone would provide the watermelons, someone else the pumpkins….Some whānau don't do that anymore... And I guess we are all like that 'oh naa well just go to the shop'. Once upon a time we used to milk the cow to get our milk." (12 July 2013)*
>
> *"I think our people are losing the kaitiakitanga of our environment…We go to our marae and we talk about the whenua and we talk about looking after it but in practice it isn't happening. There are lot of reasons why it is isn't happening. Even within our community here there is a breakdown in our values that were traditionally there…" (12 July 2013)*
>
> *"There is a need to encourage whānau to get to know each other, stay involved with the marae, and to come back regularly, especially the young people." (12 July 2013)*
>
> *"There are a lot of whānau in Australia… But because of the [Marae] Facebook page they can see what is happening with the marae…" (12 July 2013)*
>
> *"The young moving away does have an impact on our resilience and our ability to react..." (12 July 2013)*

The value of working relationships with local authorities and government agencies was also raised, particularly from the point of view minimising the degree to which people (and place) are directly and indirectly impacted by climate related hazards and stresses. Some participants were critical however of the way local authorities' and external agencies engaged with the community and were sceptical of their intentions and motivations. The lack of equality in these interactions was also a common criticism and thereby a recognised barrier to forging better relationships as most community members felt they had no voice. A small number of interviewees also expressed frustration in the lack of support they received from central government and national agencies. Although, according to one community member trying to gain access into the community can be very hard, particularly as many of the *whānau* believe they can solve their own challenges without outside help. In spite of the common displeasure surrounding external relationships there were a number of interviewees who acknowledged the importance of improving these dynamics in order to more strategically meet the challenges surrounding future social-ecological change.

> *"You can see why people think, oh why bother, and, we'll just deal with it ourselves and do what we can and just try and be sensible about what we do and move on. It's just another barrier to try and get some action. And you get hōhā. You feel like you're wasting your energy and time." (28 November, 2011)*

> *"To me it's like the mako and the kahawai scenario. You have a voice but you don't really have one cos [they have already decided] these are the rules." (28 November, 2011)*

> *"To me, I feel like when they come, we're ticking their boxes. And it's the compliance requirements. Often they're coming and telling us the rules, and I'm thinking…Why are you doing this?" (28 November, 2011)*

> *"Everyone will band together but this can also be a barrier to getting into communities because people believe they can do it themselves without outside help…" (18 November, 2011)*

> *"Trust – both internally and externally – there must be strong relationship building before whanau will be open to whatever the kaupapa..." (12 July 2013)*

> *"I think that when it comes to relationships with external organisations or if you are doing projects with others whether it's a council or runanga they need to learn to take their time...because trust takes time to develop..." (12 July 2013)*

7.2.2 Resourcing, self-reliance and innovation

Discussion of the factors that influence the way people are affected by, and deal with, climate hazards, risks and related stresses, often resulted in conversations about the importance of resourcing, limited employment opportunities, low incomes and the poor state of some community infrastructure such as the Mātihetihe Marae. Specific financial constraints included limited funding for upgrading lifeline and community infrastructure, the potential acquisition of land for relocation, and the preparation for and response to climate-related hazards and risks. Notwithstanding these resource challenges, the attributes of the self-reliance and innovation were also evident through the narratives of those interviewed. These narratives centred on the importance of solutions that emerge from the *whānau* such as

planning and being prepared, to more simply (but no less profound) supplementing household supplies (and incomes) through fishing, hunting and gardening. Together all these factors influence and shape everyday living at Mitimiti.

Almost all of the interviewees discussed the lack of economic development, including a contracted local labour market once dominated by employment in farming, shearing, fencing and small-scale harvesting of natural resources such as *korari* [flax], lupin and *kauri*. Many of the interviewees recalled how their generation were encouraged to leave Mitimiti once they were old enough to leave home and move to the city. This led on often to discussions about the diminishing number of *whānau* on the ground, vacant houses in disrepair and the impact of low incomes on housing quality and general building maintenance. Some interviewees also described the strain that changes in government social policy surrounding unemployment assistance have caused *whānau*, both *whānau* who have remained in Mitimiti and those who have moved in search of work elsewhere. Some of the narratives are articulated below:

> *"Yeah, they needed work. And the land was difficult to farm as well. So they had to move. So [up until this time] there were quite significant settlements right down along [the Mitimiti coastline]… at Waitaha there was the flax mill, and everything else. We had our woolshed down there…a lot of people used that woolshed, including people from the other side of the [Hokianga] harbour when they brought their stock across… So there was a lot of sheep farming going on. Mum said that even when she came here (when she was first married); there were remnants of the flax mill… [But eventually] my dad and her left here to move away for work." (28 November, 2011)*
>
> *"Unemployment is a definite [issue] around at home… It always has been, in a way. I mean it's ok for the guys cos there's a forestry there if you wanna get into that. But as far as the females back in those days, nah, you had to come away [to the cities]… And we were encouraged by our father. We weren't encouraged to stay there. When we left school we were just out of there. He didn't care what we were doing, we weren't staying there…." (8 December, 2011)*
>
> *"The financial side of it is a lot. There's no employment out here. You have to really make your own employment out here." (29 November, 2011)*
>
> *"A lot of our land is land-locked around here. We have whānau up the road who want to build up behind Moetangi. Money is barrier though…there is a whole lot of land that is untapped…" (12 July 2013)*
>
> *"And social policies, government policies are driving you away from home, like……employment, you know. You can't get your benefit, so you have to go elsewhere to work, in order to survive… which is really sad because some of them have got homes there. And they've left them empty because of that." (8 December, 2011)*
>
> *"This area is classed as a no-go area. You can go over the hill [Panguru] and get it [the unemployment benefit] and we get nothing. And they expect us to pay the same rates…" (12 July 2013)*

"And in actual fact it works out worse for them [when they move away to gain employment] because they're only probably making $20 or $30 more [than the benefit] by the time they pay all their expenses and all that sort of stuff, so it doesn't work out beneficial for them. But government policies drive a lot of stuff." (8 December, 2011)

"The nature of Māori is that Māori usually have two homes – their tūrangawaewae or wherever they come from and where they are living now. And they have to sustain both at significant cost..." (12 July 2013)

"Even us keeping our own urupa...which we do off our own backs. But you and I down in Auckland are paying rates for local cemeteries that we are never going to be buried in...so our incomes are looking after 2 places at the same time. And you don't get any break and councils do not understand that...so it's a different playing field." (12 July 2013)

Many of the interviewees discussed the importance of increasing the economic base of the community. Commonly, the economic potential in multiple blocks of Māori owned land in the area was identified, as well as the need to realise economic opportunities for *whānau* who live both in and away from the community. A key matter emphasised by these interviewees included the requirement for *whānau*, *hapū* and *iwi* generated business opportunities that provide meaningful, long-term employment options and economic benefits for the community as a whole. One interviewee thereby described a number of elderly *whānau* wanting to move back to Mitimiti and that the creation of *hapū* housing for elderly to stay and retire in could provide economic spin offs generating jobs for carers, nurses, cooks and cleaners whilst also creating demand for local health services. These aspirations were not driven by financial motivations, but rather were seen to be more fundamentally about increasing *whānau* health and well-being; and thereby being able to better meet challenges when they arose.

"[W]e want to be entrepreneurs, and we want our community to be. We want to earn our own living here and use our resources so that we don't have to ask for hand outs and go to the government. To look at what we have and not what we don't have a lot of the time. Use what you've got, yeah. Because we've got so much here, but a lot of people don't see it. They just see what they haven't got…it's not money you need sometimes…its communication, knowledge." (28 November, 2011)

"I think there are great opportunities here, in terms of forestry and farming...I see these as key drivers in this area that could kick-start other small industries, cottage industry stuff, niche industry stuff." (12 July 2013)

"Mainly get people back working that's a big one [that's our biggest issue]…. And that's pretty hard here as well. To find work or somebody to be able to create work and get people working, get people working together eh. As it is today… fullas haven't got work, and they stay at home, they get whakaaro kore, you know, and spiritually, it knocks them back eh. You can imagine yourself if you didn't have work, and you had nowhere to turn, you're just sitting at home and dunno where to go, you're gonna get all stressed out and depressed etc. So all those things people need to be mindful of, my neighbour's living like this, and [they] need a bit of tautoko, just go and talk to them. Or try and offer somehow.

But I think in Mitimiti especially, they're pretty good that way." (28 November, 2011)

"You can't just go and buy land easily at Mitimiti. Those sections don't come up very often so this keeps some whānau away….but it doesn't have to be a barrier if we are a bit more creative about how we have more homes of whānau land..." (12 July 2013)

A number of interviewees thereafter explained the importance of having access to financial resources to better prepare for, manage, and recover from adverse climate related hazards and stresses when they occurred. There was concern amongst a couple of interviewees that some *whānau* were particularly vulnerable during severe weather events because they lacked sufficient funds to adequately protect their homes and/or re-build/relocate if their homes were seriously damaged. One *whānau* was affected by flooding on numerous occasions where flood waters entered their home and they subsequently left Mitimiti because of the financial cost and emotional stress caused by the flooding. Further still, a number of high priority tasks were identified for the marae to make sure that it remains viable. These include repairing the roofing on all of the buildings on the marae, upgrading the *wharekai* and ablution facilities, and replacing the *wharehui* building because of its age and it not being big enough to meet the demands of the future.

"Yeah, people not having their own resources I guess as well. Especially for emergency things. You've got to make sure that if there is a flood or a tsunami or something, you're ready for it. Most people are, but... there was an aunty and her house was close on the other side of the bridge, and I guess they prepared as much as they could, but the flood went through their place a couple of times, and they just moved away. That seems to be what happens." (28 November, 2011)

"When the bridge was out we had to shut more or less... It impacted tourism big-time because whole Hokianga got a flood…Waima, Whirinaki, Panguru, Waihou. It must have been January just before school went back when it happened, and it really just cut off the season for Hokianga, because you know devastating floods, there was all these headlines. And people complained that the news had beaten it all up and then tourism finished for everyone, and it did really that year." (12 July 2013)

The issue of insurance was also raised by a few interviewees. In general, most interviewees believed it was important for *whānau* to hold insurance, but remained unsure about how many *whānau* living at Mitimiti had insurance for their homes (and other assets). Due to the high number of 'temporary' homes and baches along the coast, it was assumed that some of the dwellings had not gained resource consent and/or were in a poor state and would therefore not be eligible for insurance cover. Further, some interviewees who were insured had had mixed experiences with insurance providers and were left unsure as to whether insurance would actually pay-out following damages from extreme climate-related events. Another interviewee also expressed uncertainty about gaining insurance in the future because of the potential increase in exposure of their property to climate-related hazards.

"We're insured, and anyone who's insured, you automatically pay a portion for the fire service and EQC in your insurance… And I mean, they're helpful, and you get a little bit for it, but it's not enough to fix the problem… The thing we learnt

about EQC that was really hard, they'll send engineers out and say "you need to do this, and they're talking this and that", and it's gonna cost $40,000. Then they might give you $4000..." (28 November, 2011)

"We don't have insurance at the marae now...they refused to insure us from last year because we are so far from Fire tenders and we do not have a sprinkler system so we will have to include this in any upgrade..." (12 July 2013)

"Eventually our insurance company could say…if the tide did come up really high or the creek came through our property, they're likely to say, we're not going to insure you anymore. You know we still have a mortgage. It's not big now, but it's a worry when you do have a mortgage." (28 November, 2011)

Another factor that a few interviewees identified was a lack of access to resources such heavy machinery and equipment to prepare for and mitigate risks as well as respond in emergency situations. In addition, greater access to new technologies such as broadband internet and improved warning systems were raised – although it was simultaneously acknowledged by some of the interviewees that the 'bush-telegraph' was highly effective in providing warnings and thereafter checking the welfare of *whānau* such as the elderly living alone.

"Yeah. We're still on dial-up you know. That's the other thing. That's probably why we don't have access to all this information, because the internet out here is crap. We're still on dial-up, and you're lucky if you can even get up on dial-up. You know, things like that. Some people don't have phones. You don't have mobile phone access out here, things like that. So we're sort of behind the times …but we're in front of everyone else when it comes to sustainability and surviving" (29 November, 2011).

"The other thing too, the interesting thing was even the emergency services, I remember when they rang for that, they kept asking for the GPS…co-ordinates. I was thinking, hello? You try and give them the nearest address and they still can't work it out. Very frustrating" (28 November, 2011).

"We have broadband here now and it has changed our lives. We have been on dial-up all this time. We can do research now about things that affect us" (28 November, 2011).

Notwithstanding the varied resourcing challenges facing different *whānau* across the community, almost all of the interviewees described the inherent self-reliance of *whānau* and the adaptability that is required to live remotely at Mitimiti. Some interviewees explained the significance of planning skills around irregular visits to distant town-centres for food supplies, others emphasised the importance of supplementing these supplies with wild-kai, and other *whānau* highlighted the significance of cultivating gardens and the important learning that is inseperable from these activities. All of these examples were qualified as vitally important for *whānau* dealing with daily realities as well as intermittent disruptions caused by climate-related hazards and stresses. Some of these narratives are captured below.

"We go to town once every 2-3 weeks. We are self-sufficient. We have a garden. We have chooks…" (12 July 2013).

"I don't go every week to Kaitaia...if you go, you're spending say 50 bucks gas. If you could save your self [a trip or two] and I had four kids bringing up… I have saved straight away. Then you have good money in your pocket and you buy bulk of everything. And then you get the extras. Someone has killed a beef and you get a quarter… And you live like that…" (12 July 2013).

"We get fish, mussels. People have cows, kill the cows. I might get a piece" (12 July 2013).

"For me you just take whatever comes along. You just have to deal with it" (12 July 2013).

"There are difficulties in being here but there are also advantages to living here. You get the opportunity to gain knowledge that you would never get unless you were actually here. There are many benefits that are not economic to living here so…soul benefits" (12 July 2013).

"When things go tough there is only one way…. If things go wrong, keep going…" (12 July 2013).

