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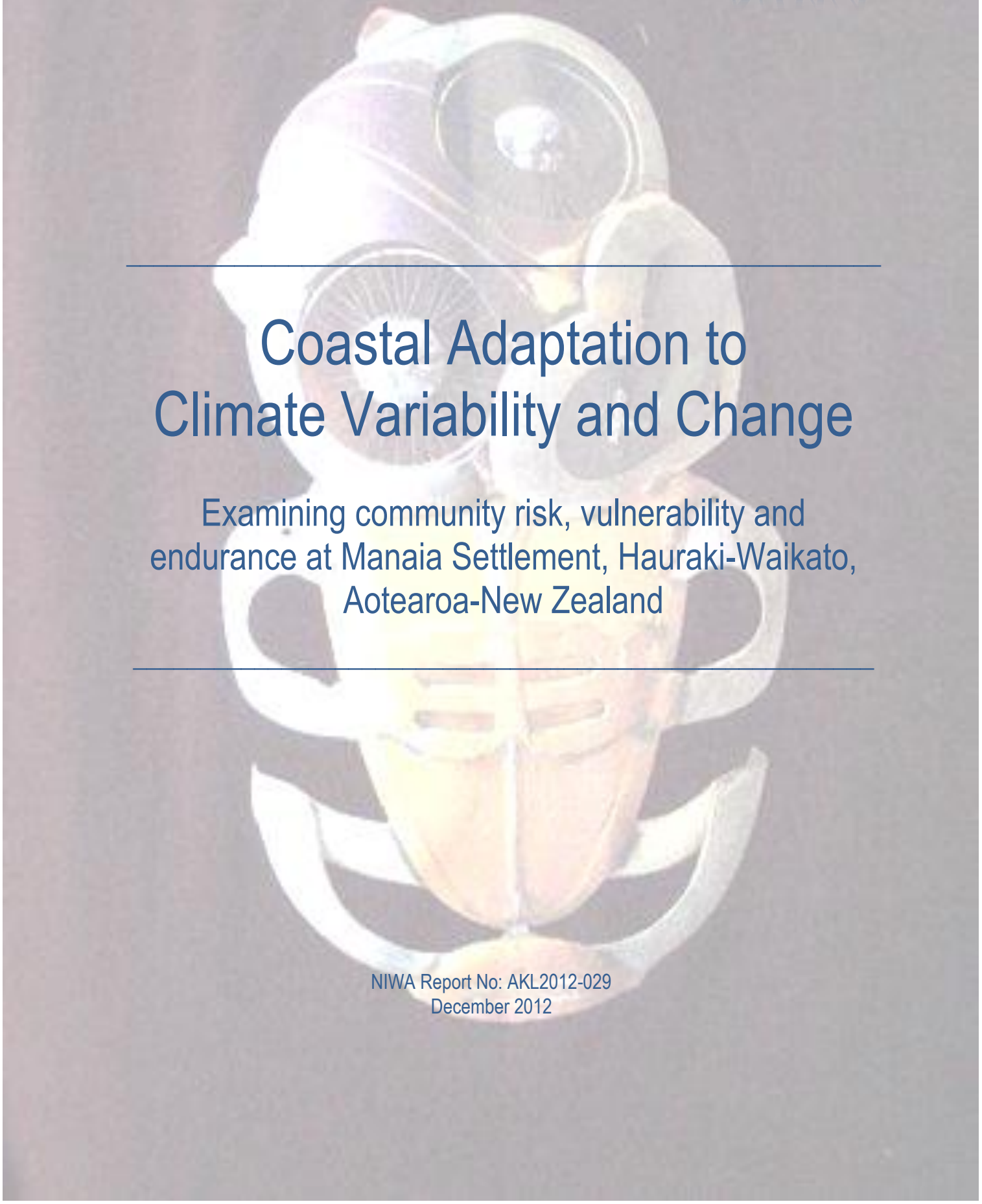

Coastal Adaptation to Climate Variability and Change

Examining community risk, vulnerability and endurance at Manaia Settlement, Hauraki-Waikato, Aotearoa-New Zealand

NIWA Report No: AKL2012-029
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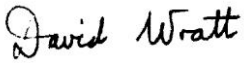

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Executive summary

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 and the obviousness that all social-ecological systems are affected in varying intensities and ways by changes in climate conditions, few empirical studies with specific populations and communities in Aotearoa/New Zealand have been carried out to better appreciate the conditions that shape and determine community vulnerability and resilience (endurance) to climate risks and change. The work undertaken in this study explores some of these contextual (and legacy) conditions through a grounded analysis of a specific Maaori community's risk, vulnerability, resilience and adaptation to climate-induced coastal change. A step guide to conducting such work involves assessing the exposure, sensitivity and adaptive capacity of the community to present (past) and future climate conditions and risks. The expectation is that such information will help to identify relevant options that can help to eliminate and/or at least minimise vulnerabilities, and simultaneously enhance the different skills and capacities across the community to cope with (and adapt to) future climate conditions and challenges. This report is the second in a series of place-based studies and involves community members from Manaia settlement in the Hauraki-Waikato region, the representative tribal body of Ngaati Whanaunga Incorporated Society, and NIWA's Maaori Environmental Research and National Climate Centres.

Multidisciplinary research approaches and methods in the physical and human systems sciences were drawn upon in this study to help explore the climate conditions and risks that the 'community' at Manaia settlement contend with. This involved collaborative research approaches and a commitment towards the sharing of information, resources and opportunities, as well as learning, action and shared decision-making concerning the project activities and goals. Downscaled projections of future climate change and related quantitative research methods first enabled examination of likely future impacts and risks - with specific attention given to sea-level rise and coupled river flooding of the Manaia River valley. Qualitative methods thereafter were used to explore how the community responds to direct and indirect climate stresses as well as the factors and processes that enable and constrain their choices and actions. These mixed starting and end-point approaches to exploring community risks, vulnerability and resilience to climate variability and change were subsequently used 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.

Consistent with the risk-based approaches advocated by the Ministry for the Environment in their guidance manuals 'Coastal hazards and climate change' and 'Tools for estimating the effects of climate change on flood flow', the quantitative methods followed in this work generated a suite of information about projected higher sea-levels for 2040 and 2090 AD as well as coastal flooding extents (and water depths) due to combined sea-level rise and high river levels from extreme rainfall under A2 (mid-high) and B2 (mid-low) climate change scenarios for the same time periods. Mapping results from our assessment of projected sea-level rise impacts for 2040 and 2090 AD under mean river flow conditions indicated that an increase in sea-level of 0.4 m by 2040 AD (compared to years 1980 to 1999) will result in broader areas of coastal marsh and pasture land being inundated by the high-tides on a regular basis. Further assessment indicates that if sea-level increased by 0.8 m by 2090,

then a large expanse of currently stable, dry land - both south and north of the river mouth - would be in the future tidal zone (i.e. it would be inundated twice daily on the high tide). Under this 2090 sea-level rise scenario, our analysis suggests the MHWS10 tide extent (i.e. the highest 10% of all tides) would propagate a considerable distance further inland and thereby reach (and possibly exceed) the current position of State Highway 25 north of Te Kapara Stream. Blocks of this coastal land remain in communal and private Maaori ownership, and current land-uses across these areas would be impacted and disrupted more frequently under such scenarios. Frequent high-tide inundation such as this would lead to an on-going decline in the utility of such resources.

Next, future extreme flood extents across the Manaia coastal-river reach were estimated based on the characteristics of an extreme flood event that occurred in June 2002, new estimates of extreme rainfall (and subsequent flood flows) under changing climate conditions for 2040 and 2090 AD, as well as projected increases in sea-level rise. The results indicate that for both the mean A2 and B2 mid-low climate change scenarios, the projected inundation extents for 2040 and 2090 AD are unlikely to differ markedly from the peak inundation extents (i.e. an ~200 year extreme flood event) experienced during June 2002. Further, in spite of the most extreme modelled estimate of future peak flood flows being more than 30% greater than those modelled for the June 2002 flood event, very little additional flooding of land area was indicated. Such an outcome is principally due to the relatively steep edges of the valley sides where heightened water levels make little change in the extent of flooding. Notwithstanding these findings, there are a number of low lying properties and buildings that are at greater risk of inundation and resulting flood damage under both the A2 and B2 scenarios in 2040 and 2090 AD given the expectations for higher peak flood levels and flow rates. Notably, Manaia School is located in an area that was inundated by more than 0.5 m of water in 2002 and it is expected that corresponding floods in 2090 would add at least another 0.1 m of depth to flood water levels. Such risks also extend to some occupied and unoccupied *whaanau* homes, storage buildings, fencing and sections of Goldfields Road and Manaia Road as well as farm-stock (sheep and cattle) that sometimes graze the lower plains of the Manaia Valley. Note that while the frequency of extreme flood events comparable to June 2002 reference event 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. Further work would be required to translate changing rainfall frequencies into future flood frequencies.

The qualitative research methods used in this study relied upon semi-directive interviews (including many informal discussions and land-walks) with 46 ‘home-people’ who reside within or live in close proximity to the Manaia settlement. These group-, paired- and individual-interviews occurred between October 2010 and September 2012, and through these engagements interviewees shared their experiences of climate and coastal hazards (and associated environmental changes) in and around the settlement of Manaia – including specific knowledge of local hydrology, areas susceptible to flooding, impacts on *whaanau* [extended family], and importantly those matters or ‘things’ that enable as well as obstruct *whaanau* from effectively ‘dealing with’ climate related impacts, risks and stresses. Consideration of how *whaanau* and different *iwi/hapuu* [tribal kin group/sub-tribal kin group] 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 are:

(i) Infrastructure and resourcing, (ii) Social-cultural networks and conventions, (iii) Knowledge, information and education and (iv) Planning, governance and competing values.

Dominant among the determinants were concerns about the unreliable state of life-line infrastructure and housing as well as insufficient finance and resourcing to adequately reduce exposures and sensitivities associated with climate hazards and stresses. Many interviewees also acknowledged that it was hard to realise "healthier" living arrangements under these constraints and that such realities actually exacerbate the susceptibility of different *whaanau* to weather and climate related variability and extremes when they occur. Notwithstanding these obstacles, the social networks of *whaanau* and perhaps more importantly elemental cultural values and approaches centred on *tikanga* [conventions, culture, custom, correct procedure, lore], *whanaungatanga* [relationships, connections], *kotahitanga* [solidarity, unity, collective action] and *aroha* [sincerity, mutual respect, love] were often referred to as the *Maaori way* of dealing with hazards, risk and human-environment well-being. Such principles and regulators of community behaviour however depend not only on the relationship between *whaanau* and *hapuu* but also on the relationship between people and the environment – which is necessarily supported through regular interaction and the complementary principles of *rangatiratanga* [control and jurisdiction] and *kaitiakitanga* [stewardship, respect, respect, guardianship].