7.2.3 Knowledge, skills and expertise

Consideration of how the community deals with, and is affected by, climate hazards and related biophysical changes resulted in detailed discussions surrounding the importance of local knowledge, environmental awareness with local hazards and risks. These responses were often moderated by acknowledgement of the loss of *hapū* knowledge and the accompanying decline of more traditional ways of learning. The desire to promote traditional learning opportunities was raised by many of those interviewed; as well as the value of promoting new skills and expertise to deal with increasingly complex contextual realities facing the community. Notwithstanding these visions, shortages in expertise and skills to deal with everyday realities were also identified including the need to better understand the relevance of the climate change issue for home-people today. Importantly, the complementary roles of the *ahi-kā* and *whānau* living away from Mitimiti were also raised by many interviewees.

Most commonly, interviewees spoke about the importance of local knowledge in understanding and dealing with environmental risks. Many interviewees acknowledged their *tūpuna* and the significant contribution their expertise had made to helping *whānau* live in Mitimiti. Maintaining close connections with the land and sea, and learning to understand local environmental processes, were thereby regarded as critical for recognising environmental risks, climate-related or otherwise. Subsequently, some participants described being able to recognise the signs of extreme weather events.

"They [our tūpuna] knew everything. When it was gonna rain, whether it's gonna be a windy day, they just gotta look at the moon and they could tell you whether it's gonna rain tomorrow or be cloudy tomorrow… they were good at it. Plus I think they had that extra sense too. They didn't rely on anything, had no TV, no radio, so they were aware of everything around them. Whereas us today, we can ring up the weather-man and turn the TV on and see what the weather's gonna be like tomorrow, but those fullas didn't. They didn't have it there, so they knew exactly how to tell… just by the birds and by the animals, where they were at the

different times of the day, they knew if it would rain or be fine." (28 November, 2011)

"Like my dad, there used to be a place up in the bush here behind my place, and there was a big rock sticking out, and he'd get out there with the binoculars, and say, it's gonna be a wet day today. My old lady would say, how do you know? He reckons the goats are up on that rock. Sure enough, it'd bloody rain. The goats would go up and hide up in those rocks eh, and if they weren't there it was gonna be a fine day." (28 November, 2011)

"You know when something's going on. You can tell by the way the birds are flying around and they make a lot of noise too…You see the wild duck flying around. I s'pose you sort of get a natural feel for things." (11 July, 2013)

"Well, actually the best sign is the horizon eh. That tells you all the time [what the weather is doing]. You can just look out there and… [see] oh it's gonna piss down soon, and guarantee it will happen." (28 November, 2011)

"Yeah Taiko, when they start coming in, you know it's gonna be rough soon… Yeah cos those birds, they can sleep on the water…cos they fly miles and miles out to sea, those birds, to feed, and they actually stay out there if the weather's good, and just wake up in the morning and they're on a food bed. But when they do come in at night, you can just about guarantee it's gonna be some rough weather coming. There used to be a lot when I was a kid." (28 November, 2011)

"Common sense is a lot of it… as soon as you know heavy rain is [approaching], you stay home. Don't start driving around the country. Cos Panguru's real[y susceptible for floods there. Even a logging truck can't get through there when the roads are in flood." (29 November, 2011)

Notwithstanding these commentaries, a number of interviewees expressed concern about the declining number of *kaumatua* and *kuia* over recent years and the resulting loss of *hapū* knowledge. Commonly these narratives turned to significant changes in the social structure of the community, the burden of *marae* work falling on the shoulders of a small group, and the declining transfer of knowledge surrounding *tikanga, kawa* and *te reo Māori*. More specifically one elderly interviewee commented on the lack of knowledge and expertise that existed within the community to deal with important issues surrounding the preservation and protection of significant sites such as *wāhi tapu*.

"My worry is that in time, nobody will know what to do. Because the younger ones coming through, their reo is, they're not learning. So there's no succession type planning happening in that respect. There's one or two, but they don't live here." (28 November, 2011)

"It sounds like urbanisation had a lot to do with it, but I think the impact had already started to happen, I reckon, before they even left [the area], if I listen to my mother about the lifestyle that people had… it doesn't sound like knowledge was readily passed on. Apparently there were wānanga up to the 1950s, and then the wānanga were closed… there were possibly people starting to shift then.

[This was the period that] the whole wānanga concept was starting to wane." (28 November, 2011)

"So, I did run a little te reo class last year, and we had about five men, and we tried to encourage them to just learn a little mihi cos people are quite understanding these days of these things. So even just a little something in Māori and then break into English is something – it's better than nothing. But they're still whakamā about it… But that's the dilemma we're facing right now." (28 November, 2011)

"I think part of [the issue] might be that we've lost a lot of kaumātua... We don't have a huge number. And I'm not too sure what's gonna happen about that." (28 November, 2011)

"We have dwindling ringawera. There is only a handful of us to do everything… And by the same token there are people who work who can't get off. But some take a day off to grave dig and stuff…"

"Some families moved away when they were young. They don't even know the kawa of the marae now. I suppose in a way it is our fault? We should be having more wananga. It is only when they come back with their tangi(s)… There were a couple of mate when they brought the tupapaku in the wrong way, headfirst, and you tell them and they would say "well we didn't know". Well you won't know if you don't come home. A lot of them disappear, I mean they just come home and bury their beloved ones and you never see them again. But, they are very important. Actually we need them more now than ever. Cause everything down our marae is getting beyond our used by date." (12 July 2013)

"What we have found is that everyone that has moved away… and we know we have issues because what we have found is that a lot of whānau think that they can now come home and then leave and like there is nothing else to do. And that they have nothing better to do than look after us. The marae is really strong but the people, our home-people, are really fatigued." (12 July 2013)

"There are so few families on the coast, some of them have been absentee families in the past, and have returned… probably in the last two or three decades, so it's almost like we have to re-develop that desire [to learn], I guess. I don't know, but to me there's not a lot of kōrero about the preservation of those sites, or even their location, in a co-ordinated way, which is sad." (28 November, 2011)

"It's not that enough is not being done… it's just timing and all sorts of other things going on … No-one can get all together at the same time and then bang we have a hui at the marae and then time moves on and we have other things to do. I don't know when we had the last wananga". (12 July 2013)

In spite of these concerns, almost all interviewees believed it was vital that *whānau* reclaimed their *hapū* knowledge before it was lost altogether. Bringing younger people in to prepare for taking over roles in the future was identified as well as Māori knowledge revitalisation initiatives carried out through regular *wananga.* Facilitating time with *kaumatua*

and *kuia* was also identified including important *hapū*-reflection of what traditional expertise and skills would help to strengthen the capacity of the community to deal with social-ecological changes in the future. Such conversations generated considerable enthusiasm among those interviewed because of the myriad of opportunities such actions would provide for those generations yet to come[47].

> *"So we talked before about wairua… I think we've gotta find a way to marry it up to our identity as a people. So I think we've got to, because you know, for us for instance, our family weren't brought up [speaking] Māori… And I think along the way, you lose a bit of who you are. And I think there's an opportunity for us to rediscover who we are, and as a part of that rediscovery, weave in a bit of ecology, a bit of the environment, because the environment in the old days was important, it was all about sustainability. So for me, there's an opportunity there for us to rediscover who we are as iwi, and also to factor in the sustainable viewpoint and how we can do things better, and things that we can do on a day to day basis that help us to achieve on-going manākitanga of our resources." (8 December, 2011)*
>
> *"…in fact a lot of our old cultures were based around sustainability. It's the western culture that's so at odds. It's about growing and taking over things and dominating. Whereas the old cultures were around living sustainably within the environment. And I think that is actually what our culture actually inherently is, and it's a viewpoint that a lot of us [have lost]…and a lot of us are living in town. Town is western. It's about getting the bigger flasher car or whatever it is, and I think we're lucky we were brought up in our situation, going back to what I said before, we know what is real, and that it isn't that stuff. It isn't getting more stuff. It's about… It's getting a feed of kūtai every week. Having a fish head when I want it." (8 December, 2011)*
>
> *"Maybe at the school level it would be more effective to connect the kids with our kaumatua…" (11 July, 2013)*
>
> *"Wānanga… Yeah I'd love to do that. I think my kids would love to do that too. Yeah. Putting our tamāriki [and/]or people that are interested, in further training, through understanding what climate change is all about and the effects of that on our community. I think that's [important], we've gotta train people" (8 December, 2011).*
>
> *"Sometimes you do not have to talk, they just pick it up. It's the way you do things…" (11 July, 2013)*
>
> *"If they [children] are not here you cannot tell them. A lot of the generation here now were brought up in Auckland and moved back…If you want to stay here you need to learn that stuff…" (12 July, 2013)*
>
> *"The levels of knowledge are not consistent across the community – but different people know different things…" (11 July, 2013)*

[47] A number of interviewees also believed that the integration of traditional as well as non-traditional educational opportunities would provide a more complete knowledge base and skill-set that might contribute to the emergence of new knowledge and skills.

"Often there are people who only come back at Christmas and they only come at the holidays and everything is fine and they don't realise how swift the current are and how big the tides are…But whether they would ever get access to finding out it is up to the hapū, and the marae to tell people there is something available…" (12 July, 2013)

Almost naturally, these conversations turned to considering what new skills and expertise might be needed to deal with the increasingly complex realities facing the *hapū* and different *whānau*. Some interviewees were concerned about the mixed messages and complexity of the climate change information, and thereby felt it would be helpful to promote new skills and expertise within the community to interpret and determine the value of new information about environmental issues, new technologies and future predictions. Consideration was also given to how climate change information could be better shared and communicated among *whānau*; particularly given that such information was regarded as highly important for informing *hapū* decision making and future planning. Mātihetihe School was thereby seen as fundamentally important for contributing to the knowledge base of *whānau* by engaging *tamāriki* in science and environmental education at a young age. Furthermore, the skills and expertise held by non-resident *whānau* living away from Mitimiti were also recognised as critical to the long-term future of the community.

"There always has to be key people, otherwise nothing ever happens…People who are prepared to pick that up…" (11 July, 2013)

"…whānau in Tamaki Makaurau provide a lot of input into the marae." (11 July 2013)

"So they can understand what's going on. There are a lot of things on TV now that tells you about climate change and everything, what's happening in certain countries. You gotta keep watching it to understand it. "What happens if I did that?" "What happens if I did this?" Those sorts of things you gotta push through your mind. A lot of the old people have been through it and they can read it. But the young people they gotta be taught now. They gotta be made aware of what's going on and what can happen." (29 November, 2011)

"I think the western world confuses us because we're so used to watching things on TV. You've got one documentary saying that global warming's happening, and then you watch another one saying it's not, they're just misleading you. So I think it confuses people sometimes." (8 December, 2011)

"Yeah, it's just that unknown. And not having a timeframe or anything like that. So I mean that's where we've embraced this study, cos we might get some answers." (28 November, 2011)

"And some actually, quite a lot don't realise there's actually resources out there. Especially our elderly, they don't realise there's actually resources from government. You know like, for instance, this healthy homes thing. A lot of our kaumātua didn't know. [But] someone got on to it… so at least all our kaumātua/kuia, at least their homes are insulated now…" (29 November, 2011)

"We've recently had a permaculture course that a lot of people have gone on. And you'll see gardens starting to pop up. I've started seeing them already from people that I know that have been on those courses… I learnt a few things and I did my garden based on what I learnt there." (28 November, 2011)

"Often the people living away are the ones that have the skills that we need at home anyway. And there could be opportunities here. And most of them do want to help at home but can't figure out a way that can help at home." (11 July, 2013)

"What I've notice with the committees now, like years ago everybody was old in the 55 getting into their 60's there input was a lot more. But now I am seeing people just over the 30 come back from Auckland to the marae. And that's a huge thing to do to travel back to meeting once a month. They bring new vision, new ideas." (11 July, 2013)

More broadly still, there was a general consensus that the 'right' decisions regarding the well-being of the *hapū* and *whānau* in general at Mitimiti will ultimately require vision, commitment, collaboration and hard-work that draws upon a wide range of skills and expertise crossing the Māori and non-Māori worlds.

7.2.4 Community structures and governance

Formal and informal community structures such as Mātihetihe Marae and Mātihetihe School were identified as significant factors that influenced the way the community deals with, and/or is affected by, climate related hazards and stresses at Mitimiti. These structures were widely seen to be underpinned by, as well as supportive of, traditional Māori values and conventions such as *whanaungatanga, manākitanga* and *kotahitanga*. However, a range of external and internal barriers that constrain the governance and efficacy of these structures to better manage community risks associated with weather and climate related hazards and change were also identified. These conversations led to comments about the influence of central government legislation and local government regulation on *whānau/hapū* well-being and aspirations, as well as questions surrounding the roles and effectiveness of existing Māori governance structures to manage complex and integrated challenges such as climate change, natural hazards management and sustainable development.

Mātihetihe Marae and School were identified by all interviewees as central community structures within the community. All of the interviewees affiliated with the marae through *whakapapa* and most had been pupils of the school. Most interviewees acknowledged the value of these formal structures when talking about 'making things happen' at Mitimiti. For example, the marae is governed by a group of marae trustees who meet on a regular basis (every second month) and are elected annually by the Mitimiti community. These trustees are responsible for making decisions about how the marae functions as well as directing future planning and ensuring agreed actions are implemented. The marae (and school) were thereby seen as vitally important for bringing the community together, identifying community relevant goals and debating priorities. Several interview contributors even related their well-being to involvement with their marae and their community generally.

"Marae are absolutely focal in communities like ours…" (12 July, 2013).

"The marae is where whānau should be untied to come together…" (12 July, 2013)

"Well, without the marae we wouldn't survive as a people. End of story! Cos it's used for everything. We use the marae for everything from fundraising for the church, for the school, the local rugby club, the school kids. Especially the school kids now, we do a lot of fundraising for them. Everything is done at our marae you know. All our funerals, and weddings, and birthdays are all held there. Without the marae here, we'd be totally buggered." (28 November, 2011)

"Everything important happens at the marae…" (12 July, 2013)

"The school is our identity as well and if we lose the school we would lose part of our identity. There are lot of people that rely on the school. For me the school is right up there with our marae… well for me anyway." (12 July, 2013)

Notwithstanding the critical importance of Mātihetihe Marae and the Marae Trustees in helping to facilitate 'community' decisions about the use, management and care of *whānau*- and *hapū* owned assets, there were some questions surrounding the efficacy and roles of some of these structures – particularly when decisions surrounding complex and integrated challenges such as climate change, natural hazards management and sustainable development were required. Some interviewees also spoke of decisions sometimes being made without full consideration of all the available information, while others reflected that the largely self-governing history of the community had created a somewhat 'insular culture' with some community members particularly resistant to 'external meddling', and this could sometimes be detrimental to the community as a whole. Importantly, some interviewees acknowledged that key individuals also contributed to raising community issues and facilitating consensus on group issues.

"There is not enough people with the appropriate governance and management skills to really get the assets that are here such as forestry and framing performing to the level they should be and performing at. And so there are lot of lost opportunities and benefits. And I think that is a big issue for this areas here." (11 July, 2013)

"It can be improved. And I have told them that too. I think the structure can be improved. There is a bit of a disconnect between the governance and the people who work day to day on the ground. So I don't think the present structure works particularly great for it. I don't know what at the solution is either." (11 July, 2013)

"Sometimes people who do not bring people together are actually the ones in charge." (12 July, 2013)

"Local Māori organisations we are not quick to think about who we could call in. We always look amongst ourselves first and then choose somebody and we don't think about what kind of expertise might be useful here. And again sometimes I wonder if think that if we get an expert in that they might take the power of the project away from us versus seeing an expert as somebody that you instruct and they do what you ask..." (12 July, 2013)

"Where else do you have to worry about your community's drainage, your community's roads...you don t have to think about that in town...you just pay your rates and go for it...you don't even have to check in on your neighbours after a flood..." (12 July, 2013)

In addition to the role formal structures play within the community, informal structures such as *whānau* and *hapū* were identified by interviewees as forming the foundation of the community. These connections between *whānau* and *hapū* in Mitimiti are especially significant because nearly everyone in the community and surrounding district share *whakapapa* links. As previously articulated, the remote nature of Mitimiti also means *whānau* and *hapū* relationships are especially important – that is collaboration and co-operation between *whānau* is often the only way to get things done. Both formal and informal institutions thereby play a role in responding to, and recovering from, weather and climate related hazards at Mitimiti. Each event is typically managed on a case by case basis however, rather than through a formal 'hazard management plan', with roles and responsibilities loosely defined within and between individuals (within *whānau*). In this way, it is 'just expected' that *whānau* from the community will 'look out for each other' and support one other when required.

"Generally people will have their own systems in place. If you talk to anyone here, they generally have ways of coping. The main thing is to have water, have something to cook on, and to have some food there, and alternative lighting for night time" (28 November, 2011).

"…we're quite resilient…we tend to prepare for ourselves, and we know where the oldies are, people check on one another, and yeah, we look after ourselves, we don't sort of worry about [it], it's just about having enough to survive on" (28 November, 2011).

"My wife works at the school. But straight away when there is a flood it is more or less shut down. So she has to ring around all of the kids… make sure they don't go out on the road. And you get to know where everyone is you know… She has to make contact with all those parents… The parents have to leave a contact number as well. Say at 1pm it has been raining, just the rain happens…there is a certain part in Panguru where if the rain and tide meet at the same time it stops everyone going through. So they have to act before that happens because the bus company says they will not go through floods anymore. The bush telegraph is marvellous …"

"I'm always checking my neighbours, they're always checking me if anything happens, just to see how you are..." (28 November, 2011).

"I think this one [the Mitimiti community] is resilient…in that you take knocks, and just bounce back. We've had floods, and we've had disasters like that, like the big Panguru flood, we got cut off out here. You've got to be able to move on and bounce back from that kind of thing." (28 November, 2011)

"So we just prepare ourselves. We prepare ourselves for if we're going to have our power cut off. We've all got gas cookers, we've purchased a generator for [our mother] because she has medical equipment, and we just have lots of water

stocked up. I generally do things like fill the bath tub. Mum's got a tap we know that drips even if the power's off, so we usually stick buckets under that, or we might fill her bath tub up for the toilet, so we've got a bucket to put water into the toilet. I've got a water tank here that I know that I can use if the pump's turned off. So it's all been set up so that I can access the water out of that easily in a storm or whatever." (28 November, 2011).

Notwithstanding these commentaries, some interviewees were hesitant to presume that future events would be comparable to what they had experienced before and therefore they felt greater caution should be promoted. A number of *whānau* also discussed the limitations of informal systems in managing risks from climate extremes and believed that establishing formal emergency response procedures would be beneficial in the future.

"They're all pretty resilient I suppose… but I don't know whether it's resilience or whether it's tolerance" (8 December, 2011).

"We've talked about it. We've talked about maybe a siren up at the school, cos the school have a plan. We've sort of started thinking about it, throwing those ideas [around]. But a siren at the school is probably the main thing, and people would gather at the school, cos it's higher than the marae. But generally its word of mouth, or people will just get in their cars and go and check. Like if I'm not here, somebody will go and check on Mum" (28 November, 2011).

Specific external barriers that constrain the governance and efficacy of local structures to better manage community risks associated with weather and climate related hazards and change were also identified. These conversations primarily focussed on the prohibitive influence of government legislation surrounding Māori land-use and management of the Warawara conversation estate which was seen to have prevented access to (and thereby utilisation of) large areas of Māori owned land. Those interviewed regarded this specific issue as particularly important for those *whānau* landowners at North Mitimiti who can only access their properties via the beach. With respect to future SLR projections, paper-roads in the hills behind Mitimiti were identified as alternative access routes; however, any such access would require revaluation of existing rules governing access across coastal reserve and conservation estate.

"Most of our land is up the valley which is land-locked. And there is no access. We don't have horses like the old days. Not even a quad bike can get up there. And they think they can rate us for something." (12 July, 2013)

"If road could be opened to grant access into the back could help a lot of people who cannot get access to their land up in the hills…" (12 July, 2013)

"If you are going to assert rights here [DOC and Council] what are your responsibilities with respect to those roads [points to fire tracks in the lower Warawara ranges]?" (12 July, 2013)

7.3 Climate change implications and risks

It is evident from the preceding narratives that extreme weather and climate related events represent hazards with varying risks for different community members across the Mitimiti

settlement. These risks arise from 'normal' day-to-day, seasonal, and year-to-year variability in climate, as well as from contextual conditions that underpin (and shape) the sensitivity and adaptive capacity (i.e. endurance) of *whānau* to respond and plan for such challenges. When dealing with the adverse impacts of climate variability in the future however, *whānau* may not be able to rely on the assumptions that the prevailing climate will be more or less the same as it has been over the past 50 or 100 years, and/or that existing ways of dealing with such challenges will be enough. Effective coping and adaptation options may require new practices and strategies, as well as new information to help consider the risks posed by changing climate conditions. This sub-section considers the implications and risks of (i) projected SLR impacts along the Mitimiti coastline for 2040 and 2090 AD, and (ii) climate-induced coastal flooding surrounding Mātihetihe Marae due to extreme rainfall under different climate change scenarios and projected higher sea-levels for 2040 and 2090 AD.

Note these results are based upon direct feedback provided by fifteen community members during the final round of interviews in July 2013 and supplemented by complimentary information and guidance gathered by the author team. Furthermore, the home-people involved in this stage of the work elected to avoid prioritising the risks identified through this analysis.

Coastal inundation from sea-level rise

The scenario results produced from our examination of the first-order impact of higher tide levels (MHWS-10) along Mitimiti Beach indicate that a creeping of tide is likely by 2040 AD, especially for those areas surrounding stream channels such as Taikarawa, Moetangi and Mātihetihe Streams (Figures 11 and 12). In addition, the MHWS10 tidal limit by 2040 AD is also likely to periodically reach the base of raised coastal terraces between Moetangi and Taikarawa Streams. By 2090 AD, even greater changes in inundation extent are evident as the MHWS-10 tidal limit pushes further inland, leading to an increase in the width of stream channels and the inundation of existing pasture land in some places. Further, by 2090 AD the MHWS-10 is likely to reach the base of raised coastal terraces on a daily basis. Not unexpectedly, even higher inundation extents are evident when the projected MHWS1 is considered (See: Appendix C and D).

In response to questions surrounding future risks for *whānau/hapū/iwi* assets, activities and things of value from SLR, there were many similar as well as some distinct responses from different members of the community. Most commonly responses focussed on the increased likelihood that access to the beach would be disrupted in some way – particularly for land-owners to the north of Taikarawa Stream who use vehicles to enter and exit their properties. Present access routes for these *whānau* are already compromised by the highest tides. Concerns about access to traditional food gathering areas were also identified, including uncertainties about the potential impacts such changes might have on the future location and availability of *kaimoana*. Coastal erosion and destabilisation of coastal slopes and dunes along the entire Mitimiti coastline from rising high-tide levels and storm surge were also acknowledged, as well as the potential loss of currently stable, dry-land and paddocks due to excess water build up and the problem this would cause for *whānau* who use these areas to graze and rotate cattle. Linked concerns also surrounded the increasing exposure of community infrastructure to higher tides and higher ground-water levels and what such changes might mean for life-line infrastructure, private homes and *wahi tapu* such as Mātihetihe Marae. Importantly, the costs of maintenance, repairs, and redesigning such infrastructure to cope with such changes were thereafter considered by some interviewees

including the anticipated higher burden that would be placed on particular pockets of the community. An annotated summary of the potential impacts and risks from climate change induced SLR identified by the Mitimiti community is provided in Box 2.

Note the possible response and adaptation options identified by *whānau* and the author team are considered and discussed separately in Section 8.2: Managing future climate vulnerability, endurance and adaptation.

Box 2: Potential impacts and risks caused by climate change induced SLR

- Semi-permanent to permanent inundation of low-lying coastal areas at high tide;
- Coastal erosion and destabilisation of coastal slopes and dunes from rising high-tide levels and storm surge;
- Coastal erosion uncovering new rocks potentially making beach driving routes dangerous;
- Adverse impacts on ecology from erosion and sedimentation.
- Structural damage to privately owned buildings and key infrastructure such as local bridges, roads and marae from higher water levels and periodic storms;
- Adverse impacts on *mahinga-kai* and *whānau* health from destruction of septic tanks and sewer lines;
- Increased interruption of vehicle access to beach and remote private homes;
- Changes in the location and availability of *kaimoana*
- Salt water intrusion (salinization) into fresh water resources and farm paddocks;
- Degradation of sacred places and sites resulting in loss of identity and *whakapapa*;
- Sand encroaching onto paddocks/private property due to dune regression;
- Danger of injury and loss of life in the case of extreme flooding and storm events;
- Increased costs surrounding the maintenance, repair, re-design and insurance of *whānau* homes and vital infrastructures to cope with such changes.

Coastal inundation from sea-level rise and extreme stream-flows

The scenario results produced from our examination of extreme coastal-river-reach flooding surrounding Mātihetihe Marae for 2040 and 2090 AD under mean A2 and B2 climate change scenarios both show inundation extents that are comparable to those observed during extreme flooding that occurred across the Hokianga in January 1986. However, as detailed in Section 5.2, the estimated future peak flood flows for the Mātihetihe Stream under the mean B2 and A2 climate change scenarios for 2090 AD were approximately 20% and 30% greater than the flows used to simulate the 1986 flood event. Consequently, water depths are higher across many places in the model domain for both 2040 and 2090 AD. Notwithstanding

this qualification, the most notable change from this modelling exercise is the gradual and on-going encroachment of water at the seaward end of the model domain from 2040 and 2090 AD. Relatively large differences in flood extent and water depth are also evident between the dune-field and the marae complex from 2040 and 2090 AD. An increase in inundation extent and water depth is also depicted across the area currently used for car-parking on the southern side of the marae complex as well as in front of the existing *whare-tūpuna* and *wharekai*. Conversely, Mitimiti Church remains free from inundation for an event equivalent to the January 1986 flood under both of the climate change scenarios assessed.

In response to these maps showing climate-induced coastal flooding surrounding Mātihetihe Marae due to extreme rainfall under different climate change scenarios and projected higher sea-levels for 2040 and 2090 AD, interviewees identified a range of potential impacts and associated risks facing *whānau/hapū* assets, activities and things of value across the community. Foremost among these responses were deep concerns about the enduring use and maintenance of Mātihetihe Marae for future generations. More specifically, interviewees identified the increasing risk of direct flood damage to marae buildings (and some *whānau* homes in other low-lying locations), including the prohibitive financial cost of repairs after flood waters have receded and/or temporary displacement (which can be a long process) while buildings dry out and/or repaired. Where severe structural damage has occurred, partial or full collapse was also identified including the possibility of injuries and fatalities during *hapū* gatherings. These heightened risks also extend to *whānau* and/or *manuwhiri* trying to gain access to the marae. Further, the difficulties of obstructed road access for emergency services was identified – including the disruption to wider road users and the community during, and in the aftermath of, such an event.

Other potential impacts and risks identified included the blocking of drainage channels and storm-water pipes by flood debris and sediment, the destruction of waste-water infrastructure at the back of the marae complex and the scouring (as well as washout) of unsealed road foundations. Any increase in the frequency of extreme flood events was also viewed as possibly leading to either increased increased premiums and/or total withdrawl of insurance cover for the marae (and some *whānau* homes) by the insurance industry which would intensify the challenges already facing the community when dealing with future flood events. Further, a couple of interviewees commented that projected future impacts and risks facing the community might be also aggravated by the return of city *whānau* as well as the arrival of new members to the community wanting to build in flood-prone areas – in spite of the wider community understanding of areas of high risk. An annotated summary of the potential impacts and risks from climate change induced SLR and coupled stream flooding identified by the Mitimiti community is provided in Box 3.

Note that the identification of possible response and adaptation options by interviewees and the author team are considered and discussed further in Section 8.2: Managing future climate vulnerability, endurance and adaptation.

Box 3: Potential impacts and risks caused by climate induced SLR and coupled stream flooding

≡ Danger to life in the case of extreme flood events - particularly for elderly *whānau* alone, people on the marae, and *whānau* with houses near streams;

≡ Damage to marae buildings and supporting infrastructure such as power and waste-water systems;

≡ Low-lying graves in front of the marae may have to be disinterred and moved for safety;

≡ Costs of clean-up, construction and maintenance of protection structures;

≡ Marae may find it more difficult to access adequate insurance cover in the face of increased flood risk;

≡ Increased pressure on formal and informal *whānau*-based support systems;

≡ Destabilisation of beach front properties due to erosion;

≡ Loss of land-holdings, farm-stock and related economic opportunities;

≡ Damage or destruction of wide community infrastructure such as roads, bridges, water, power, sewerage, communications;

≡ Costs from service disruption to water, power, gas, communications;

≡ Road access is likely to be impeded into the marae as well as for *whānau* that use the beach for access – particularly *whānau* with homes at North Mitimiti;

≡ Timing of seafood collection may be compromised

≡ Damage and loss of other historic sites/places resulting in loss of identity and *whakapapa*;

≡ Adverse health impacts: injury, stress, trauma, and sickness;

≡ Future development in low-lying areas of the flood plain by returning *whānau*.