The value of quality external relationships (formal and informal) with other *iwi*, wider community groups and government organisations/authorities was also emphasised as important for helping to meet the emerging demands of increasingly complex social, economic, political and bio-physical system changes facing the community. Linked to these insights, the loss (and significance) of Maaori knowledge (which includes traditional activities and practices) and the importance of knowing about environmental change and risk was also regularly raised – including the importance of traditional as well as non-traditional educational opportunities that allow young people to draw from more than one intellectual tradition and thereby realise new knowledge and skills. In addition to these challenges, institutional and legislative influences were also recognised as having a determining impact on *iwi/hapuu/whaanau* well-being and development. These include questions over equitable representation in local planning and resource management arrangements, the nature of participation afforded to the community in social as well as environmental policy development and decision-making, and the even deeper challenge of competing human-environment values, beliefs and behaviour which are inseparably linked to ethics surrounding the integrity of life and the responsibility to future generations.

Integrating these results, it is evident that climate is only one of several factors that influence the vulnerability and adaptability of the 'community' at Manaia to cope and deal with climate threats and stresses. That is, it is the changes that take place within, and connections between, biophysical and human systems that drive and shape how different individuals, *whaanau* and groups within the community are affected by, and deal with, climate induced hazards and related stresses. Viewed in this way, vulnerability, resilience (endurance) and adaptation to climate variability and change are issues inextricably linked to sustainable development, political institutions and structures, and natural hazards management. This point is critically important for leaders and policy makers across a range of scales and institutions, as well as for *te hau kaainga* [home-people] on the ground who often indicated how much less of a priority climate change is when compared with other challenges currently

confronting the community. Notwithstanding these outlooks, many community members from Manaia simultaneously acknowledged the need to strengthen their social, cultural and economic capacities to 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 through this work represent points of entry for strategic community, *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 at Manaia; and therein the capacity of the community to deal with future climate risks largely rests upon responding to existing issues linked to resourcing, political participation, governance, *whaanau* health and education, cultural capital and 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.

Experience gained through this work confirms that integrated assessment of the environment and human development is arguably the most difficult and most important "systems" problem that society faces. New interdisciplinary approaches and deeper forms of analysis are 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 Maaori communities would help to ground-truth diverse exposures, sensitivities and adaptive capacities. The benefit of such work would 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 Maaori 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 challenges.

Lastly, 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 New Zealand. For other Maaori communities interested in examining in their own climate change challenges it is important to emphasise that consideration of community vulnerability and resilience 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 *whaanau*/*hapuu*/*iwi* development.

Whakaraapopototanga matua

Ko ngaa paanga huarere, te noho whakaraerae me te kaha ki te urupare, ki te urutau, he hua katoa eenei o te whanaunga matatini i waenganui i te tangata me te ao koiora, ao kikokiko. Ahakoa raa eenei maaramatanga, me te moohio o te hinengaro maarama ka paangia nuitia ngaa puunaha paapori-rauropi e ngaa huringa i te huarere, he ruarua noa iho ngaa maataitanga a ngaa tohunga rangahau i roto i ngaa taupori me ngaa hapori i aata whakahuatia i Aotearoa New Zealand, e moohiotia ai ngaa aahuatanga taketake e noho whakaraerae ai te hapori, e kaha ai raanei ki te tuu maaia i roto i ngaa aakinga o ngaa mooreareatanga, me te huringa o te huarere. Ko taa ngaa mahi i teenei maatainga he tuuhura i eetehi o ngaa aahuatanga o te horopaki (tuku iho hoki), maa teetehi tirohanga hoohonu ki te noho moorearea o teetehi hapori Maaori, toona noho whakaraerae, toona kaha me toona urutau ki ngaa huringa o te takutai, naa te huarere te take. Ki te hangaia he aratohu mahi moo teenei tuu kaupapa me maatua aromatawai te waatea, te noho tuwhera me ngaa puumanawa urutau o te hapori ki ngaa aahuatanga huarere o naaianei (o mua) me oona mooreareatanga. Ko te tuumanako ka noho eenei moohiohio hei aawhina ki te tautuhi i ngaa whiringa whai paanga, hei aawhina ki te whakakore/te whakapaapaku raanei i ngaa whakaraeraetanga, me te whakapiki i ngaa puukenga, ngaa puumanawa huri noa i te hapori hei kawe (hei whakaurutau hoki) i ngaa aahuatanga huarere aa ngaa raa e tuu mai nei, me oona piikauranga. Koinei te puurongo tuarua o teetehi rangatuu maatainga, i whai waahi ai ngaa mema hapori o te kaainga o Manaia i Hauraki-Waikato, te ruunanga whakahaere aa-iwi o Ngaati Whanaunga Incorporated Society, me Maaori Environmental Research raaua ko National Climate Centre i raro i a NIWA.

He maha ngaa huarahi rangahau me ngaa tikanga o ngaa puutaiao aa-kikokiko, aa-tangata i tiikina atu ai hei whakamahi moo teenei rangahau, hei tuuhura i ngaa aahuatanga huarere me ngaa mooreareatanga kei runga i ngaa pakihiwi o te kaainga o Manaia. Teetehi waahi o teenei ko ngaa tikanga rangahau kootui, me te uu ki te tiri i ngaa moohiohio, i ngaa rawa me ngaa whaainga waahi, tae atu ki te ako, ki ngaa mahinga me te whiriwhiri ngaatahi i ngaa whakatau moo ngaa mahi me ngaa whaainga o te kaupapa. Naa ngaa tirohanga whakamua ki ngaa hurihanga i te huarere me ngaa tikanga rangahau tatau i whakaahei kia tirohia ngaa paanga me ngaa mooreareatanga aa ngaa raa e tuu mai nei - otiraa i aata tirohia te pikinga o te hoohonu o te moana, me te waipuketanga i te riu o Manaia awa. Noo muri mai i whakamahia ngaa tikanga aata rangahau i te tino aahua, kia moohio ai he peehea rawa te urupare a te hapori ki ngaa heemanawatanga huarere, tae atu ki ngaa puutake me ngaa tukanga ka whakahohe, ka here raanei i oo raatou whiringa me aa raatou mahi. Naa eenei huarahi tiimatanga, whakamutunga hoki ki te rangahau i ngaa mooreareatanga hapori, te noho whakaraerae me te maaia ki te urupare ki ngaa piki, heke o te huarere me oona huringa, ka tautuhitia eetehi whiringa hei whakakore hei kaupare kia iti rawa/raanei ngaa whakaraeraetanga, hei whakapiki hoki i ngaa puukenga me ngaa puumanawa huri noa i te hapori hei kawe, (hei whakaurutau hoki) ki ngaa aahuatanga huarere, me oona piikauranga.

I runga anoo i ngaa tikanga take-moorearea e kauwhautia ana e te Manatuu Taiao i aa raatou aratohu ‘Coastal hazards and climate change’ me ‘Tools for estimating the effects of climate change on flood flow’, naa ngaa tikanga tatau i teenei mahi i whakaputa eetehi kaapuinga moohiohio moo te pikinga o te hoohonu o te moana moo 2040 me 2090 AD. I whaaia hoki ngaa paringa takutai moana (me ngaa hoohonutanga wai) naa te pikinga ake o te hoohonu o te moana me ngaa waipuketanga awa naa ngaa uanga aawhaa-nui i raro i

ngaa tirohanga huringa huarere A2 (aahua tiketike) me B2 (aahua paapaku) moo aua roanga waa anoo. Naa te whakamahere i ngaa hua mai i taa maatou aromatawainga o ngaa paanga pikinga moana moo 2040 me 2090 AD i raro i ngaa aahutanga rerenga awa toharite i kitea ai teeraa e piki te hoohonu o te moana maa te 0.4 m kia tae ki 2040 AD, (ina whakatairitea ki ngaa tau 1980 ki 1999), aa, ka puta i konei eetehi repo whaanui kee atu, ka waipuketia hoki ngaa whenua paamu e ngaa tai pari i teenaa waa, i teenaa waa. E ai ki eetehi atu aromatawai kua kitea, ki te piki te hoohonu o te moana moo te 0.8 m aa te tau 2090, ka ngaro atu teetehi kotinga whenua maroke, moomona tonu o teenei waa, ki te raki, ki te tonga hoki o te wahapuu- te waipuke e ngaa waitai i te paringa tai (araa, e rua rawa oona waipuketanga ia raa, i te waa o te tai pari). I raro i teenei tirohanga ki te hoohonu moana aa te tau 2090, ki taa maatou titiro maa te rere o te MHWS10 (araa, 10% o ngaa tai katoa, ko aua tai ngaa tai teitei rawa) e tino whaatoro te waitai ki te tuawhenua, me te tae tonu (ki tua atu raanei) i te takiwaa o te State Highway 25 ki te raki o te Te Kapara awa. E noho ana eetehi waahanga o eenei whenua takutai i roto i ngaa ringaringa aa-iwi, aa te tangata Maaori raanei, aa, ka paangia ngaa whakamahinga whenua i eenei waa, ka whakapoorarutia auautia raanei i raro i eenei momo tirohanga. Ki te peenei tonutia te waipukenga ka tino heke te painga me te whakamahi i eenei momo rawa whenua.

I matapaetia ngaa whaanuitanga waipuke puta noa te puuau awa o Manaia i runga anoo i ngaa aahuatanga paerewa o teetehi waipuke kino i te marama o Pipiri 2002, i ngaa matapae hoki o ngaa ua aawhaa tino nui (me ngaa waipuke ka rere i muri), i raro i ngaa aahuatanga huarere panoni moo 2040 me 2090 AD, tae atu ki ngaa matapae moo te pikinga o te hoonohu o te moana. Naa eenei hua ka kitea moo ngaa tirohanga toharite o A2 me B2 aahua paapaku moo te huringa o te huarere, e kore pea e tino rerekee rawa ngaa whaanuitanga waipuketanga moo 2040 me 2090 AD i ngaa whaanuitanga waipuketanga tino nui (araa, teetehi waipuketanga whakaharahara o “ia 200 tau”) i puta i te marama o Pipiri 2002. He mea anoo, ahakoa te kii a ngaa matapae i whakatauiratia ka piki ngaa paringa waipuke tino nui kia te 30% te rahinga atu i eeraa i whakatauiratia moo te waipuke o te tau 2002, e ai ki ngaa tohu kaaore e tino whaanui kee atu te waipuketanga whenua. Te take i peenei ai, naa ngaa taha tuupoupou o ngaa riu, ahakoa he hoohonu kee atu te wai, naa te whaaiti o te riu e kore e tino whaanui kee atu te waipuke. Ahakoa eenei kitenga, araa eetehi whare, kaainga hoki kei te noho moorearea i te tatanga mai o ngaa wai me ngaa tuukinotanga o te waipuke, araa, he teitei kee atu i raro i ngaa tirohanga A2 me B2 i te tau 2040 me 2090 AD, i runga i ngaa matapae ka teitei kee atu ngaa tino paringa waipuke me ngaa paapaatanga rerenga wai. Otiraa me koorero raa te kura o Manaia, e tuu raa i teetehi waahi i waipukengia ai e te wai 0.5 m te hoohonu i te tau 2002; ko te whakaaro maa ngaa waipuke hei te tau 2090 ka taapiritia teetehi 0.1 m te hoohonu ki ngaa teiteinga waipuke. Ka whaatoro eeraa mooreareatanga ki eetehi whare e nohoia ana, ki eetehi hoki kaaore e nohoia ana, ki eetehi whare rokiroki, ki eetehi taiepa me eetehi waahi o Goldfields Road me Manaia Road tae atu ki ngaa kararehe (ngaa hipi me ngaa kau) ka noho raanei i eetehi waa i ngaa raorao whaka-te-takutai o Manaia. Kia moohio te kapaanui ahakoa kaaore i aata whakatauria ka peehea rawa te auau o ngaa tino waipuke taumaha oorite ki too Pipiri 2002, i roto i ngaa tirohanga huringa huarere moo ngaa raa kei mua i raro i teenei maatainga, ko te matapae ia, teeraa tonu e kaha ake ngaa uanga aawhaa nui i eetehi rohe maha o Aotearoa. Me haere eetehi atu mahi hei whakawhiti i te huringa o ngaa auautanga aawhaa, hei matapae moo te auau o ngaa waipuke.