8 Synthesis and discussion

This section synthesises the results derived from our quantitative and qualitative analyses by discussing the existing as well as emerging vulnerability (and endurance) of the community at Mitimiti to climate-induced coastal changes. The aim here is to summarise the context within which the vulnerability and adaptability of the community at Mitimiti is taking place, and thereafter, to consider how the changing nature of climate risks and challenges might be managed by the community in the future. Entry points for reducing vulnerability and enhancing future adaptability are therein identified; and a range of coping (tactical) and adaptation (strategic) options that might assist the community to manage the risks associated with future climate hazards and stresses are offered. Note that irrespective of ones views on climate change, most of the options identified are investments that will contribute to enhancing *iwi/hapū/whānau* development and well-being.

8.1 Constraints, capacities and opportunities

Before discussing the determinants of community vulnerability and endurance, it is important to reiterate that social-ecological systems are by their nature complex involving an array of biophysical, political, social and economic influences that interact across a range of spatial and temporal scales. Given that the responses of community members to such influences can be highly variable based on differing skills, experiences, perceptions and sensitivities, even deeper complexity is often reality. Notwithstanding this, any appreciation of community vulnerability and endurance to climate risks must take into account not only the interactions between climate risks relative to other factors, but also the contextual conditions which shape the constraints, capacities and opportunities that individuals, *whānau* and groups within the community experience and respond to on a daily basis.

Social-cultural networks and community change

Social-cultural networks and related cultural conventions and values are widely recognised as central to the long-term health, well-being and resilience of *whānau/hapū/iwi* and associated Māori communities to deal with adverse or unexpected socio-ecological challenges (Durie, 2005; Panelli and Tipa, 2007; Moewaka-Barnes, 2010; Mikaere, 2011; King *et al.*, 2012a, 2012b). Much of this work, particularly in the health sciences, points to the importance of feeling valued, safe and respected, having strong social supports, and a positive sense of connection and belonging, as important pathways for better health outcomes which promote values and behaviours that help deal with adversity and stress should, and when, they arise (Moewaka-Barnes, 2010). A number of international studies undertaken by, and on behalf of, indigenous peoples have also emphasised the importance of cultural arrangements and social networks in responding to natural hazards and community recovery from adverse impacts and conditions (Barnett, 2001; Berkes and Jolly, 2001; Berkes *et al*., 2003; Smit and Pilifosova, 2003; Ford *et al*., 2010; Pearce *et al*., 2010; among others).

The work in this study confirms the fundamental role of social-cultural networks for managing and ‘dealing with’ climate induced hazards, related stresses and risks. As articulated through the commentaries of home-people across the settlement, much of this capacity is rooted in the collective strength of *whānau* and *hapū* relationships as well as more elemental cultural principles defined by *whakapapa* and *tikanga*, and thereafter actioned through practical

values of *whanaungatanga, manaakitanga, kotahitanga* and *aroha*[48]. According to Durie (2005) these values, conventions, rules and behaviours are all important indicators of Māori endurance (resilience), bringing people together to support and share in times of abundance and adversity. However, he also argues that access to *Te Ao Māori* is integral to Māori endurance - as the separation of Māori from culture, environment, and history runs counter to the essential meaning of endurance because it fails to take into account the world that is a part of being Māori. Mikaire (2011) also points out that while Māori society is open to change it is nonetheless protective of these fundamental norms and principles[49].

Notwithstanding the importance of Māori values and conventions in helping to deal with diverse social-ecological stresses, many interviewees discussed the diminishing numbers of *whānau* (and *kaumatua*) at Mitimiti (often driven by low levels of economic development and opportunity) and the resulting pressure this was placing on the remaining *whānau* living there or nearby to fulfil obligations that once were shared by large numbers of *whānau*. These pressures include the responsibility and up-keep of the marae, *papakainga* and multiple owned land, looking after *mahinga kai* and other *kaitiaki* roles, as well as attending inter-*hapū* and inter-tribal events. Such responsibilities can of course happen repeatedly and thereby lives get put on hold while important maintenance and cultural actions are carried out at the marae. According to Baker (2010) with the majority of the Māori now living in urban areas, the role of *ahi-kā* is even more critical for the maintenance of *tūrangawaewae* for *hapū* and *iwi*, and thus for the intergenerational well-being of the *whānau* living away. Added to this, many Māori living away from ancestral areas make significant financial and social sacrifices travelling all hours of the day and night for *tangi* and other important events (Baker, 2010).

Linked to these challenges, a number of interviewees considered that the levels of comprehension surrounding traditional values and practices were diminishing, unobserved by some *whānau* and unknown altogether by others. Analogous challenges and transformations have been identified in place-based studies with Inuit communities where socio-ecological resilience and adaptive capacity have been weakened by changing relations of exchange, reciprocity and trust (Berkes and Jolly, 2001; Ford, 2009). Such conditions highlight the dynamic linkages between human-environment interactions, and further underscore that the implications of future climate change cannot be given serious attention by focussing on the physical dimensions of change alone. Rather it is the connectedness and interactions between biophysical and societal processes that operate within and across local, regional, and global scales that must be recognised and carefully considered if meaningful responses are to be developed. A central task ahead for Māori leadership will be to negotiate the pathways between people, their resources, and the worlds in which they live, so that relationships are strengthened, ties to customary resources are renewed, and the principles that underlie Māori world views are endorsed (Durie, 2005).

[48] The Iwi Research and Development Unit from Te Runanga o Te Rarawa also indentified that many community members' efforts are courageous and can involve substantial risk-taking. They state that "in our rural communities where people know each other well, they perhaps are encouraged to take greater risks out of a sense of duty. Maybe because things are happening so quickly and so urgently and there are no formal civil defence services available, people take risks that they are unaware of at the time" (TRTR - IRD, 2010).

[49] Importantly, Moewaka-Barnes (2010) cautions that what are considered to be protective factors are actually cultural ideals – and that while we might, on some level, know or feel that these relationships make sense; there is a diversity of Māori realities and therefore to buy into an homogenous notion of what it is to be Māori actually assists in the process of colonisation and government politics which desires to deal with one voice. This of course also runs the risk of essentialising what an authentic Māori looks like, what a healthy Māori looks like, and what we need to do to achieve health for Māori.

Resourcing, self-reliance and innovation

Resourcing challenges feature repeatedly in domestic and international studies of vulnerability to climate hazards and risk, with connections often made between this contextual driver and the resulting outcomes for different sectors, systems and groups (Cooper and Brooking, 2001; Waldegrave *et al*., 2006; Tribbia and Moser, 2008; among others). Financial position is also widely recognised as a critical determinant that can either facilitate or constrain effective and enduring management of climate related community risks (Adger *et al*., 2007; Smit and Wandel, 2006; Ford *et al*., 2008; among others).

The work in this study strongly indicates that the financial capacity of many *whānau* within (and connected to) the Mitimiti community is constrained; and that subsequently, many activities or actions (particularly structural or engineering based adaptations – but not limited to these) that might help to reduce risks associated with adverse climatic impacts are limited at best. Economic hardship and resource limitations means that for many *whānau,* actions and plans that would help to minimise sensitivities and enhance capacities to respond to adverse climate challenges must often be met on the "back foot" because everyday issues effectively take precedence over possible future outcomes and preparing for such risks. Potential impacts may even be compounded by the cost of (and hence access to) appropriate health-care services in remote areas (Woodward *et al*., 2001). If some of these *whānau* who face significant financial constraints were able to minimise such hurdles it would contribute enormously to the capacity of these *whānau* being able to better respond and plan for adverse climate consequences and related stresses when they arise.

Note that while it is accepted in general terms that communities rarely have all the resources they require to achieve their goals, more could be done to help take advantage of the significant natural and social capital assets of the wider Mitimiti community. Further, perhaps new initiatives such as the availability of financial grants through the Government's Social Housing Unit to assist building new housing stock on Māori land, might assist these challenges. According to Wixon (2008) the initiative is probably best for *whānau* trusts and entities that have a genuine interest and commitment to build three-plus houses, because that's the number needed to make sharing of infrastructure more cost-effective. The process is also supported by the Papakainga Development Guide, which was written because of the complicated laws and regulations that Māori need to come to terms with in order to realise housing projects on Māori land. However, there are a number of questions surrounding the future design, dynamics and values that might underpin such developments, including concerns about ownership, property maintenance and the potential 'reservation' status ascribed to such developments. Notwithstanding these, Baker (2010) suggests that supporting *whānau* in accessing and maximising their assets and resources as Māori and as individual citizens of New Zealand is critical to strengthening *whānau* resilience to individual and collective risk factors.

Finally, often climate adaptation guidance will argue that unique opportunities to address the impacts of climate change and plan for the future are available to those whose infrastructure is in need of renewal or upgrade, and that such actions will make infrastructure both more resilient to our current hazards and less vulnerable to the impacts of climate change (Hennessy *et al*., 2007). In short, decisions surrounding future lifeline infrastructure, community assets and private housing will need to take account new climatic conditions such as higher sea-levels and altered hydrological regimes. However, while there is value in such actions – particularly from the point of view of setting objectives, the reality is that for some of

the *whānau* financial stresses are actually preventing maintenance of the most basic infrastructural standards and thereby added improvements that take into account changing risks are beyond the capacity of many of the *whānau* at present. More equitable policy interventions that can provide resource assistance through subsidies and technical support to *whānau* to help launch and finance their own strategies for climate risk reduction, readiness, response and recovery would contribute considerably to ensuring safety and quality of life, as well as reducing long-term costs.

Knowledge, skills and expertise

A great deal of consideration has been given to the loss of indigenous knowledge and associated skill-sets, practices and beliefs that underpin the resilience (endurance) of different indigenous peoples to social-ecological stresses and risks (Berkes and Jolly, 2001; Nuttall *et al*., 2005; Durie, 2005; Ford *et al*., 2006a, 2006b; King *et al*., 2008; among others). Recognition of such challenges among community members from Mitimiti centred around the importance of local knowledge in understanding environmental risks, and recognition that the loss of Māori knowledge and the accompanying decline of traditional ways has implications for not only tribal identity and the supplementing of household food supplies but also risk management and right practice - *kaitiakitanga*.

Explanations for these changes are not entirely different from those offered by other groups and commentators - and mainly include references to fewer *whānau* remaining active on the land; more time spent away from the area by many *whānau* (particularly younger members of the 'community'); and legislative barriers that discourage settlement and development of *whānau* land assets. Such changes have thereby minimised practical learning opportunities, as well as face to face contact between younger and older generations which is crucial for effective transfer of traditional knowledge, skills and expertise[50]. These changes are recognised as constraining the endurance and ability of some community members to overcome adversity and therein respond as needed to future extremes in weather and climate. Ways must therefore be found to promote 'walking the land', thereby reaffirming culture and connecting *whānau* with those who have gone before.

In spite of such commentaries of loss and deficit, many interviewees acknowledged the importance of local knowledge and experience in dealing with, and being prepared for, local hazards and environmental risks. High-risk flood areas were recognised by many interviewees, as too was detailed understanding of coastal processes such as the role of tides in governing the timing of extreme flood episodes at Mitimiti. Some *whānau* also referred to the use of environmental indicators to predict when extreme weather/climate conditions and associated impacts were imminent and most likely to occur; although, there were also a number of *whānau* who stated that they no longer possessed such knowledge and subsequently used radio and television-based forecasts as well as warnings communicated by *whānau* through the 'bush-telegraph'.

[50] For example, Penny (2007a, 2007b) argues that collecting wild kai is more than just about aubsistence and nutrition. Rather, the harvesting of shellfish, recreational fishing or diving is an activity involving the development and application of knowledge, tools, planning, cooperation, teaching and learning. Such activities build social capital, especially when undertaken collectively, which for Māori is/was typical. Such activities are further of value because they engender social interaction around a collective good, reinforcing shard values whicle providing the opportunity for individuals to exchange thoughts, feelings and stories spanning generations, thus building culturally relevant knowledge and a sense of identity and unity. In many instances these outcomes are equally as valuable as the 'primary' reason for the activity.

In combination with collective-based values and conventions, these insights and skills were commonly recognised as the 'Māori-way' of managing risks and thereby mitigating harms. Similar conclusions have been drawn by Durie (2005) and King *et al*., (2007), whom argued that Māori knowledge, practice and belief offer a range of learning opportunities that can contribute to not only managing extreme events and related risks but also appreciating fundamental ecological principles about environmental constraints, among other contributions. For the Inuit community of Igloolik, similar issues have led to the organisation of 'Land Camps,' whereby elders take young Inuit on the land for weeks at a time throughout the year and teach hunting skills, and these have been reported as successful in developing essential survival skills and strengthening inter-generational relationships (Wachowich, 2001; Takano, 2004). New strategies that can assist the maintenance, transfer and revitalisation of such knowledge (and linked cultural values) to the next generation at Mitimiti are regarded as central to ensuring that Māori lifeway's continue and that *whānau* are in turn able to minimise risk and sustain themselves in the future. Some suggested actions already identified in the Mātihetihe Marae Hapū Plan (2011) include *whakapapa wananga*, *hikoi* to places of significance for each *hapū marae*, erecting story boards with local history, and holding an annual social function for *kaumatua*, among others.

New interactions and the development of new skills and expertise by *whānau* spending more time away from Mitimiti for work and education as well as the regular return of 'city-*whānau*' wishing to contribute and reconnect with their *tūrangawaewae* and *whanaunga* were also identified as important for meeting the demands of increasingly complex social, economic, political and bio-physical system issues facing the community. Although, most interviewees qualified such statements by emphasising the need to find ways to benefit from both traditional and non-traditional educational opportunities – whereby people can draw from more than one intellectual tradition and thereby realise new knowledge and skills.

Incidentally, to help increase the ranks of Native American hydrologists, the Salish Kootenai College in Montana, now has Bachelor of Science degree programs in hydrology - the first hydrology and geoscience degree programs offered by any of the Tribal Colleges and Universities in North America. It is anticipated that the emphasis on Native American worldviews and the application of science to indigenous issues will help to develop hydrologic technicians and leaders to manage Native American lands who in turn will uphold Native American traditions of respecting the Earth (Dalbotten, 2012). Such strategies have been identified by a range of indigenous and non-indigenous commentators as critical to meeting the complex challenges facing social-ecological systems on a range of scales – not least of which includes the need for people with expertise that can 'walk between worlds' (Furgal and Seguin, 2006; Gearheard *et al*., 2006).

Community structures and decision-making

The importance of community structures (also referred to as institutions) and their influence on indigenous planning and decision-making surrounding social-ecological change and risks is increasingly acknowledged (Berkes *et al*., 2005; Matunga, 2006; King *et al.,* 2010). Much of this work tends to focus on the benefits of community structures to manage natural resources and own local hazard risks, as well as plan their response to them. The work carried out here confirms the central role of community structures such as Mātihetihe Marae, Mātihetihe School and the Marae Trustee in bringing the community together, identifying community relevant issues, debating priorities and 'making things happen'. Such institutions

and governance arrangements also provide formal structures for dialogue at the *hapū* and *iwi* level, as well as linkages with external organisations such as local and regional authorities.

Notwithstanding these benefits, the appropriateness of community governance and institutional arrangements can affect the way that communities and groups respond to complex issues such as climate change. Addressing barriers to climate change adaptation will therefore necessarily involve a continuous emphasis on good governance (Productivity Commission, 2012). There is however no single 'good governance' approach that can be universally applied to minimise the negative impacts of governance arrangements on adaptation decisions. Nevertheless, there are a number of different formulations of good governance principles that commonly include the elements of accountable and transparent decision-making; coordinated policies and plans; flexibile systems that can accommodate uncertainty; community involvement; and capability to effectively meet responsibilities and deliver outcomes and aspirations.

Many Māori communities and populations have also identified central and local government planning arrangements as critical factors that facilitate and/or 'stand-in-the-way' of better outcomes for Māori including the management of risk associated with natural hazards and environmental changes (MfE, 2007; King *et al*., 2008; King *et al.,* 2012). Some members of the Mitimiti community discussed 'prohibitive' legislation and planning policies that restricted how Māori land assets could be developed and used, while others spoke of the inability of some *whānau* to even access land-based resources. Hapū management plans recognised through the 2005 Resource Management Act (RMA) amendment have partly assisted Māori to break through mainstream planning systems. However, indigenous planning needs to be taken seriously and accepted as legitimate; and might even require that extra assistance be given to planners in the mainstream profession to help navigate dual planning traditions and demands. According to Matunga (2006) indigenous planning offers a basis for more socially inclusive planning practice and in doing so can re-include some of the more marginalised, disempowered communities in New Zealand society. The question is whether local, regional and central government agencies have the statutory, regulatory and institutional machinery to accommodate indigenous planning? Māori participation in climate adaptation planning, either through *iwi* management plans or directly into council adaptation plans, is likely to ensure that the setting of priorities for Māori are actually grounded in Māori community realities, aspirations and goals (Matunga, 2006).

Climate change planning for Māori communities moving forward will require dynamic approaches that comprehensively address the interrelationships between the things that affect change and the things that magnify or dampen the drivers of vulnerability. This necessarily includes understanding local livelihood strategies and vulnerabilities; recognizing that a diversity of knowledge systems can contribute to solutions; and, identifying and addressing barriers to change (at all levels) (Hayward, 2008). Effective adaption will also require individuals to absorb complex scientific evidence on the impacts of climate change and to choose between different adaptation options based on their perceptions of the costs and benefits. This will necessitate individuals incorporating the uncertainties of climate change into these decisions. However, research has shown that people can struggle to gather and process complex information and as a result take short cuts in order to make decisions, either consciously or subconsciously (Crowle and Turner, 2010). Such a situation could result in sub-optimal adaptation decisions that are chosen out of habit. Further, in some circumstances people might find it difficult to assimilate multiple sources of information

and consequently additional information on climate change impacts or adaptation options may not improve matters (Nicholls, 1999).

Much remains to be done to include climate change adaptation into community planning and decision-making. Reducing sensitivities and enhancing adaptive capacity will be successful however when they are integrated with community led planning and policy surrounding land-use, environmental conservation, disaster preparedness and sustainable development. The development and implementation of such policies will however require institutional awareness, vision and perhaps even the creation of new institutional and governance arrangements whereby Māori are represented and participate as citizens and as *tangata-whenua*. Further, future *whānau/hapū/iwi* development and management of social-ecological risk (and by extension climate change) will not only come from greater Māori involvement in local, regional and central government institutions however; but will also demand the strengthening of existing (and perhaps the creation of new) tribal governance structures. Durie (2005) concurs that successful Māori endurance requires Māori participation in mainstream planning in order to realise and convert vision and possibility into sensible realities.

8.2 Managing future climate risks, vulnerability and endurance

This penultimate section presents selected coping and adaptation strategies that would help: (i) minimise (reduce) present and projected future community exposure to climate induced coastal flooding and risks at Mitimiti, and (ii) move towards eliminating (or at least minimising) community grounded sensitivities on the one hand, and enhancing coping and adaptive capacities to deal more effectively with climate induced hazards and stresses on the other. The benefits and co-benefits that might be realised from short and long-term strategies and actions are briefly considered including any risks or unintended consequences associated with implementation[51]. These options are based upon direct feedback from interviews with members of the Mitimiti community to projected climate change impacts and risks, the results of the Community Emergency Response report produced by the Iwi Research and Development Team from Te Runanga o Te Rarawa, as well as national and international assessments of climate adaptation practices and options.

In varying ways and degrees, future projections of SLR[52] and coupled river inundation (along with concomitant transformations in living arrangements) are expected to challenge how different *whānau* and activities across the community at Mitimiti deal with climate induced changes (including extreme events) over the next few decades. One way to minimise and avoid the adverse impacts from such changes is to reduce the 'exposure' of the 'community' and/or connected system of interest. Listed below are a series of options (or alternatively entry points) that might help to limit projected impacts, support coping strategies and facilitate adaptation decisions and activities.

Before proceeding, it is important to acknowledge that the coping and adaptation strategies and actions identified below are based upon fundamental risk management principles which

[51] Estimated costs associated with the options identified have not been quantified. Future work will be required to estimate such costs.

[52] Please note that sea-level is not expected to stop rising at 2100 AD but rather to continue rising for many centuries into the future. Consequently, decisions on how to manage climate-related coastal hazards will have to remain responsive not only to changing societal pressures but also to new information about future risks. The Ministry for the Environment (2008b) suggests using a risk-based approach to manage future sea-level rise which includes consideration of the potential consequences of higher sea-levels. For planning and decision timeframes beyond the end of this century, an additional allowance of 10 millimetres per year is recommended.

recognise that risks can be avoided (or mitigated) by modifying any of the elements of vulnerability (MfE, 2008a; MfE, 2008b). This approach is also consistent with the New Zealand Ministry of Civil Defence and Emergency Management which promotes four key components in managing societal risk from natural hazards: reduction, readiness, response and recovery. Together these four R's can contribute to limiting impacts and supporting adaptation (MCDEM, 2004). Although, given the inherent complexities of the climate system, and the many social, economic, and technological factors that determine impacts, future adaptation will also likely need to be iterative where risks and possible response options are revisited over time taking advantage of new knowledge, information, and technological capabilities.

Reducing community exposure

(i) Future-proof existing infrastructure and buildings.

This option recognises the existing exposure of key access roads (i.e. West Coast Road), high-value infrastructure (i.e. Mātihetihe Marae) and private *whānau* homes (among other structures), to coastal flooding in association with high rainfall coincident with high tides and possible storm surge conditions on the coast at Mitimiti. Options include raising the lowest lying sections of West Coast Road which when flooded can prevent access in and out of the Mitimiti area, as well as raising and strengthening the bridge over Moetangi Stream and building larger culverts to cope with larger stream discharges. Other related options include elevating existing homes, raising floor levels for all new and existing buildings in areas close to streams and the sea, and wind-proofing decks, roofs, windows and doors. Galvanised roofs and aluminium joinery can also help to slow-down salt corrosion. The costs of future proofing this infrastructure might be moderated by factoring in climate change when routinely maintaining, upgrading or replacing such infrastructures. Removal of barge boards from the footing of flood prone infrastructure prior to flood events can also help to lessen potential damages caused by elevated and high-velocity surface waters.

(ii) Implement building restrictions in high risk areas.

Building set-back zones can reduce climate-induced coastal risks through restoring and maintaining a protective natural buffer between infrastructural development and coastal-river reach systems. At present in New Zealand, coastal development and the effects of coastal hazards (and the impacts climate change has on these hazards) are primarily managed by regional, territorial and unitary councils through the statutory land-use planning process; however, the effectiveness of risk management through land-use planning depends upon how effective the rules are in actually controlling development activities in coastal hazard areas. Land-use rules at Mitimiti might be made more effective through community defined standards that are designed to preserve community well-being, history and identity, and the integrity of ecological system. Through reasonable understanding and analysis of future environmental change, climate change impacts can (and should) be taken into account when contemplating new activities and developments in the coastal zone. Any decisions to establish set-back zones however will likely require flexibility and regular re-assessment, as SLR is expected to push some shorelines and dunes further inland. Thereafter, any development planned forward of such set-back zones would idealy be based on precautionary approaches that involve a combination of risk-avoidance and risk-reduction considerations.

(iii) Stream maintenance and modification.

Regular removal of gravel, sand, and wood debris from streams across Mitimiti such as Moetangi and Mātihetihe Streams would improve channel conveyance helping to confine higher flows to the main river channel and thereby reducing the risk of erosion and floodwaters spilling onto higher ground. This would also help to reduce the amount of debris catching under structures such as bridges which can result in floodwaters backing up and being dammed behind such obstructions. Such strategies are a part of many river management practices, which require regular work and maintenance to be carried out. Other options include native planting of riparian areas and the fencing of stream banks from wandering stock, in order to prevent stream bank erosion. A further option might include the diversion of elevated flows via previous stream channels. In some cases this would result in an increased gradient encouraging flood waters to flow faster to the sea. While such an option might help to minimise the risk of the elevated waters spilling onto higher ground, there are a number of challenges surrounding the stability of such channels on an open sandy coast including on-going maintenance, heightened risks associated with potentially faster stream flows, and unknown biophysical environment effects.

(iv) Retreat or relocate at-risk dwellings and other infrastructure.

Retreat provides for the relocation and/or abandonment of built assets from a high risk area to a lower-risk site. This may be considered necessary where the cost to protect or accommodate existing risks outweighs the value of the land and/or infrastructure that is at risk. Managed retreat from ancestral areas, sites and *whānau* homesteads is also likely to have other costs such as the dislocation of land-owners who may otherwise choose not to retreat, community anger, and administrative and infrastructure costs. These costs will need to be carefully considerd against the benefits before embarking on a retreat scheme. Notwithstanding these considerations, the discussion of potential risks caused by climate-induced SLR and coupled stream flooding led almost all interviewees in this study to conclude that at some point in the future Mātihetihe Marae would eventually have be raised to accommodate higher surface-water and ground-water levels and/or be moved altogether to a less exposed location. There may be deep heartache involved, long-running debates, and even people who will never agree to such a proposition, but community led planning around risk avoidance and the pragmatic movement of *whānau* away from high risk areas would be easier for *whānau* to accept. It has happened before and it will happen again[53]. Importantly, there was also a common desire amongst most of the participants interviewed to take up this responsibility in their own lifetimes rather than leave it to future generations. Questions however remain about where the marae would go.

(v) Encourage sustainable infrastructural development.

Major long-life infrastructure (such as roads and bridges) will likely need climate change factors incorporated into future design, planning and construction; and improvements in energy supply, house-hold water and sewerage (among others) would likely assist *whānau* to reduce climate risks and thereupon better face adverse conditions caused by climate extremes. Avoidance of new development in areas already or potentially hazard prone is also important for avoiding or limiting adverse consequences. A further sustainable infrastructural development challenge for the community at Mitimiti is the future development of healthy

[53] There are a number of cases in recent years around the country where marae have been moved due to costly flood impacts and on-going risks – e.g. Hinemaurea Ki Mangatuna Marae, Te Tairawhiti.

homes that are affordable for the *ahi-kā* as well as those *whānau* wishing to return home to their *tūrangawaewae*. At present there are a number of barriers to building on *whānau* land, such as the high cost of permit and resource consent fees. Working with other communities to share lessons and experience as well as regional and government authorities to develop more equitable policies and plans that recognise such barriers for *whānau* who have land and wish to develop this for *whānau* housing is crucial. Actions across many of these sustainable infrastructural development options may even lead to employment creation for local people.

(vi) Support integrated catchment management.

This sustainable planning approach is based on a comprehensive catchment perspective, in contrast to fragmentary resource management approaches that artificially separate land management from water management. Consistent with traditional Māori perspectives, such an approach provides for the complex role of ecosystems in supporting and regulating human-environment interactions and well-being. In practice, integrated catchment management is supported by a wide range of strategies and actions from protecting and enhancing the ability of wetlands and watersheds to store water - thereby reducing some of the potential impacts and risks caused through extreme flood flows; to monitoring the processes that reduce or prevent sediment build-up and erosion from floods and/or human activities such as farming; to long-term recording of rainfall and river flows to better understand the dynamics of local hydrological system; to increasing native bush around the streams to reduce sediment release to the coast, among others. Note that a popular community vision for the Mitimiti area involved restoring stream/river water quality for wildlife and other human resource values and activities, dune planting with native plants to reduce erosion and sand movement, and closer working relationships between people in general to support the improved care and use of the natural environment.

Minimising community sensitivity and enhancing adaptive capacity

As we have argued throughout this document, there are a range of existing community sensitivities and adaptive capacities that influence the vulnerability and resilience (endurance) of the community to deal with climate risks and stresses. While engineering solutions are expected help minimise some risks associated with future changes in climatic regimes simultaneously a range of non-structural measures (i.e. social, cultural, economic determinants) will also be required to minimise climate vulnerability and related risks from adverse impacts. Listed below are a series of actions (or entry points) to limit impacts, support coping strategies and facilitate adaptation decisions and activities.

(i) Raise awareness of the links between climate change, sustainability and natural hazards management.