Ko ngaa tikanga rangahau titiro i te tino aahua i whakamahia i teenei maatainga i takea mai i eetehi uiuinga i aahua aratakina (tae atu ki eetehi matapakinga oopaki, me ngaa hiikoi) ki eetehi taangata whenua 46 e noho ana i te kaainga o Manaia, i te taha raanei. I haere eenei uiuinga takirua, takitahi hoki i waenganui i Whiringa-aa-rangi 2010 me Mahuru 2012, aa, raa roto i eenei noho tahitanga ka taapaetia mai e te hunga i uia oo raatou whakaaro moo ngaa mooreareatanga huarere, takutai hoki (me ngaa huringa ki te taiao) i roto, i te takiwaa hoki o Manaia. Ko eetehi o ngaa matapakinga i haangai ki ngaa moohiotanga o ngaa rerenga wai o te rohe, ngaa wai he tere tonu ki te waipuke, ngaa paanga ki te whaanau, otiraa ko te mea nui pea, ko ngaa tino aahuatanga ka whakapooraru i ngaa mahi a te whaanau ki te urupare ki ngaa huringa o te huarere, ngaa mooreareatanga me ngaa heemanawatanga.

I runga anoo i eenei whiriwhiringa i ngaa mahi a ngaa whaanau, a ngaa iwi/hapuu, moo ngaa mooreareatanga huarere me ngaa huringa aa-iwi, aa-paapori hoki, ka tohua eetehi puutake matua e whaa o te noho tuwhera me ngaa puumanawa urutau o te hapori ki ngaa mooreareatanga huarere. Ina raa aua puutake: (i) Ngaa rawa taketake me ngaa rauemi, (ii) Ngaa whatunga paapori-ahurea me ngaa ritenga, (iii) Te maatauranga, te moohiohio me te akoranga me te (iv) Whakamahere, te arataki me ngaa uara tauwhaainga.

Ko ngaa puutake matua ko ngaa aawangawanga moo te noho o te iwi i roto i te korekore, araa, ngaa heemanawa moo te iti o ngaa rawa taketake e ora ai te tangata, ngaa whare, te iti o ngaa puutea moni me ngaa rawa e tika ana hei aata kaupare atu i te waatea me te noho tuwhera ki ngaa mooreareatanga me ngaa heemanawatanga o te huarere. He maha te hunga i uia i whakaae he uaua ki te whakatinana tikanga ‘noho toiora’ hauora kee atu i roto i eenei taumahatanga, aa, he tika te kii, naa eenei uauatanga ka taumaha kee atu ki kaupare i te noho moorearea o eetehi whaanau ki ngaa rerekeetanga o te huarere me ngaa aahuatanga kikino, ina paa mai. Ahakoa eenei maioro, ka haangai ngaa taura o te whaanau me ngaa uara o te ahurea ki ngaa tikanga, ki te whanaungatanga, te kotahitanga, te aroha, aa, koia eenei ngaa whakaritenga a te Maaori hei kaupare atu i te moorearea, me te toiora o te tangata i roto i te taiao. Ka whirinaki tonu eenei maataapono me eenei tuaapapa o te whanonga o te hapori ki te whanaungatanga o te whaanau me te hapuu, otiraa i runga tonu i te whanaungatanga i waenga i te iwi me te taiao – he mea tautoko e te tuu tahitanga me ngaa maatapono tauwhitiwhiti o te rangatiratanga, o te kaitiakitanga.

I whakahuahuatia hoki e ngaa kaikoorero te tootika o te whanaungatanga o roto o waho hoki, ki eetehi atu iwi, ki ngaa roopuu hapori whaanui tonu, ki ngaa roopuu kaawanatanga hei mea nui i te aawhinatanga ki te whakatutuki i ngaa piikauranga nunui , hei kawe i ngaa huringa puunaha matatini, aa-puumanawa paapori, aa-oohanga, aa-toorangapuu hoki, kei mua i te hapori. Ko teetehi waahi o eenei whakaaro, i whakahuatia nuitia hoki te ngaromanga o te maatauranga Maaori (e whakamahi nei i ngaa mahi me ngaa ritenga tuku iho) me te mea nui kia maarama hoki te tangata moo ngaa huringa huarere me oona mooreareatanga - tae atu ki te nui o ngaa whaainga waahi ki ngaa akonga tuku iho, o te ao hou hoki, e moohio ai te rangatahi ki ngaa taonga o ngaa ao e rua, me te whai i ngaa huarahi o te maatauranga me ngaa puukenga hoki, me te pupuri i te taha Maaori. I tua atu i eenei piikauranga, i whakaarotia eetehi paanga aa-whakahaere, aa-ture raanei hei paanga nui ki te ora o te iwi/hapuu/whaanau. Ko eetehi o eenei ko ngaa paatai moo ngaa maangai Maaori i ngaa ritenga whakahaere aa-rohe, whakahaere rauemi, te aahua o te whaainga waahi mai o te hapori i ngaa mahi taarai kaupapa here taiao, whakatau take taiao hoki, te wero nui o ngaa uara tauwhaainga, ngaa whakapono, me te whanonga i te ao tangata, inaa hoki e kore eenei

e taea te wewete i te noho toiora o te tangata, me ngaa haepapa ki ngaa whakatupuranga kei mua.

Ina huia eenei hua, he maarama tonu te kite ko te huarere teetehi raruraru kotahi, e whakaawe nei i te whakaraerae me te kaha ki te urutau o te 'hapori' i Manaia, e kaha ai ia ki te kaupare i ngaa mooreareatanga me ngaa heemanawa o te huarere. Araa, ko ngaa huringa ka haere whakaroto anoo, ko ngaa here i waenga i ngaa puunaha aa-koiora, aa-kikokiko ki ngaa puunaha tangata ngaa take e herea ai te aahua o te paanga o ngaa whaanau me ngaa roopuu o te hapori e ngaa mooreareatanga huarere, me oona heemanawatanga. Ina peenei te titiro, ka noho ko te whakaraerae, ko te manawaroa me te urutau ki te huringa o te huarere hei waahi nui o te whakawhanaketanga toituu, ka paangia hoki e ngaa whare toorangapuu me oona whakahaere, me te whakahaere i ngaa mooreareatanga taiao. He mea tino nui teenei moo ngaa kaihautuu me ngaa kaihanga kaupapa here mai i ngaa waahi katoa, tae atu ki te hau kaainga, e kaha rawa nei ki te kii ko te huringa o te huarere teetehi o ngaa piikauranga iti iho i eetehi atu piikauranga taumaha kei te wahaina e te iwi. Ahakoa eenei tirohanga, he maha ngaa mema o te hapori o Manaia i whakaae me maatua whakapakari oo raatou puumanawa aa-paapori, aa-ahurea, aa-oohanga hei aromatawai, hei whakamahere, hei urupare hoki ki ngaa wero nui o te huringa o ngaa ritenga huarere me ngaa aahuatanga ka haere i te taha.

Teetehi, he maarama tonu te kite atu (peenei i eetehi atu maatainga ki ngaa heemanawatanga huarere) ka noho ngaa here me ngaa pakaritanga o teenei mahi hei tomokanga moo eetehi mahi whakamahere, hua kaupapa here rautaki aa iwi, aa-kaawanatanga hoki, hei whakangaawari (hei whakakore rawa atu raanei) i ngaa nohonga tuwhera o naaianei, hei whakapiki, hei whakauru hoki i eetehi atu puumanawa hou moo te urupare, moo te urutau. I runga anoo i ngaa koorero i konei, ko eetehi o ngaa tomokanga kua paiakatia hoohonutia ki roto i ngaa aahuatanga aa-oohanga, aa-toorangapuu, aa-taiao i Manaia, aa, ka takea mai i reira ngaa puumanawa o te hapori ki te kawe i ngaa mooreareatanga huarere o mua i runga tonu i te urupare ki ngaa take o te waa e paa ana ki te whaangai rawa, ki te whaainga waahi toorangapuu, ki te arataki, ki te hauora whaanau me te maatauranga, ki ngaa rawa ahurea me te whakahere i te mooarearea e paa ana ki ngaa moorea taiao. He tini tonu ngaa aarautanga me ngaa taapokopokotanga ka paa ki te whakahaere i ngaa mooreareatanga o ngaa moorea huarere kei mua i te hapori – tae atu ki te puumanawa (me ngaa hiahia) ki te waihanga tikanga whakahaere i roto i te waa e taea ai te whakauru i ngaa moorea whakarerekee, me ngaa aahuatanga aa-paapori, aa-rauropi, i roto i te takanga o te waa.

Naa ngaa wheako i roto i eenei mahi kua moohio ko te haumitanga tika o ngaa whanaketanga tangata me te taiao te mea uaua tawa, te raruraru "puunaha" nui rawa kei mua i te iwi. Me maatua rapu eetehi huarahi maha me eetehi tikanga wewete hoohonu kee atu kei whakapiki i te haumitanga o ngaa moohiohio mai i ngaa kaipuutaiao, i ngaa kaitaatari kaupapa, i ngaa kaiwhakatau take mai i te ao iwi taketake, me ngaa iwi o te ao hou. Maa konei e aawhina ki te whakapakari i ngaa whakatau o teenei waahi reo-nui, me te hora i eetehi mahere, mahinga whai take hei aawhina i ngaa whakaraeraaetanga me ngaa huarahi urutau moo ngaa raa kei mua. Me wewete haere tonu ngaa mooreareatanga kei mua i te iwi Maaori me oona hapori, kia tino kitea ai he aha ka paa, he aha hoki te rongoaa. Teetehi hua o eenei mahi ko te manaaki i ngaa whakaaro o te takitini, o te takimano, me te whakahaangai i ngaa rongoaa ki ngaa aahuatanga ahurei o te Maaori i teenaa takiwaa, i

teenaa takiwaa. Ko eetehi take whaaiti he kimi huarahi ki te whakawhanaunga atu ki eetehi roopuu whakaraerae rawa i oo taatou hapori (tae atu ki ngaa roopuu aa-whaanau kua noho takitahi, i ngaa taupatupatu i te taha toorangapuu, i te aha i te aha) me te whakapuumau i ngaa tikanga tuku iho, me te kimi huarahi waihanga i runga i ngaa tikanga puutaiao hei urutaunga maa te iwi. I runga i te moohio ka tuupato tonu te hapori ki ngaa mea hou, moorearea pea, he mea nui kia rapua ngaa kanohi 'tika' hei whakamoohio i te iwi, hei kanohi whakawhiti koorero.

Hei whakamutu, kaapaa ka hanga te huringa huarere i eetehi moorea hou, engari ka puta i toona taha he pikinga ake i te auau me te kaha o ngaa mooreareatanga o naaianei, tae atu ki te whakauru mai i eetehi rerekeetanga waa-roa aa-huarere moo Aotearoa. Moo eetehi atu hapori Maaori e hiahia ana ki te tuuhura i oo raatou mooreatanga huringa huarere he mea nui kia moohio raatou ehara i te mea me tatari kia 'tino oti' ngaa rangahau moo te huringa huarere, i mua i te tiimatanga, ehara hoki i te mea me tatari kia kimihia ngaa rangahau 'aa-rohe motuhake' peenei i teenei puurongo. Me kii peenei kee, kei te tino waatea ngaa matapae moo te pikinga o te moana, me ngaa aratohu moo te hoohonutanga o te moana ki te katoa, ka taea eeraa te whakamahi hei whakapiki i te maaramatanga ki te paanga me ngaa mooreatanga i te taha. Otiraa ko te mea nui pea ia, ka taea ngaa rautaki me ngaa kaupapa here hei kaupare i te whakaraeraetanga, hei whakapiki i te kaha ki te urupare, te waihanga, ahakoa ngaa taapokopokotanga, naa te mea ko te nuinga o ngaa puutake ngaa huarahi hei whai he huarahi ka haere tahi me ngaa take o teenei waa, moo te oranga aa-paapori, me te whanaketanga aa- whaanau, aa-hapuu, aa-iwi anoo hoki.

1 Introduction and background

Few empirical studies with specific populations and communities in Aotearoa/New Zealand have been carried out to better appreciate the conditions that shape and determine community vulnerability and resilience (endurance) to climate risks and change. NIWA in response is undertaking a series of placed based studies with Maaori communities investigating 'community' vulnerability, adaptation and resilience to climate variability and change[1]. This report thereby documents a participatory-based research study involving community members from across the settlement of Manaia in the Hauraki-Waikato region, the tribal representative body Ngaati Whanaunga Incorporated Society and NIWA's Maaori Environmental Research and National Climate Centres. The information and learning derived from this work is expected to assist not only the community at Manaia but also provide relevant information to assist adaptation planning by other Maaori 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 first provided, followed by a brief review of what is currently known about the differentiated nature of expected climate change impacts and risk for Maaori 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 Maaori, 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 Maaori 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)[2] series of reports (more commonly referred to as fourth

[1] This study is part of the Coastal Adaptation to Climate Change (CACC) project funded by the Ministry of Business, Innovation & Employment[1] (MBIE). The intended outcome of the CACC project is more informed proactive communities and councils developing local adaptation strategies to climate change, the inclusion of these strategies in regional and community coastal planning documents, and evaluation and monitoring of the uptake and performance of adaptation strategies.

[2] 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 expected to be released in 2013 and 2014. It is

assessment reports – AR4) and for the New Zealand context through the Ministry for the Environment (MfE) funded guidance manuals: 'Climate change effects and 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 most recent summary reports 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 and volcanoes do not fully explain the increases in temperatures that are observed in the instrumental record – particularly the latter part of the twentieth century. In contrast, when GHGs are included into 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 variations 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 latest 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.

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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.

[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 likely increase in the frequency of heavy precipitation (rainfall) events.
- Continued widespread retreat of glaciers throughout the 21st century.
- A basic rise in global mean sea-level of between 0.18 to 0.59 m by the 2090's relative to the 1980-1999 average[6].

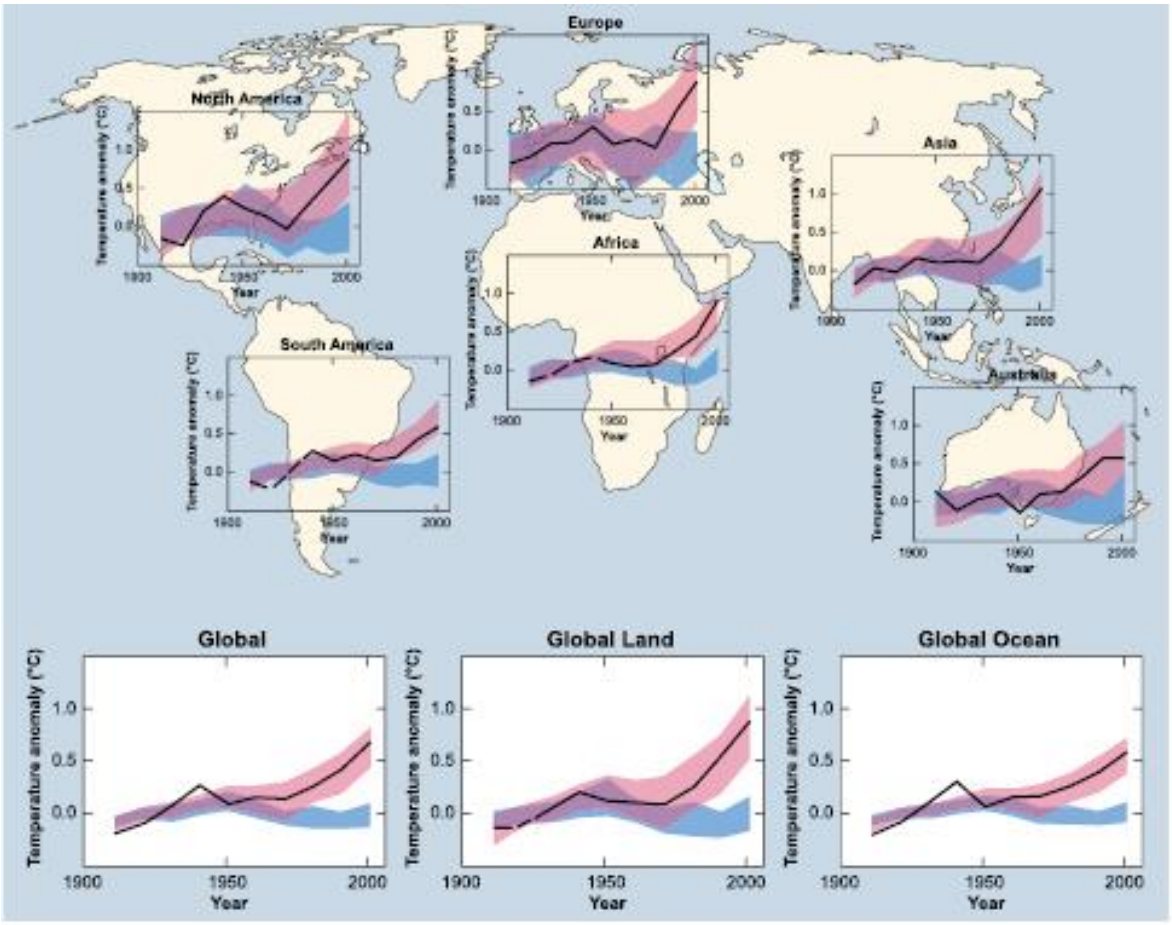

Figure 1: The figure shows the influence in modelled output when GHG's are excluded and included in globally and regionally modelled temperature. The black line indicates the observed increases in temperature over the years. In the blue band modeled average temperature takes into account solar, volcanic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

[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).

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 New Zealand, in the context of Local Government, is summarised in the guidance manual referred to above (MfE, 2008a). Broad patterns of change over New Zealand 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 New Zealand
- 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, possibly of the order of 1 m or more by 2100[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 sea-level rise. 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 changes in the likelihood of extreme events and climate variability, 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 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 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 New Zealand, 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] Sea-level rise projections for New Zealand are currently based on global model output. There remains considerable uncertainty over how much sea-level rise will occur globally and therefore little guidance about a possible upper limit for New Zealand (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 New Zealand'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 New Zealand'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 Maori 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 Maaori 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 thereby acknowledged using the Local Government Act 2002 as a reference point for linking climate change to existing land, water and energy management strategies – in spite of this legislation not specifically referring to climate change (Greenaway and Carswell, 2009; Reisinger *et al.,* 2011). And, responsibilities under the Civil Defence Emergency Management Act (2002) have also seen this 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 Maaori communities and climate change

To date, only a handful of studies have considered how Maaori 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) 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 Maaori society, it is generally recognised that Maaori society is climate sensitive due to the strong links that exist between Maaori 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 Maaori will be differentiated depending on social, political, economic and environmental circumstances (Figure 2).

The vulnerability and resilience of Maaori will also vary between Maaori living in small rural settlements to Maaori 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 Maaori governance structures (including policy makers and local authorities) have adequate information and tools to respond to the pressures that Maaori face? And, how should

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

priorities 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, Maaori society. Although it is well known that Maaori 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 Maaori 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.