Raising *whānau* awareness of climate change risks, mitigation and adaptation; as well as the linkages with sustainability and natural hazards management requires access to relevant information and the ‘right people’ to communicate such information. There is a number of areas where there may be scope to improve the provision of information. Transmission pathways might include learning programmes through *marae*, *wānanga* [seminar, forum, to meet and discuss], *kura* [school], websites, public talks, Māori radio and television, as well as through first-hand experience on-land or on-sea. New ways of story-telling might also help to build awareness and therein assist the up-take of new (as well as traditional) messages. There are also ways of raising awareness through statutory mechanisms, such as

incorporating hazard and risk information in regional and district plans, and other planning documents such as iwi/hapū plans. Formalising Civil Defence capabilities and emergency procedures would also help to promote awareness, readiness and first-reponse to emergency situations arising from extreme events. Linked to this, an improved forecasting system supported by local rainfall and stream flow information to deliver advance warning of extreme flood events was identified by many of the participants in the study[54]. The community's management of risk in the future will therefore be about drawing upon the best available information to determine the likelihood of extreme weather and climate impacts as well as the secondary or flow-on effects of their consequences. Along with precautionary approaches, this information will provide a firm basis upon which to select and implement risk management options such as emergency gathering sites that will help to avoid potential harm or loss.

(ii) Leverage economic support and technological resource pathways.

In most instances, economic support will be required to assist risk reduction, emergency preparedness and adaptation to new climate-induced changes along the Mitimiti coast. Given that the vulnerability and endurance of the community is strongly shaped by economic conditions, assistance will likely be required to assist any maintenance, improvements and/or relocation of lifeline services, key community infrastructure and *whānau* assets. Linked to these needs, financial support is likely to be required to assist more sustainable development opportunities. Financial mechanisms might include rating relief from local authorities, and land management agreements with organisations such as the Queen Elizabeth II National Trust that encourage landowners to maintain undeveloped coastal areas. Fostering partnerships with government, industry, *iwi/hapū* groups, and neighbouring communities might also yield important opportunities that promote innovation, creativity and technological development.

(iii) Collaborate on climate change-focused initiatives and programs.

Managing climate change risks and programs will require collaboration and co-operation with many groups. This might include building partnerships with local agencies and organisations that support direct climate change adaptation activities such as sustainable infrastructural development and remedial plans that help to prepare for climate-induced coastal flooding and erosion problems; or indirect climate change adaptation activities that demand greater Māori involvement in regional hazard management, health services development and integrated catchment management. Working with other communities to share lessons and experience as well as regional and government authorities to better align efforts might also assist the design and execution of local scale initiatives and programs. Importantly, realising any of these objectives will require responding to the pressure being placed on a few *whānau* living at Mitimiti or nearby who fulfil important obligations on behalf of the *hapū* such as maintenance and cultural factors carried out at the marae that were once were shared by large numbers of *whānau.* Good communication between the *ahi-kā* and those living away

[54] Lack of warning systems surrounding extreme events at Mitimiti was also recognised as a key theme in work conducted by the Iwi Research and Development Unit from Te Runanga O Te Rarawa in 2010. This group explored community experiences associated with the 1999 January flood that devastated rural communities in the Far North (both during and after), to understand what happened and why, what resources could have reduced the risks, people's needs, the way in which *whānau*, *hapū* and marae deal with local emergencies, and the roles and responsibilities of *whānau/hapū*, and marae. All participants suggested that a warning system would help their communities to better prepare and respond to future natural disasters.

will thereby be crucial – particularly as many *hapū* members live in Auckland, elsewhere in Northland, and increasingly overseas.

(iv) Reaffirm human-environment relationships and Māori ways of knowing.

The reaffirming of human-environment relationships through *whakapapa*, *tikanga, kaitiakitanga* [stewardship, respect, guardianship] and related Māori ways of knowing and being was acknowledged by some of the community as critical to realising a sustainable future. From this perspective, prosperity and well-being are viewed as dependent upon the balance between social, cultural and economic development as well as the strengthening of *Te Taiao* by minimising damage to *Papatūānuku* [Mother-Earth, the ecological system]. Based on a vision of inheritance for future generations, actions might include promoting awareness of the connections between spiritual and physical well-being, being usefully and gainfully employed or alternatively being able to support oneself by living off the land and sea, conducting *marae*-based *reo* [language, voice] and *tikanga wānanga* to teach the young to strive for balance and harmony in their lives, and establishing an education and communication strategy aimed at informing the *ahi-kā* (and *whānau* living away) about appropriate or inappropriate behaviour related to the use of the natural world and culturally important sites and places.

(v) Consider climate change adaptation in all *hapū/iwi*-management planning efforts.

There are likely to be opportunities to consider climate change adaptation planning in wider *iwi/hapū* planning efforts. These might include integrating disaster preparation, flexible resource management regimes, and environmental conservation into *hapū/iwi* plans for sustainable development. It might also comprise formally supporting external organisations that promote the protection and enhancement of ecological systems. Advocacy strategies focussed on conservation of natural heritage and biological diversity values can also greatly contribute to increasing the adaptive capacity of natural systems by reducing other environmental stresses. However, greater Māori political participation and involvement in broader societal decision-making processes and institutions, including formal recognition and provision of *hapū/iwi* management plans, principles, practices and values by relevant territorial authorities, will be crucial to the implementation of *whānau* and *hapū* aspirations, health and well-being. Further, community-based strategies can provide long-term direction for, and identification of, the range of issues relating to sustainable development and natural hazards management.

(vi) Support climate change research and its evolving implications for the community.

Scientific research and indigenous knowledge development can expand the range, and improve the effectiveness of, options to adapt to climate change. Further work is required however to improve the modelling of regionally-based climate change impacts, to better understand the relationship between changes to frequency and magnitude of extreme events and the critical thresholds for individual risks. Greater understanding of the relationship between past and present variations in climate and the performance of economic, social and environmental systems is also required. New systems for collecting and sharing information would help to ensure that climate-related risk management decisions are informed by the best available knowledge and analyses, and would moreover help to evaluate the effectiveness of actions taken. Locally embedded scientific tools would provide an invaluable opportunity to understand scientific techniques and processes as well as positive examples of working alongside scientific and academic agencies.

8.3 Conclusions

The place-based work undertaken in this study has explored future projections of climate change-induced coastal hazards and risks for the community at Mitimiti. We have also examined the contextual conditions that influence the vulnerability (and inversely the endurance) of the community to effectively respond to climate-induced coastal hazards and risk. Through our analysis we can readily identify key climate exposures faced by different *whānau* and groups across the community as well as begin to understand the factors and processes that constrain and facilitate *whānau* and wider community choices and responses to climate hazards, risks and stresses. Such information is critical in identifying community relevant options (i.e. entry points) to eliminate and/or at least minimise vulnerabilities and, to enhance the different skills and capacities across the community to cope with (and adapt to) future climate conditions and challenges.

In-depth semi-directive interviews (including many informal discussions and land-walks) were carried out between November 2011 and July 2013 with a total 31 participants who reside within, and/or have close involvement with the community. During these group, paired and individual engagements, the interviewees shared their experiences of climate and coastal hazards (and associated environmental changes) at Mitimiti – including specific knowledge of coastal change, areas susceptible to flooding, and importantly the range of 'things' or matters that enable as well as obstruct *whānau* from effectively 'dealing with' climate related impacts, risks and stresses. Subsequently, analysis of how *whānau* and different *hapū/iwi* activities deal with, and/or are affected by, climate hazards and related socio-ecological changes resulted in the identification of four key determinants that influence the sensitivity and adaptive capacity of the community to deal with climatic risks. These determinants included:

(i) social-cultural networks and community change,

(ii) resourcing, self-reliance and innovation,

(iii) knowledge, skills and expertise,

(iv) community-based structures and decision-making.

The importance of social-cultural networks and values held by the community were recognised as fundamental to being able to 'deal with' climate and coastal related hazards and risks at Mitimiti. Much of this capacity is rooted in the collective strength of *whānau* and *hapū* relationships, as well as more elemental cultural principles defined by *whakapapa* and *tikanga*, and thereafter actioned through practical values of *whanaungatanga, manākitanga, kotahitanga* and *aroha.* However, major changes in the composition of the community, in combination with low levels of economic development and the appearance of new values and behaviours, were regularly identified as constraints to 'getting things done'. Notwithstanding these challenges, the importance of strengthening connections between the *ahi-kā* and non-resident *whānau* was emphasised, particularly in terms of realising *hapū* priorities and aspirations.

Limited employment opportunities' and associated resourcing constraints to adequately reduce risk and exposure to potential impacts dominated many conversations – particularly limited funds to upgrade and future-proof Mātihetihe Marae. Such constraints were recognised as making it harder for *whānau* to realise "healthier" living arrangements, and thereby were seen to exacerbate the sensitivity of different *whānau* to climate-related hazards and associated stresses when they arose. However, attributes of independence,

self-reliance and innovation were also evident through the interviews. These included the importance of solutions that emerge from the *whānau* such as planning and being prepared, to more simply supplementing household supplies (and incomes) through fishing, hunting, and gardening. Together all these factors influence and shape everyday living for *whānau* at Mitimiti.

Māori knowledge and the maintenance of close relationships with the land and sea were acknowledged by a number of interviewees as crucial to understanding, and dealing with, local hazards and environmental risks at Mitimiti. However, rapid changes in community structure were commonly identified as having affected the transfer of *hapū*–specific knowledge. Examples typically ranged from the loss of understanding about the reasons behind traditional practices to interpreting environmental signals about local hazards and risks (among other forms of knowing). The importance of Mātihetihe School for engaging *rangatahi* was thereby regularly cited, including the challenge to finds ways to support traditional and non-traditional educational opportunities that allow young people to draw from more than one intellectual tradition to realise new knowledge and skills.

The roles and effectiveness of community structures to 'deal with' complex and integrated challenges such as climate change were also raised. Commonly, the *ahi-kā* as well as those *whānau* who live away from Mitimiti emphasised the importance of Mātihetihe Marae and Mātihetihe School in bringing the community together, identifying community relevant issues, and 'making things happen'. Such community arrangements were also recognised to provide formal governance structures for dialogue at the *hapū* and *iwi* level, as well as linkages with external organisations such as local and regional authorities. However, the diminishing numbers of *ahi-kā* to meet the various requirements and services provided by Mātihetihe Marae as well as shortages in expertise to deal with increasingly complex social-ecological issues (and decision-making) facing the community were identified as future challenges.

Next, the mapping results from our assessment of projected sea-level rise impacts along the Mitimiti coastline for 2040 and 2090 AD indicated that an increase in base sea-levels of 0.4 m by 2040 AD would result in broader areas of coastal land being inundated by the ocean more frequently. The most pronounced changes show extensive inundation of stream discharge zones such as low-lying farm-land surrounding the Moetangi Stream and Taikarawa Stream. Not unexpectedly, our assessment indicates that an increase in sea-level of 0.8 m by 2090 AD would lead to more extensive areas of coastline being inundated with present low-lying farm-land and dune-fields surrounding the streams at Moetangi and Taikarawa in the future tidal zone. Other changes indicated for a sea level rise of 0.8 m would include the formation of a tidal embayment around Moetangi Stream, and greater propagation of the tide is evident around Mātihetihe Stream where increasing water extent and depth are indicated as far upstream as the Mātihetihe Marae complex.

Assessment of flooding surrounding the Mātihetihe Marae complex due to the combined effects of extreme rainfall under the mean B2 and A2 climate change scenarios and projected higher sea-levels for 2040 and 2090 AD, indicated that future peak flood flows would likely be 20% and 30% greater respectively than the flows experienced by home people during the January 1986 reference flood event. Notwithstanding this outcome, our modelling indicated for both scenarios minimal differences in projected flood extents when compared to the January 1986 reference flood event. This somewhat unexpected outcome is mostly due to the relatively steep land around the edges of the flooded area where the water level can change without much corresponding change in the extent of flooding. Finally, while

the frequency of extreme flood events under future climate change scenarios was not determined in this study, heavy rainfall events are projected to become more frequent in many parts of Aotearoa/New Zealand, especially where mean rainfall increase is predicted.

Notwithstanding these qualifications, the most notable change from this modelling exercise is the gradual and on-going encroachment of water at the seaward end of the Mātihetihe Marae complex. Relatively large differences in flood extent and water depth are also evident between the dune-field and the marae complex from 2040 and 2090 AD. This is likely to exacerbate existing erosion problems and increase the risk of damage to waste-water infrastructure at the back of the marae complex. An increase in inundation extent from 2040 and 2090 AD is also depicted across the areas currently used for car-parking on the southern side of the marae complex. Beyond these new flood extents, the modelling for both 2040 and 2090 AD under the mean of the B2 and A2 climate change scenarios indicates increasing water depth around the *whare-tūpuna* and *wharekai* located centrally within the marae complex. This is likely to increase the risk of direct flood damage under both scenarios given the expectations for slightly higher peak flood levels and possibly increased flow rates.

Integrating the results from these cross-disciplinary research approaches and methods, it is evident that climate is only one of several factors that influence the vulnerability and adaptability of the 'community' at Mitimiti to cope and deal with climate threats and stresses. That is, it is the changes that take place, and connections between biophysical and human systems, that drive and shape how different individuals, *whānau* and groups within the community are affected by, and deal with, climate induced hazards, risks and related stresses. From this perspective, risk and vulnerability to climate variability and change are not random outcomes, but rather are issues inextricably linked to sustainable development, political institutions, and natural hazards management. This point is critically important for *hapū/iwi* leaders and decision makers across a range of scales and institutions, as well as the *ahi-kā* because the way we talk about issues and the way in which we conceptualise them are fundamental to the outcome of policy, planning, action and behaviour and thereafter to the issue of who benefits. Not surprisingly, many community members from Mitimiti thereby recognised the need to strengthen the social, cultural and economic capacities of *whānau* across the community to help assess, plan, and respond to the direct and indirect challenges brought on by changing climate regimes and conditions.

It is further evident (as in other studies of vulnerability to climate stress) that the constraints and strengths identified represent points of entry for strategic community, *hapū/iwi* and government level planning and policy development that can minimise (or eliminate) existing sensitivities and enhance (as well as introduce new) coping and adaptive capacities. As expressed above, such points of entry are deeply connected with existing social-economic-political and environmental conditions; and therein the capacity of the community to deal with future climate risks, largely rests upon responding to existing issues linked to infrastructure and resourcing, political participation, community governance, *whānau* health and education, cultural capital and the management of risk associated with natural hazards. There are, of course, numerous complexities and uncertainties that will affect the management of future climate risks facing the community – including among others, the capacity (and willingness) to create management practices that can accommodate changing risk and social-ecological conditions over time.