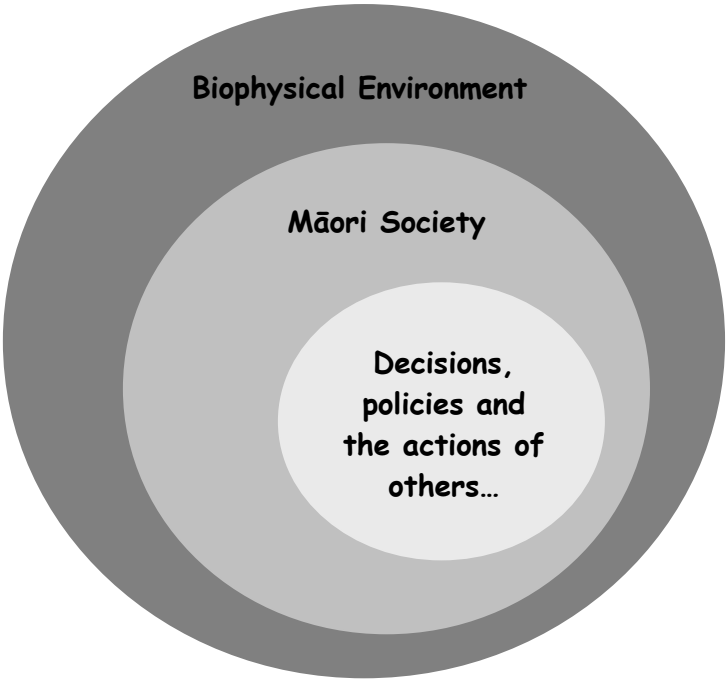

Figure 2: The key spheres of influence that complicate the climate change issue for Maaori society. (Source: King *et al*., 2010).

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, Maaori coastal communities and associated infrastructure have been identified as being highly vulnerable to sea-level rise 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 on resources and widespread coastal development – in both urban and rural areas (Penny *et al*., 2007a, 2007b).

[15] Treaty of Waitangi claims and settlements have been a significant feature of New Zealand 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 Maaori 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.

A further challenge in understanding the dynamics of these drivers across Maaori 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 *whaanau/hapuu/iwi* [extended family/sub-tribal kin group/tribal kin group] and Maaori 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 Maaori 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 Maaori, 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 Maaori '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 Maaori 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 *whaanau*, *hapuu* and *iwi*, Maaori society also needs to be understood as consisting of individuals, groups, pan-Maaori 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 Maaori 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 impossible to know in the case of the precise probability of an extreme or unlikely event occurring. Moreover, this will sometimes require groups or

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

individuals to make the best educated guesses possible in order 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 minimise risk and therein reduce potential harm or loss. In this way, climate adaptation is basically a risk-management strategy (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). 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 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 Manaia.

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

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).

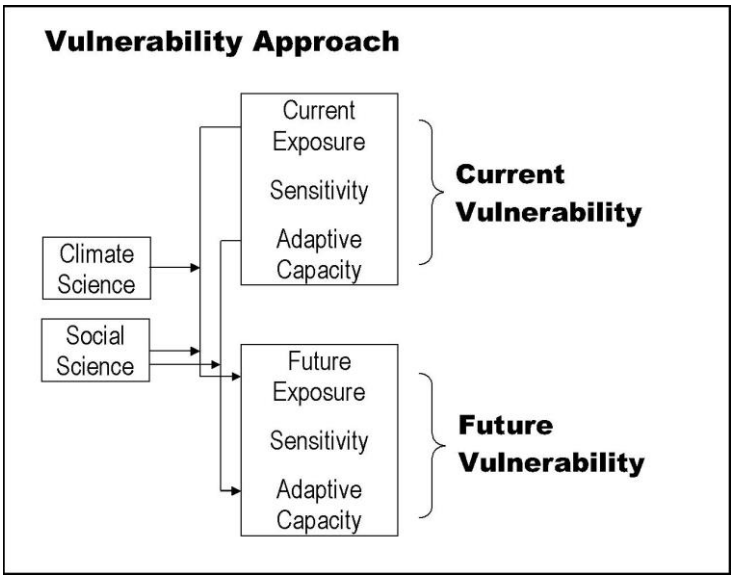

Figure 3: Analytical framework for vulnerability.

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 integrated with other programs and strategies (e.g. natural hazards management, land-use

[18] Durie (2005) provides a valuable analysis of the position of Māori society at the beginning of the twenty-first century by considering the elements of time and resilience as key measures for Māori 'endurance'. 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.

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 $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 and non-indigenous coastal fishing groups is highly dependent on regulation, legislation and

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

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 sea-level rise 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 better understand the contextual conditions and/or drivers of Maaori '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. Importantly, we do not seek to presume any of these community variables, but rather to identify these empirically through open conversations with *te hau kaainga* [home-people] from Manaia. Through this work it is expected that grounded information will be generated to assist the community at Manaia 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 explore selected future scenarios of climate-induced coastal change and consider how the potential impacts and risks facing the 'community' at Manaia might change under altered environmental conditions.
- To examine the processes that contribute to 'community' vulnerability (includes adaptive capacity) as well as those processes that lead to adaptation – paying close attention to the impediments and strengths that facilitate or constrain adaptations.
- To identify coping practices and adaptation strategies that assist in reducing vulnerability (and building adaptive capacity) appropriate to the community at Manaia.

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 coastal river-reach flooding

Phase IV: Model projected sea-level rise and coastal river-reach flooding scenarios

Phase V: Explore current community vulnerability to climate-induced coastal hazards

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 Ngaati Whanaunga – Manaia, Coromandel

This section provides background information on the people and landscapes within and across the Manaia catchment. It also provides a brief overview of previous coastal change and process studies conducted in and around the area.

2.1 Ngaati Whanaunga

Extending from the sacred mountain of *Tawhitirahi* to the waters of *Te Wahapuu o Manaia* (Manaia Harbour), Ngaati Whanaunga is one of several *iwi* who hold *mana-whenua* [territorial rights, power from the land, power and authority associated with possession and occupation of the tribal land] over the Manaia catchment area (HMTB, 1999; Monin, 2001; NWIS, 2011) (Figure 4). The on-going relationship that Ngaati Whanaunga and its 15 *hapuu* have with the area is reflected through the approximately 300 full-time residents who 'keep the home fires burning' at Manaia settlement as well as through the many culturally valued sites in and around the area – e.g. *waahi-tapu* [sacred area, sanctuary, shrine], *urupaa* [burial sites, cemetery] and historical *paa* [traditional settlement] (Kennedy and Jefferies, 2008). These connections between people - both the living and those who have come before - and place, are further demonstrated through the continuing tradition of *whaanau* burying the *pito* [umbilical cord] and *whenua* [placenta, land] of new-born babies along the harbours edge (Penny *et al.,* 2007a). Ngaati Whanaunga also holds *mana whenua* rights over areas outside of the Manaia catchment which are interspersed with other *iwi* and neighbouring *hapuu* through the eponymous ancestor Marutuuaahu (Kennedy and Jefferies, 2008).

The Manaia area is understood to have been a *papa-kaainga* [habitation] for Ngaati Whanaunga at the time of the earliest colonial contact in the late 1700's and has accordingly sustained generations of *whaanau* and *hapuu* (Monin, 2001). Freshwater species such as *tuna* [freshwater eel], watercress and *kooura* [freshwater crayfish] have been gathered from the main stem of the Manaia River and its many tributaries. Although, the main source of *kai* [food, to eat, consume] is the harbour and surrounding waters, where species such as *taamure* [snapper], *paatiki* [flounder], *paua* [abalone], *kina* [sea urchin], *kuutai* [mussel], *pipi* [clam, endemic mollusc], *tuangi* [cockle], *puupuu* [whelk, sea snail], and *tio* [pacific and indigenous oyster] were found in abundance (HMTB, 1999; Penny *et al.,* 2007a). Ngaati Whanaunga consider many of these traditional food gathering areas to be sacred as they offer *taonga* [treasure, asset] species that are of physical and cultural importance. These sites and species continue to provide permanent tangible connections between the people of Ngaati Whanaunga and Manaia. The people define themselves through these associations which are an intrinsic part of their identity (Waitangi Tribunal, 1988; Kennedy and Jefferies, 2008).

The formalisation of the colonial period for Ngaati Whanaunga arguably began with the signing of the Treaty of Waitangi on 4 May 1840 by the paramount chief of Ngaati Whanaunga, Te Horeta Te Taniwha (NWIS, 2011). Notable developments that followed this event include the gold rush in the Coromandel region in the 1860's – which led to a significant influx of immigrants to Manaia and the logging of large *kauri* [native coniferous tree] in the upper Manaia catchment (including gum digging and the clearing of land for farming) in the 1890's (Burns, 1984; Skinner, 1993). Together these activities provided economic sustenance for a growing population. However, by the early 1900s the resources being exploited by these industries were dwindling, resulting in the collapse of the gold mining and *kauri* logging operations (Penny *et al.,* 2007a). During the 1940s, 50s and 60s, like other rural Maaori communities across the country, many *whaanau* living across Manaia

moved into the cities such as Auckland, Hamilton and Palmerston North in search of work. There were many reasons for this 'urbanisation' ranging limited employment prospects for young Maaori in the countryside, to a growing demand for labour in the towns and cities, to government policy initiatives that included the provision of state housing on the one hand but limited support on the other for the development of Maaori land holdings and family farmlets in rural areas, among others.

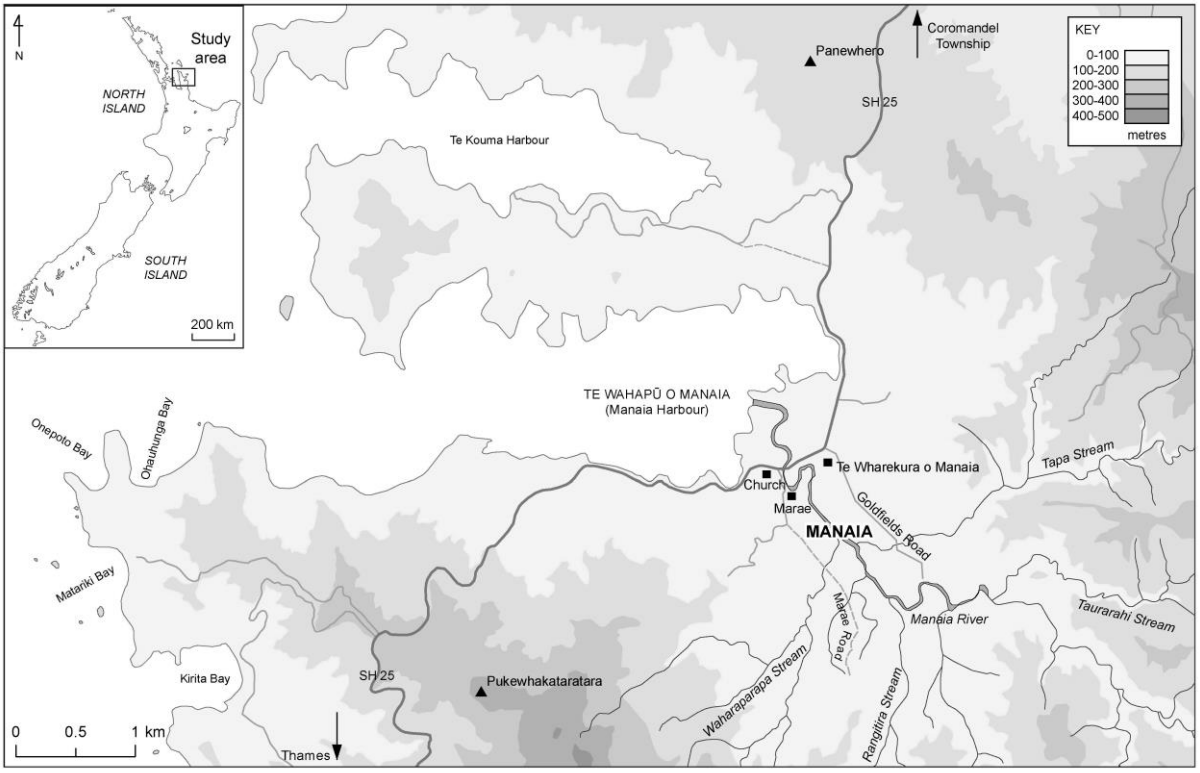

Figure 4: Manaia Harbour and settlement – Coromandel Peninsula, Waikato Region.

A number of Ngaati Whanaunga *whaanau* still reside within the Manaia catchment and in the neighbouring towns of Thames and Coromandel. It is estimated that there are some 2,500 people who *whakapapa* to Ngaati Whanaunga, of which 52% are aged 25 years or younger. An estimated 450 people now reside in the Manaia Valley, although it is assumed that about 100 of these are transient (Penny *et al.,* 2007a). There has been also a vast reduction in the scale of farming in the area since the 1970s, although several small (including some organic) cattle blocks and family gardens are maintained. Employment in the area now consists mainly of seasonal service-based work for businesses in Thames, Coromandel and Whitianga. The development of shellfish farms and factories across the Coromandel Peninsula also provides employment. Like many rural communities in Aotearoa, residents now have to travel to neighbouring townships to purchase provisions, although household food supplies are also supplemented by hunting, fishing and gathering traditional *kai* species throughout the Manaia catchment (HMTB, 1999; Penny *et al.,* 2007a).

The present settlement of Manaia is supported by the *marae* [meeting house and surrounding area], a school [Te Wharekura o Manaia], an Anglican church, a volunteer rural fire brigade unit and small businesses including a hydroponic business, and a mussel

processing depot. Te Wharekura o Manaia[22] is a Special Character School (Kura-aa-Iwi), and caters for students from years 1 to 13. All of the 86 children enrolled in the school identify as Maaori. Over the last 5-10 years residents have observed a gradual growth in the numbers of people living in Manaia, as *whaanau* return from other areas of Aotearoa and overseas to reside and build on their ancestral lands[23] (Pers. Comm.: Ms Betty Williams, Oct 2010).

Like Te Wharekura o Manaia, Manaia Marae is also a focal point for the community. It borders the Manaia River and is located on Marae Road which often floods, blocking the only exit onto State Highway 25 (SH25). The State Highway crosses an extensive wetland which is bounded by the Manaia River and Harbour. During flood events this section of SH25, which travels north to Coromandel and south to Thames, is often impassable (Penny *et al.,* 2007a). On a regular basis *waananga* [seminar, forum, to meet and discuss] are held at the *marae*, for *kapa-haka* [traditional performing arts], '*te reo me oona tikanga'* [Maaori language and customs], *maatauranga* Maaori [Maaori knowledge] and other educational initiatives. Many *whaanau* members who have relocated to cities regularly return to Manaia during holiday periods and to attend *tangi* [funeral, grieve, cry], *hura koohatu* [unveiling], *waananga*, birthdays, and weddings at the *marae*. As a result, the population in Manaia often varies in accordance with events occurring at the marae or the time of the year.

In spite of diverse living arrangements and clear socio-economic disparities across different *whaanau* and *hapuu* in the area, the people of Ngaati Whanaunga remain staunchly independent in many respects and take strength through strong internal relationships. Through NWIS (the legal entity responsible for managing tribal assets and affairs) the iwi is currently working through the Treaty of Waitangi claims process and is committed to a sustainable future through the *kawa* principal: "*Ki te whakarite te taha tinana, te wairua, te hinegaro, te whaanau, ki te Aotuuroa, ka tino whai-mana te mauri*" [That there is a holistic balance with the environment to protect and sustain, nurture the very essence of its life giving force].

2.2 Environmental setting

Manaia settlement is located 34 km north of Thames on the western side of the Coromandel Peninsula (Figure 4). It lies to the east of State Highway 25 and is crossed by the Manaia River which flows through alluvial flood plains before reaching the extensive estuarine habitat of Manaia Harbour to the west. Steep gravel-bedded streams feed into the Manaia River with the upper catchment consisting mainly of steep bush-clad land rising to the Coromandel range between the peaks of Tawhitirahi and Kakatarahae (HMTB, 1999). At the seaward end of the catchment, the Manaia Harbour is a shallow intertidal estuary. Characterised by extensive areas of tidal mudflats and sediments of sand and silt the inner harbour is fringed with mangroves and saltmarsh. The intertidal area represents approximately 76% of the estuary high water area. Although the shores of the harbour are sheltered from ocean swell they remain exposed to small wind waves generated in the Gulf that enter the bay when the tide is in (i.e. low wave energy). The mean tidal range is 2.4 m and the mean water depth across the estuary is 3.2 m. Sea surface temperatures range from 12 to 21°C. The area

[22] Te Wharekura o Manaia delivers all curriculum areas in Te Reo Māori and in accordance with the *tikanga* [customs] and *mātauranga* [knowledge] of the *whānau*, *hapuu* and *iwi* of Manaia.
Website: http://www.manaia.schoolzone.net.nz/.

[23] Some long-standing residents refer to this movement as 'de-urbanisation', which they believe is fuelled by cheaper living costs and the desire of whānau members to reconnect with their ancestral roots.

receives average daily maximum and minimum temperatures of 19.3° C and 7.6° C respectively, with northerly and westerly airflows occurring most frequently (NZMS, 1982).

The high elevation (800 m above msl) of the ranges behind Manaia settlement makes the area susceptible to orographic uplift and accentuated rainfall. This tends to be heightened when warm-moist and slow-moving weather systems approach from the north-northwest sector (Kidson, 2000; Griffiths, 2006). Rainfall varies significantly across the region with the western coastline of the Coromandel typically receiving 1200–1400 mm/year. In contrast, falls of 3500–4500 mm/year are common at gauge sites near the central axis (Hume and Dahm, 1992). Such high and intense rainfall combined with the steep terrain of the area can also lead to extensive flooding and sometimes debris flows across the settlement. This situation occurred over the 20th - 21st June 2002 when an intense low pressure system developed over the Northern Tasman Sea, deepening as it traversed the North Island (Figure 5). The central pressure of the low fell by approximately 24 hPa over a 24 hour period, leading to its classification as a meteorological bomb. During this event Manaia received 230 mm of rainfall over a 24 hour period (Leslie et al., 2005).

Prior to Early European arrival, Maaori land use is understood to have had very little impact on the catchment, with mainly low lying areas of bush and scrub being cleared for cultivation. Early European arrival saw more significant changes take place, and in 1890 the Kauri Timber Company built three driving dams (Burns, 1984) as a means of removing felled trees from the steep upper catchment. The steep landscape saved the larger trees from logging; however gum digging and associated bleeding left areas of burnt forest and many large trees with scarps cut into their trunks. The 1867 gold rush was the driving force behind the huge population influx to the Coromandel region. Mining within the catchment was not intensive compared to other settlements close by, however from 1885-1901 the Manaia stream catchment had two prospecting claims producing 9.2 kg of gold bullion (Skinner, 1993). Significant changes to the catchment resumed around the 1940s, when the Manaia River was altered as part of a drainage and road works programme (HMTB, 1999).

Today, land use within the Manaia catchment consists predominantly of native forest, pine forest, pastoral land and shellfish farming. The Manaia Sanctuary in the upper catchment has the only remaining concentrated stands of mature mid-altitude Kauri on the Coromandel range (Burns, 1984), and is home to the North Island Brown Kiwi. The Whangapoua pine forest extends into the Manaia catchment and is managed by Ernslaw One Ltd. Forestry activities undoubtedly contributes to the ~6700 tonnes of sediment Manaia estuary receives each year (Mead and Moores, 2004). Stock damage to the harbour environment continues to be a serious problem, with pugging and defecation affecting parts of the salt marsh. Access to stream banks will have increased suspended sediment levels entering the harbour which can affect the health of sea grass and shellfish (Graeme, 2009). This increased sedimentation and associated estuarine infilling is clearly evident by the 195 % increase in mangrove coverage from 1971 to 1995 (Turner and Riddle, 2001). The environmental impact of mussel farming in the harbour entrance is so far unknown; however the Hauraki Maaori Trust Board and Environment Waikato[24] have acknowledged the need for increased monitoring (HMTB, 1999).

[24] Environment Waikato officially changed its name to the Waikato Regional Council in March 2012.