In spite of the range of matters explored in this work, more remains to be done. Notably, the authors' experience gained through this work confirms that integrated assessment of the

environment and human development is arguably the most important yet most difficult "systems" problem that society faces. New interdisciplinary approaches and deeper forms of analysis are therefore needed to improve the integration of information from scientists, policy analysts, and decision-makers across indigenous and non-indigenous worlds. This would help to strengthen the conclusions reached in this congested and complex space as well as help to facilitate actual plans and actions that respond to existing vulnerabilities, and that support different adaptation options. On-going analysis of the comparative climate change risks facing different Māori communities is also required to ground-truth diverse exposures, sensitivities and adaptive capacities. The benefit of such work will not only provide insight into the diversity and range of influences which shape attitudes and perceptions, but also help to avoid the danger of generalisation by recognising the specificities and uniqueness of Māori in different places. More specific issues to be addressed include how to engage with the most vulnerable groups within communities (including kin-groups isolated and/or discounted by political differences and/or strained relationships), and how to reaffirm traditional ways and build capacity to use scientific knowledge for adaptation. Given that perceptions of risks are known to be important in influencing communities' actions, tailored information and the 'right people' to communicate such information would greatly assist such gaps.

For other Māori communities interested in examining in their own climate change challenges it is important to emphasise that consideration of community vulnerability and endurance does not require the science of climate "prediction" to be more developed and nor does it require location-specific climate information of the kind produced in this report. Rather, first-order climate change projections and associated guidance on SLR are readily available and these can be used to enhance awareness about potential impacts and associated risks. Arguably more important, strategies and policies to tackle vulnerability and enhance adaptability to future climate risks can be developed in spite of the uncertainties, because most of the factors and processes that constrain choices and actions intersect existing issues of *whānau*/*hapū*/*iwi* development and social-ecological well-being.

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10 Glossary: Māori language

A	
Āheinga	Ability, capacity
Ahi kā	Home-people.
Ahotini	Integrated
Āhuarangi	Climate
Ahurea	Culture, cultural
Ākau	Coast(al)
Anamata	Future
Aroha	Sincerity, mutual-respect, love
Auahatanga	Innovation
Auau	Frequent, frequency
Aumangea	Endurance, resilience
Autaki	Indirect
Awangawanga	Be uneasy in mind, disturbed, worried, anxious, distressed.
H	
Hui	Assemble, meeting, gathering
Hapori	Community
Hapū	Sub-tribal kin group
Horapa(tanga)	Spread, widespread, extent
Hau kāinga	Home people
Hura kōhatu	Unveiling – a ceremony at the graveside to unveil the headstone
I	
Iwi	Tribal kin group
K	
Kai	Food, to eat, consume
Kaiao	Ecology, ecological
Kaitiakitanga	Stewardship, respect, identity, guardian
Kanohi kitea	Seen face, in person, literally means ‘face to face’
Kaupapa here	Policy
Kauri	Native coniferous tree
Kawa	Ceremonial rituals, protocol, etiquette, correct procedure

Kaumātua	Elders (plural) – not gender specific
Kotahitanga	Solidarity, unity, collective action
Kuia	Elderly woman, grandmother
M	
Māhaki	Humility
Mahinga kai	Food gathering, cultivation
Mamae	Ache, pain, injury, wound
Mana	Dignity, authority, control, prestige, power
Mana-motuhake	Self-reliance
Mana whenua	Territorial rights, power from the land - power and authority associated with possession and occupation of the tribal land.
Manāki	Take care of, support, give hospitality to, protect, look out for
Manākitanga	Hospitality, kindness
Manuhiri	Guests, visitors
Māori	Indigenous person/people of Aotearoa/New Zealand
Marae	Meeting house and surrounding area
Matapae	Predict(ion), forecast, project(ion)
Matatini	Complex
Mātauranga Māori	Māori knowledge – the body of knowledge origination from Māori ancestors, including the Māori world vies and perspectives, Māori creativity and cultural practices
Mihi whakatau	Formal welcome speech
Mōrearea(tanga)	Risk, hazard, danger
O	
Ohu	Group, institution
P	
Pā	Village, settlement
Pākeha	New Zealander of European descent
Pākeke	Adult (plural)
Pānga	Impacts, effects, exposure
Papa-tū-ā-nuku	Mother-Earth, the ecological system
Pāpori	Social
Pepeha	Tribal saying, proverb
Pūnaha	System

R	
Rāpopotonga	Executive summary
Rangatahi	Younger generation, youth
Reo	Voice, language
Rohe	Area, boundary, region, district
Rūnanga	Tribal council
T	
Tāheke	Steep
Tāhuahua	Dune, sand-dune
Taiao	Environment(al), natural
Takatū	Adapt
Taketake	Indigenous
Tangaroa	Deity of the sea/oceans
Tangi	Funeral, grieve, cry
Tāpotupotu	Low-lying
Tātari	Assess, evaluate
Taupori	Population
Tautoko	Support, prop up, verify, advocate, accept, agree
Tikanga	Conventions, culture, custom, correct procedure, lore
Tōrangapū	Political, politics
Tūpatotanga	Caution
Tūāhua	Scenario
Tukanga	Process
Tūpuna	Ancestors, forbears
Tūrangawaewae	A place to stand, home grounds through rights of kinship and *whakapapa*
U	
Urupā	Cemetary
W	
Wāhi tapu	Sanctuary, sacred area
Wānanga	Seminar, forum, to meet and discuss
Wawaenga	Mean, median
WH	
Whānau	Extended family, born

Whakapapa	Ancestral and kinship linkages to people and place, genealogy, literally means ‘to place in layers’
(Whaka)parawhenua(tia)	Inundate, inundated
Whakapiki tangata	Empowerment
Whakaraerae(tanga)	Vulnerable, vulnerability, sensitive, sensitivity
Whakatuia	Integration
Whakawhanake(tanga)	Develop(ment)
Whakawhanaungatanga	Kinship, process of strengthening relationships
Whanaungatanga	Relationships, interconnection, birth
Whanonga	Behaviour
Wharekai	Dining room at a marae
Wharenui	Main meeting house at a marae

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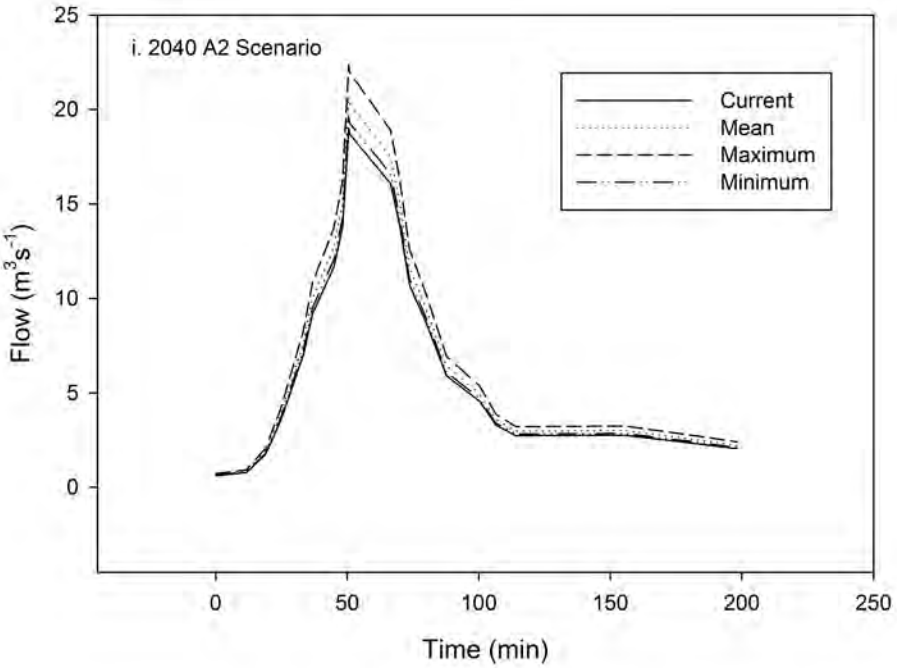
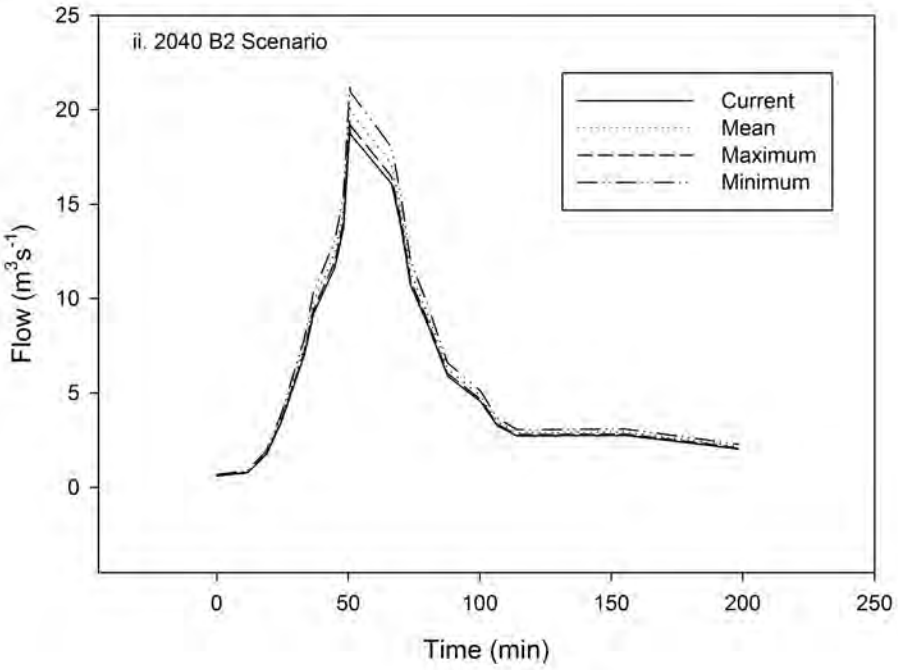
Appendix A Flood flow hydrographs – Mitimiti 2040 AD

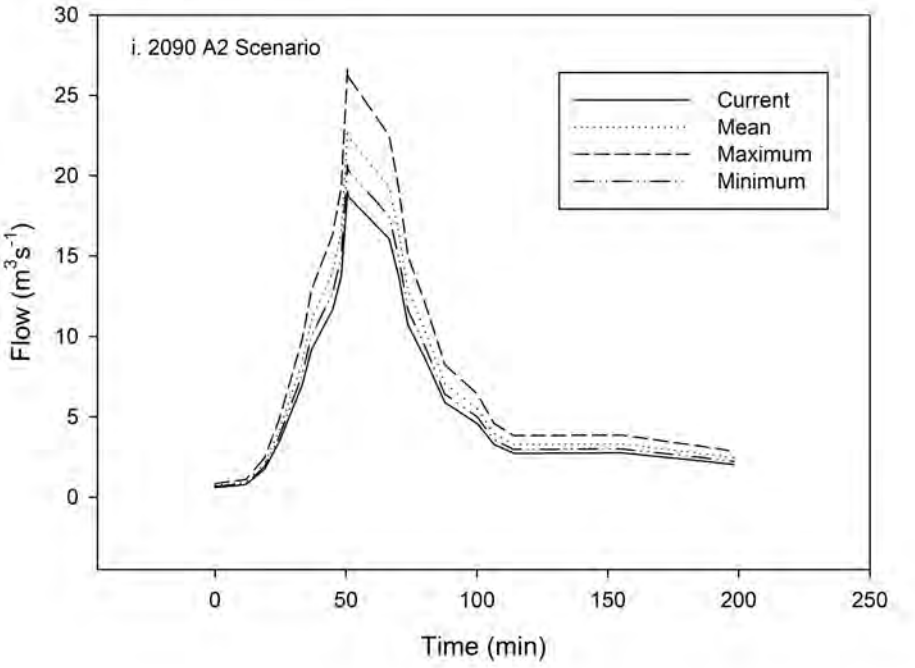
This appendix contains flood hydrographs for Mitimiti for Janury 1986 (current) and 2040 AD under the A2 and B2 climate change scenarios for maximum, average and minimum emissions.