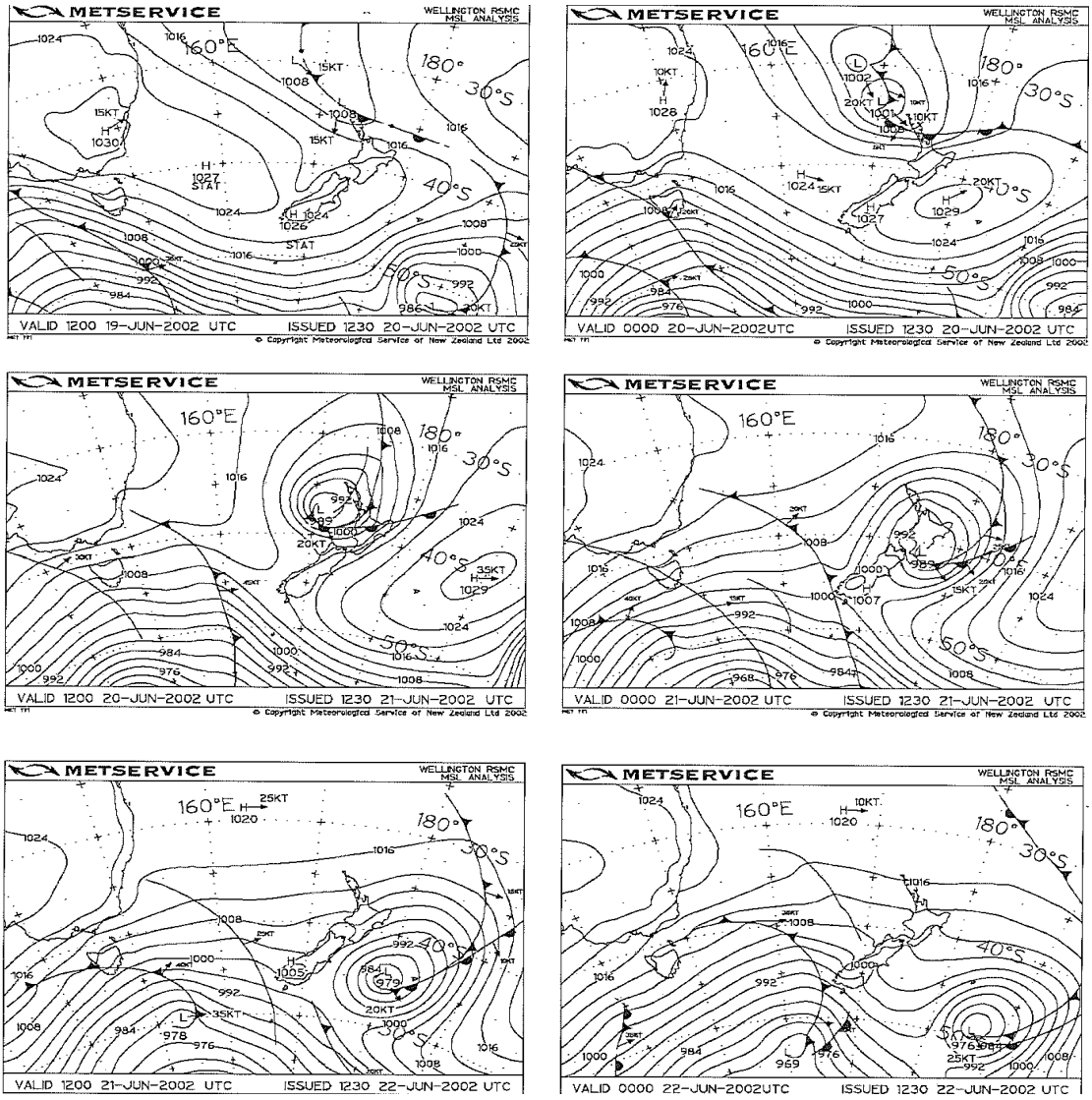

Figure 5: Development of the 'Meteorological bomb' that brought heavy rainfall and flooding to Manaia - 20th-21st June 2002. (Source: Meteorological Society of New Zealand, 2002)

2.3 Previous studies of environmental change and risk

Few studies have examined in detail the nature of environmental risks and change facing the community within and across the Manaia catchment. Arguably the earliest formal considerations on record trace back to 1917 when an assistant engineer from the then Department of Public Works suggested the planting of willows and wattles along the edge of the Manaia River as a means of erosion control. The urgency for flood protection was expressed in his letter (September 14, 1917) to the then district store keeper requesting they "please send urgently 2/- worth of Acacia Decurrens seed from Yates or O'Leary & Downes for planting…to protect against floods" (Department of Public Works, 1917). While unconfirmed, it is likely that the aforementioned seeds were planted sometime around this date and make up the majority of wattle and willows currently standing (and/or felled) along the Manaia River.

More recently, Environment Waikato (2009) modelled the physical characteristics of the flood hazard facing the Manaia community and identified three engineering-based flood mitigation options to help manage the potential impacts caused by flooding of the Manaia River and its

tributaries[25]. This was followed by a further report in 2010 which summarised flood issues across the wider Coromandel Peninsula - including how they were being addressed, priorities for action and how they might be progressed and funded (Environment Waikato, 2010). Among a list of other small coastal communities Manaia was identified as highly exposed to flooding with 'significant localised impacts' a risk to the immediate community. Consequently, a proposal to carry out the river works on the Manaia River in line with the current funding policy for the Peninsula Project[26] was developed by Environment Waikato, forwarded to the community for their consideration, and initiated through a collaborative arrangement between Ngaati Pukenga ki Waiau Society Incorporated and Environment Waikato in May 2011. To date, this work has involved removing all the willows, alders and weeds from the sides of the river (and in the river) from below the school to the river mouth as well as fencing and replanting the banks of the river with sterile willows to hold the banks and natives for long term retention. In some instances removal of gravel in the lower channel has also occurred. These first-order river management works are expected to help stabilise the river and stream banks and thereby lessen the impact of erosion and flooding on the Manaia River (Environment Waikato, 2010).

Aside from these assessments of flood risk and mitigation (i.e. reduction efforts), fisheries and estuarine vegetation surveys have also been conducted within the Manaia Harbour. The first conducted by Graeme (1998) concluded that Manaia was an excellent example of how New Zealand harbours should be and thereby worthy of high protection. She reasoned that there had been little modification to the estuarine environment and there was excellent water clarity and plentiful food resources for fish and birds. However in a follow-up survey, Graeme (2009) noted several factors that could be of detriment to the harbour if not contained. Stock access was identified as the main concern with implications for elevated sediment and nutrient runoff. Additional points of interest related to the control of saltwater plants such as paspalum, spartina, swamp oak, and the extensive spread of mangroves in the central harbour (Graeme, 2009). A related study by Turner and Riddle (2001) also reported on estuarine sedimentation and vegetation issues for the Waikato region – which included the Manaia Harbour. As part of their study they compared aerial photographs of Manaia from 1971 and 1995. They calculated a 195 % increase in mangrove distribution over this period. These authors concluded that while mangroves are important components of estuarine ecosystems, their expansion can have undesirable consequences and might even conflict with other estuarine resources and values, both natural and human (Turner and Riddle, 2001). In association with this work, Mead and Moores (2004) estimated that some 6700 tonnes of sediment per year was accumulating within the Manaia Harbour. No information was provided on how this figure was calculated however. The outcomes from these studies are consistent with work produced by the Hauraki Maaori Trust Board in 1999 who prepared a report for the Ministry for the Environment on the nature and use of Hauraki customary fisheries indicators. Based on accounts provided by kaumaatua and information extracted from historical sources the work offered an iwi-specific view of the use of environmental indicators to monitor changes in the marine and freshwater environment. Among a number of

[25] By way of some further background, this analysis followed on the heels of a successful business case to central government in 2004 by Environment Waikato and Thames-Coromandel District Council seeking financial support for managing flooding along the Thames coast. The government announced it would contribute $10 million to the cost of various flood management works that same year.

[26] The Peninsula Project aims to address river and erosion issues by integrating three key areas of work - flood protection, river and catchment management, and animal pest control. The Waikato Regional Council, Thames-Coromandel District Council, Department of Conservation and Hauraki Māori Trust Board are working together to carry out this work.

changes, a large decline in shellfish resources was identified – in particular the diminishing availability of *pipi* and *tuangi*, with significant decreases in abundance also recognised for *paatiki* and *taamure* in comparison to historical levels. Finally, NIWA worked collaboratively alongside Ngaati Whanaunga Incorporated Society and the wider community at Manaia between 2009 and 2012 to develop the Estuarine Monitoring Tool-kit (Ngaa Waihotanga Iho) (Swales *et al.*, 2012). The principal objective of the work was to develop a standardised resource and method (based on scientific and Maaori principles) for *tangata whenua* [people of the land, hosts, home-people] to measure and assess environmental changes in estuaries. Early findings indicate a deterioration of harbour health shown by increasing sedimentation, mangrove expansion and declining numbers (some significant) of stingray, mullet, *kahawai* [inshore pelagic fish] and herring to *pipi*, *puupuu* and *tuangi* (Swales *et al.*, 2012). The English version of the report was completed in January 2012 with the Maaori version expected to be officially launched in March 2013.

Insights on the changing character of the Manaia community are provided Baker (2003), Penny *et al*., (2007a) and (Carroll, 2009). In 2003, a working party mandated by the Manaia community at Manaia Marae produced the 'Manaia Community Plan' (Williams, 2003). This document included a sustainable vision for the community and is underpinned by a suite of guiding principles headed by the recognition of the importance of *whakapapa* between people and the environment. A comprehensive list of key issues relevant to community well-being was also produced based around what the community 'has', 'wants', 'do not want' and prioritises 'for action'. Of relevance to this work 'accommodation, housing and building' issues were identified – with references made to housing quality and repair requirements. Linked to this, a number of barriers such as high permit and resource consent fees preventing Maaori building homes on *whaanau* land were identified including the role of Council in creating fairer systems that recognise the needs of unemployed and low-income families. 'Community Safety' was another key issue – and in particular the threats to people's homes from flooding and erosion, and the linkages with compromised services and ineffective remedial actions and flood control management.

Subsequently, Penny *et al*. (2007a) conducted a survey with Ngaati Whanaunga in order to document the *tangata whenua* experiences, values, uses and observations of change associated with the estuarine/harbour environment. The survey was constructed from interviews, focus groups, a questionnaire and *hiikoi* [field trip, land-walk, to step], involving over 60 community members with observations that span the second half of the last century (Penny *et al*., 2007a). Some observations relevant to this present work include: a general increase in the magnitude and frequency of floods; water table close to surfaces on land surrounding the Manaia settlement; increasing frequency of large slips and slides in the upper reaches of the catchment; increasing harbour siltation and spread of mangroves; and depletion and movement of traditional shellfish beds (*pipi, puupuu, tuangi*), among other changes. The report summarises that Manaia community development is closely linked to the state of the harbour, river and catchment; and that *iwi*-based environmental monitoring is critical to informed management and local decision-making.

And most recently, Carroll (2009) explored the 'realities' of people living in 'informal housing' across Auckland and the Coromandel (including Manaia) and considered in detail the implications of such living arrangements on health and well-being. Analysis of interviews highlighted significant differences between mainstream perceptions of housing and health and the perceptions of many of the respondents, particularly across the Coromandel. Almost none of the Coromandel respondents considered their informal housing compromised their

health and wellbeing, although results were more mixed in Auckland. A possible explanation advanced for such a difference was the sense of empowerment and choice articulated by many of the Coromandel respondents, coupled with a strong sense of connection to family, land and the healing qualities of these environments. Carroll (2009) thereby concluded that while doing everything possible to ensure more equality of access to housing would be beneficial; at the same time there is a need to accept that, for some, informal housing is a choice based on different values and different priorities, and is not necessarily injurious to health and well-being. Hence, how we talk about issues is fundamental to social policy outcomes. Given such a conclusion, Carroll (2009) inferred that there is a need for greater flexibility in housing policy and related issues of compliance so that the resourcefulness of people in general can be built on to promote broader notions of health and well-being.

Finally, 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.

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 Maaori-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 Manaia, 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[27] (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 system is influenced by a relatively persistent forcing function such as sea-level rise, 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 conceptualisation of reality and

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

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 Maaori 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 volume 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 the 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 Maaori 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 reinforce the grounded theory approach to generating understanding. 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. 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). While climate change was not regarded as the top research priority for the community at Manaia the idea of investing ‘community’ time in such a project was recognised by Ngaati Whanaunga Incorporated Society 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 Manaia.
- 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 Manaia.
- Improving the capacity of the community at Manaia and Ngaati Whanaunga Incorporated Society to speak the language of climate change and adaptation with local and central governments.