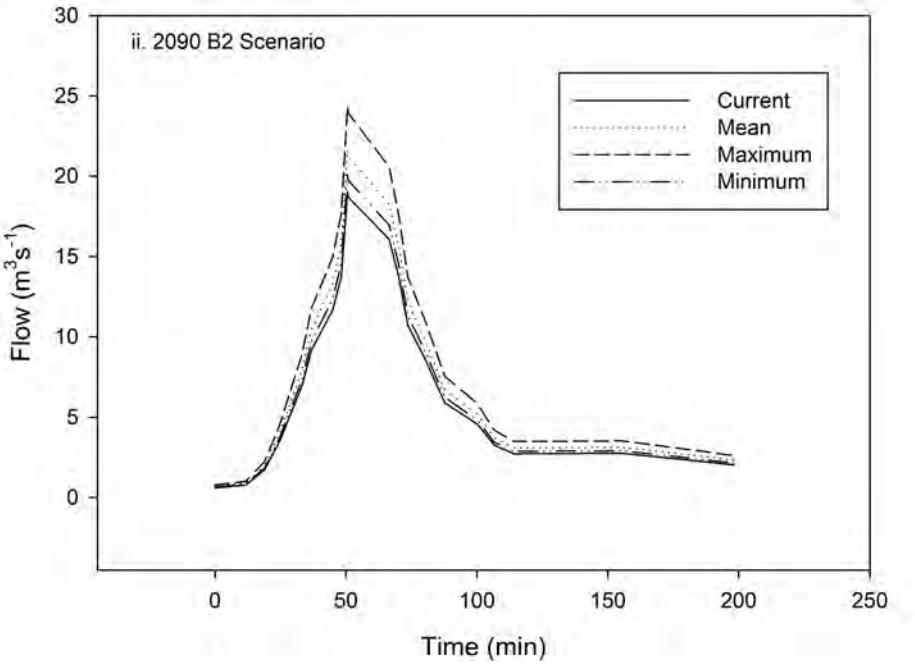




Appendix B Flood flow hydrographs – Mitimiti 2090 AD

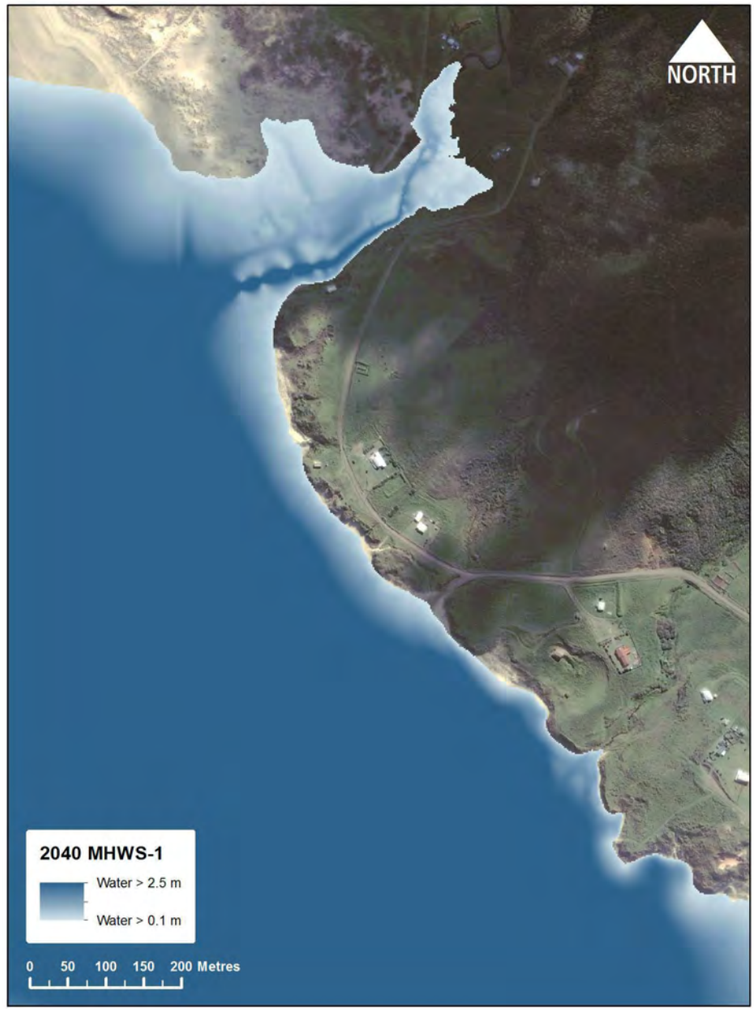
This appendix contains flood hydrographs for Mitimiti for Janury 1986 (current) and 2090 AD under the A2 and B2 climate change scenarios for maximum, average and minimum emissions.

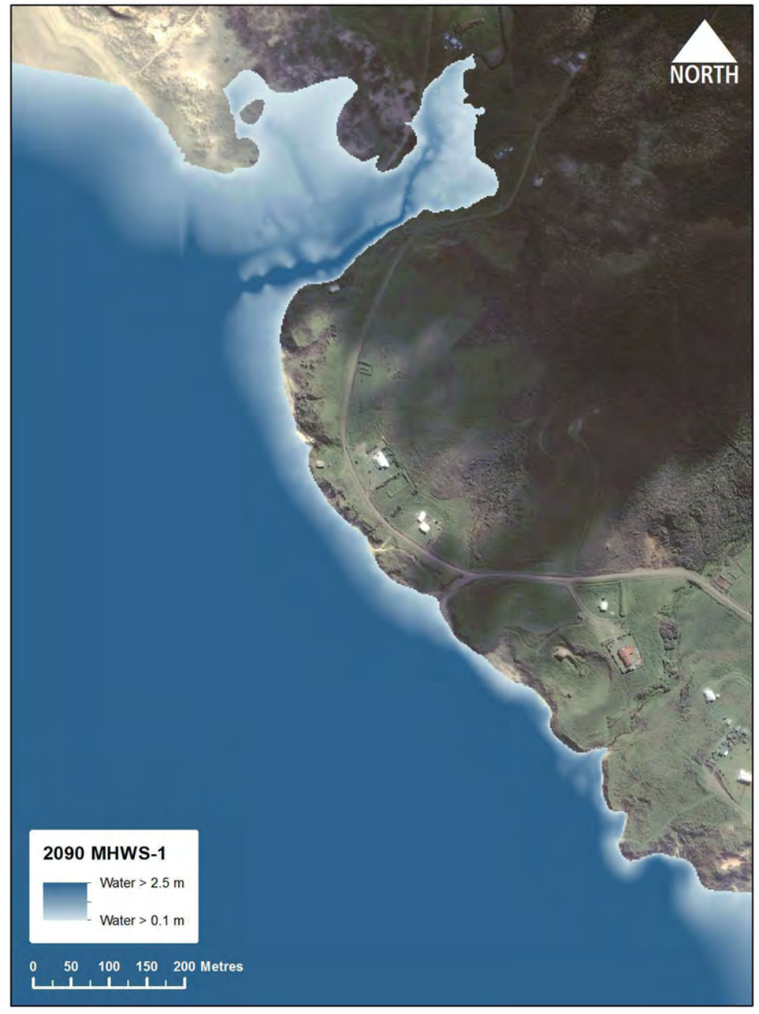




Appendix C Sea level rise - MHWS1 - Mitimiti

This appendix contains maps of MHWS-1 tide scenarios for central Mitimiti – Hoikianga, Aotearoa/New Zealand. Coastal inundation depth and extent are shown for current (present-day) conditions as well as projected higher sea-level scenarios for 2040 and 2090 AD described in the text.



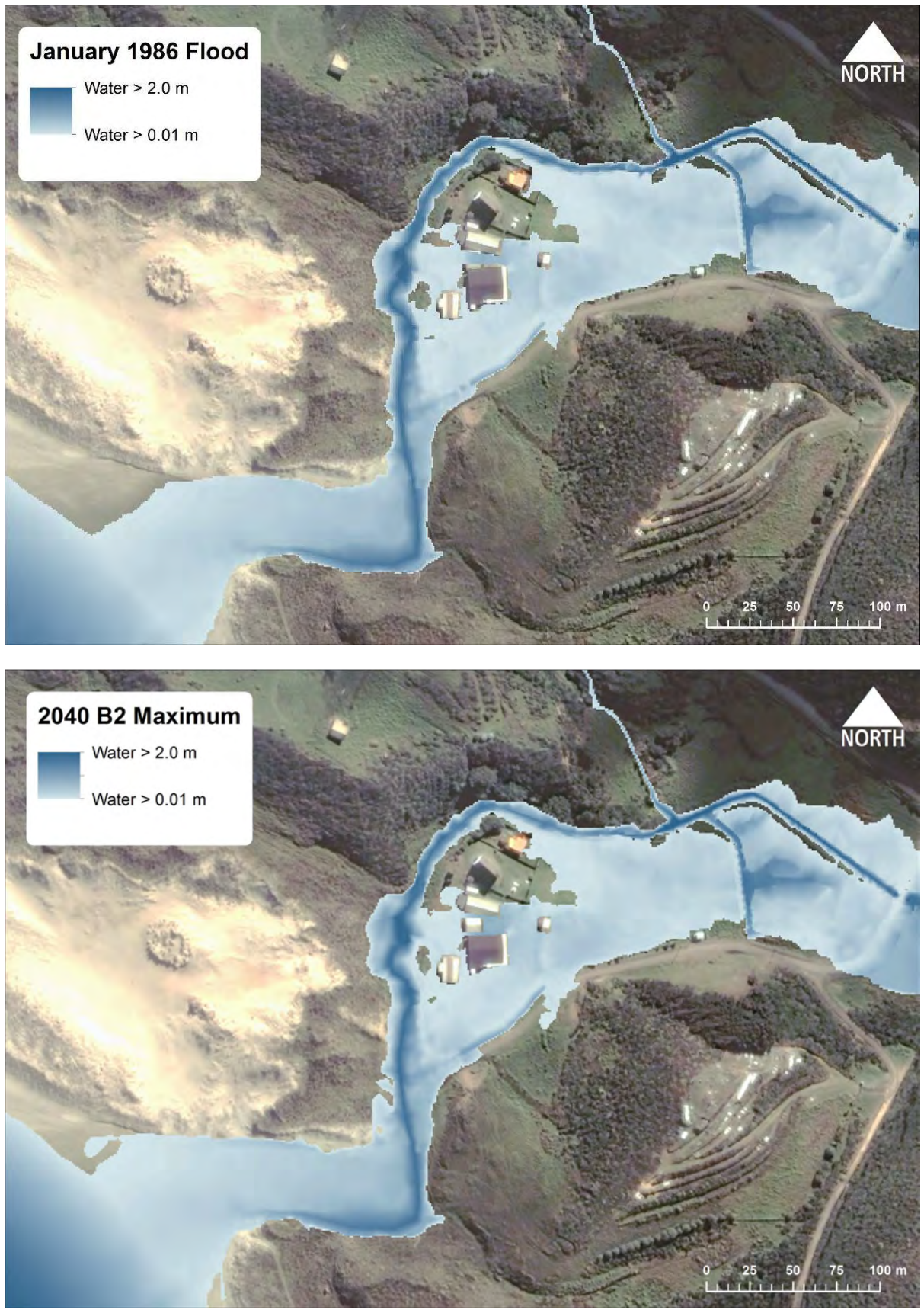


Appendix D Sea level rise - MHWS1 - Mitimiti

This appendix contains maps of MHWS-1 tide scenarios for southern Mitimiti – Hoikianga, Aotearoa/New Zealand. Coastal inundation depth and extent are shown for current (present-day) conditions as well as projected higher sea-level scenarios for 2040 and 2090 AD described in the text.

Appendix E B2 Climate change scenarios - Matihetihe Marae

This appendix contains maps of the simulated January 1986 flood as well as modelled ‘minimum’ and ‘maximum’ climate change induced flooding for 2040 and 2090 AD under the B2 climate change and the sea-level rise scenarios described in the text for Mātihetihe Marae.

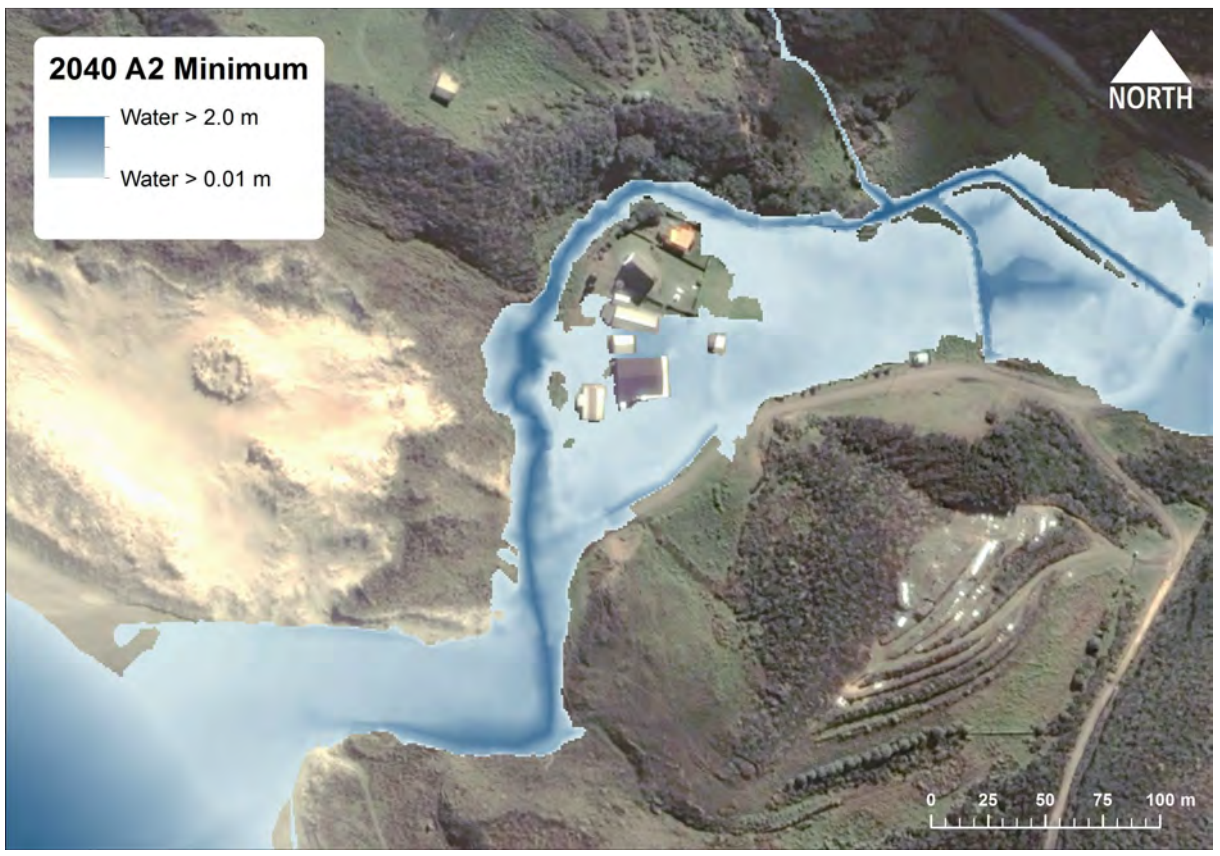

January 1986 Flood
Water > 2.0 m
Water > 0.01 m
NORTH
0 25 50 75 100 m

2040 B2 Maximum
Water > 2.0 m
Water > 0.01 m
NORTH
0 25 50 75 100 m


2090 B2 Maximum
Water > 2.0 m
Water > 0.01 m
NORTH
0 25 50 75 100 m

Appendix F A2 Climate change scenarios - Matihetihe Marae

This appendix contains maps of the simulated January 1986 flood as well as modelled ‘minimum’ and ‘maximum’ climate change induced flooding for 2040 and 2090 AD under the A2 climate change and the sea-level rise scenarios described in the text for Mātihetihe Marae.




January 1986 Flood
Water > 2.0 m
Water > 0.01 m
NORTH
0 25 50 75 100 m


2040 A2 Maximum
Water > 2.0 m
Water > 0.01 m
NORTH
0 25 50 75 100 m


2090 A2 Maximum
Water > 2.0 m
Water > 0.01 m
NORTH
0 25 50 75 100 m

Appendix G Photo Gallery

This appendix contains a selection of photos conducted with Mitimiti community members throughout the duration of the project.