- Incorporating Maaori vulnerability and adaptation options/responses into iwi management documents, local planning arrangements and regional plans.
- Recovering local stories and experience of climate variability and change from *whaanau*, *hapuu* and *iwi* history.
- Leading research and thinking. This study is a first for New Zealand – and although the findings are most relevant to *te hau kaainga* at Manaia and Ngaati Whanaunga Incorporated Society, there are likely to be general principles and lessons that are of value to other Maaori communities.

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 Manaia 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, Ngaati Whanaunga Incorporated Society and *whaanau* from across Manaia. These principles were applied through (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]; *manaakitanga* [to support, take care of, give hospitality to visitors, protect, look out for]; *whakapiki tangata* [empowerment]; *maahaki* [humility]; *whakatuia* [integration]; *tuupatotanga* [caution]; and *whakawhanaungatanga* [kinship, process of strengthening relationships].

Finally, this study was expected to generate data, research analyses and knowledge of benefit to Ngaati Whanaunga Incorporated Society and home-people from across the Manaia 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. Maaori 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 Ngaati Whanaunga 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 Ngaati Whanaunga Incorporated Society in July 2010.

4 Quantitative research methods

This section outlines the quantitative research methods used to generate information about climate-induced coastal flooding due to extreme rainfall under different climate change scenarios and projected increases in sea-levels for 2040 and 2090 AD. The principal steps followed include: (i) the refinement of an existing hydrodynamic model and simulation of an extreme flood event that occurred on the Manaia River in June 2002, and (ii) the estimation of inundation extents and depths under two different climate change scenarios that also take into account the base-level estimates of sea-level rise (SLR) of 0.4 m and 0.8 m for 2040 and 2090 AD (MfE, 2008b), respectively. This specific climate-induced coastal hazard was selected for analysis based on existing community knowledge and concerns about present and future environmental risks and conditions at Manaia[28]. Before outlining the procedures followed in this study, 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 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 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

[28] Note that 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).

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'[29] over New Zealand (MfE, 2008a). The

[29] Downscaling is a technique for building in local scale detail that is consistent with the global model output at a much larger spatial scale. 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 New Zealand with 0.05° latitude-longitude (approximately 5 km) boxes. This is more commonly

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 guidance manual MfE (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[30]. 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 Flood simulation modelling

Before considering the impact of new estimates of extreme rainfall and associated extreme flood flows on the Manaia River due to climate change, a peak flow estimation model for the Manaia catchment, as developed by Environment Waikato (2009), was applied to an extreme rainfall event that occurred on the 20-21 June, 2002. A flood hydrograph was constructed using information available in Environment Waikato (2009). Following simulation of the flood peak and construction of the flood hydrograph, a hydrodynamic model was used to simulate the inundation (See: Section 4.3). In the absence of rainfall and flow records within the Manaia catchment during this flood event, Environment Waikato previously assumed this rainfall event to be an extreme event of 90-minute duration[31] occurring once in every 100 years (Environment Waikato, 2009). Following this assumption, the rainfall event was estimated to be 58 mm h^{-1}, based on the High Intensity Rainfall Design Systems (HIRDS) software package that estimates the frequency of extreme rainfall anywhere in New Zealand (See: http://hirds.niwa.co.nz/). Next, based on flows at the Kauaeranga River flow recorder near to Thames Township, Environment Waikato developed an empirical equation to translate rainfall intensity into peak flow as well as a dimensionless unit hydrograph using flood hydrographs from actual flood events. Subsequently, these rainfall-to-flood hydrograph conversion methods were adopted in this study. They are described in more detail in the Memo File Number: Z21 S300 (Environment Waikato, 2009).

Based on a survey of eight first-hand observations of the flood extent and depth across the Manaia catchment in June 2002, it was found that our simulation of the peak flood resulted in less inundation than actually had occurred. This led to a re-evaluation of the original hydraulic model and the assumed rainfall return period, as well as a re-appraisal of the input

known as the Virtual Climate Station (VCS) network (Tait *et al*., 2006). There are approximately 11,500 grid-points over the New Zealand 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.

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

[31] The 90-minute duration is indicative of 'time of concentration' (i.e. the time it takes the farthest point within the catchment to contribute flows to the catchment outlet) for the Manaia Catchment (Environment Waikato, 2009).

tributaries. Subsequently, calibration of the peak flow model for Manaia resulted in: (i) the addition of Te Kapara Stream on the northern boundary of the catchment and (ii) the hind-casting of higher rainfalls[32] and subsequent flood flows to better match the inundation depths and extents surveyed. Note that while the actual intensity of the rainfall event was increased, the duration of the event, the rainfall to peak flow relationship, and the dimensionless unit hydrograph originally developed by Environment Waikato were maintained (Environment Waikato, 2009). It was thereby determined that a rainfall event of 77 mm h^{-1} and 90-minute duration, with a return period in excess of 200 years, was required to result in levels of inundation similar to those observed in June 2002. Further, as hydrological, soil, topographical and land cover information for Te Kapara catchment were unavailable, it was assumed that this catchment would behave similar to the neighbouring Tapa catchment. The constructed flood hydrographs for a rainfall event of 77 mm h^{-1}, and 90-minute duration at the Manaia catchment are shown in Figure 6.

Importantly, although the magnitude of a flood is often described using the peak water level or peak river flow rate during the flood, this is only a partial indicator of flood severity. The severity of inundation by floodwaters is also dependant on the volume of floodwater during the portion of the event when inundation takes place. For coastal-river reaches, inundation is strongly affected by sea-level, including tides and storm surge that impede drainage to the sea.

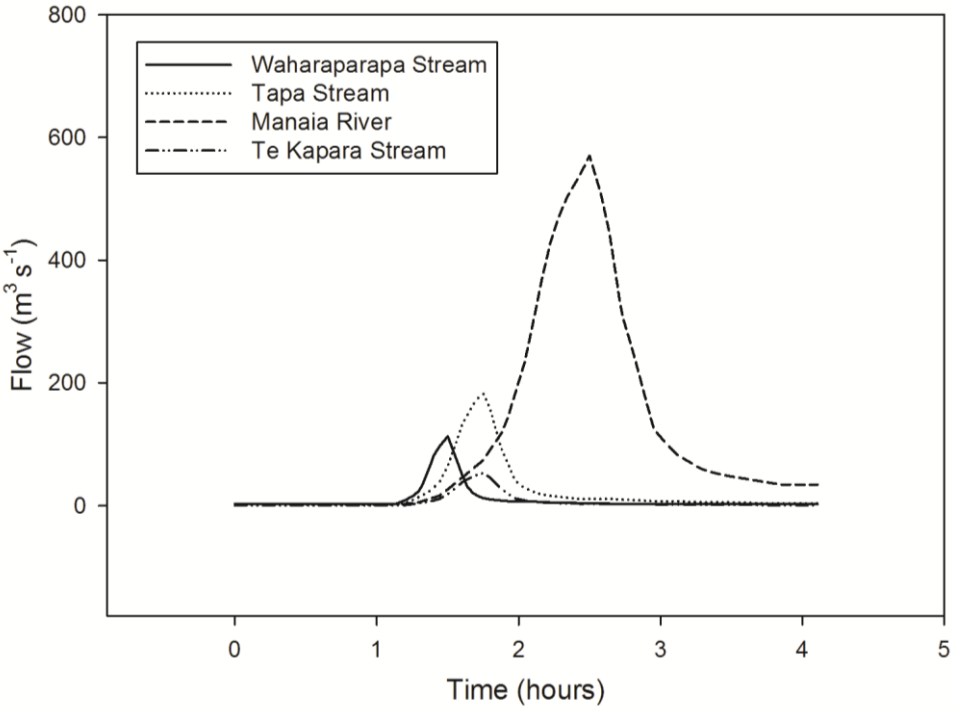

Figure 6: Flood flow hydrograph for a 90-minute rainfall event at Manaia.
(Adapted from: Environment Waikato, 2009)

4.3 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 of the Manaia catchment for 20-21

[32] The resulting changes in hind-cast rainfall were assumed to be constant across the entire catchment.

June, 2002[33]. Hydro2de is based upon a digital elevation model (DEM) which was constructed in this study using airborne laser survey data (LiDAR) captured by AAM Hatch for the Environment Waikato in September 2004. These data have a horizontal accuracy of 0.55 m and a vertical accuracy of 0.15 m. Test points had a vertical standard error of 0.102 m. The domain of interest for the Hydro2de flood inundation model was 2.08 km from west to east and 2.12 km north to south (Figure 7). However, the LiDAR data did not cover the whole of the domain of interest and so 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 LiDAR data were originally referenced to ellipsoidal heights and then converted into elevations in regard to mean sea-level (MSL) using the EGM96 geoid model. Conversion into a local datum (Moturiki 1953) was not possible at the time of initial data processing due to the lack of appropriate survey marks on the western shore of the Coromandel Peninsula. A 2-D flood simulation by Environment Waikato was based on an uncorrected DEM (Environment Waikato, 2009). To enable comparison of the results from our study with the work conducted by Environment Waikato, the Environment Waikato's uncorrected DEM was used for the modelling reported here, even though a corrected version is now available. This required an adjustment to the sea-level by raising it 0.39 m (which is the offset between Moturiki 1953 datum and LiDAR datum).

Inspection of the DEM used by Environment Waikato revealed that the lower river channel contained large variations in elevation. These variations were introduced by interpolating between LiDAR hits on the top of trees at the edge of the channel to points on the opposite bank (water was masked out in the data delivered). In our model these spikes were removed and the channel bed smoothed by interpolating between points of minimum elevation along the course of the river. Since no bathymetric data were available, interpolated minimum water surface elevations were used instead of actual bed elevations. Given the shallow depths and limited extent of the low flow channel and the relatively large depth (>3 m) of the flood flows to be modelled, this assumption is unlikely to materially affect maximum flood levels.

Hydraulic resistance assessment

Hydro2de requires an estimate of hydraulic resistance for each model cell (2 m x 2 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)[34]. The land cover in the domain was categorized with the z0 values assigned based on experience with other inundation 2D models of Canterbury braided rivers and the Buller River flood plain (See: Table 1) (Duncan and Hicks, 2001; Duncan and Shankar, 2004; Duncan and Bind, 2008). The boundaries between significant areas of each land cover type

[33] 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 effectually 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.,* 2012).

[34] 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. It uses a log-log relationship that makes flows insensitive to the choice of z0 value.

were digitized and appropriate values assigned to the cells in each cover type polygon[35]. For this study, it was assumed that there was no debris build-up on any piers that the SH25 Bridge may have. The effect of this assumption would be to decrease the depth and extent of inundation immediately upstream of the bridge. Note that SH25 crosses the flood plain and contains a number of culverts. The locations and dimensions of the culverts were obtained from the local people and were incorporated into the model. The total capacity of the culverts is very much lower than the floods that were modelled and most of the flood waters passed over the road.

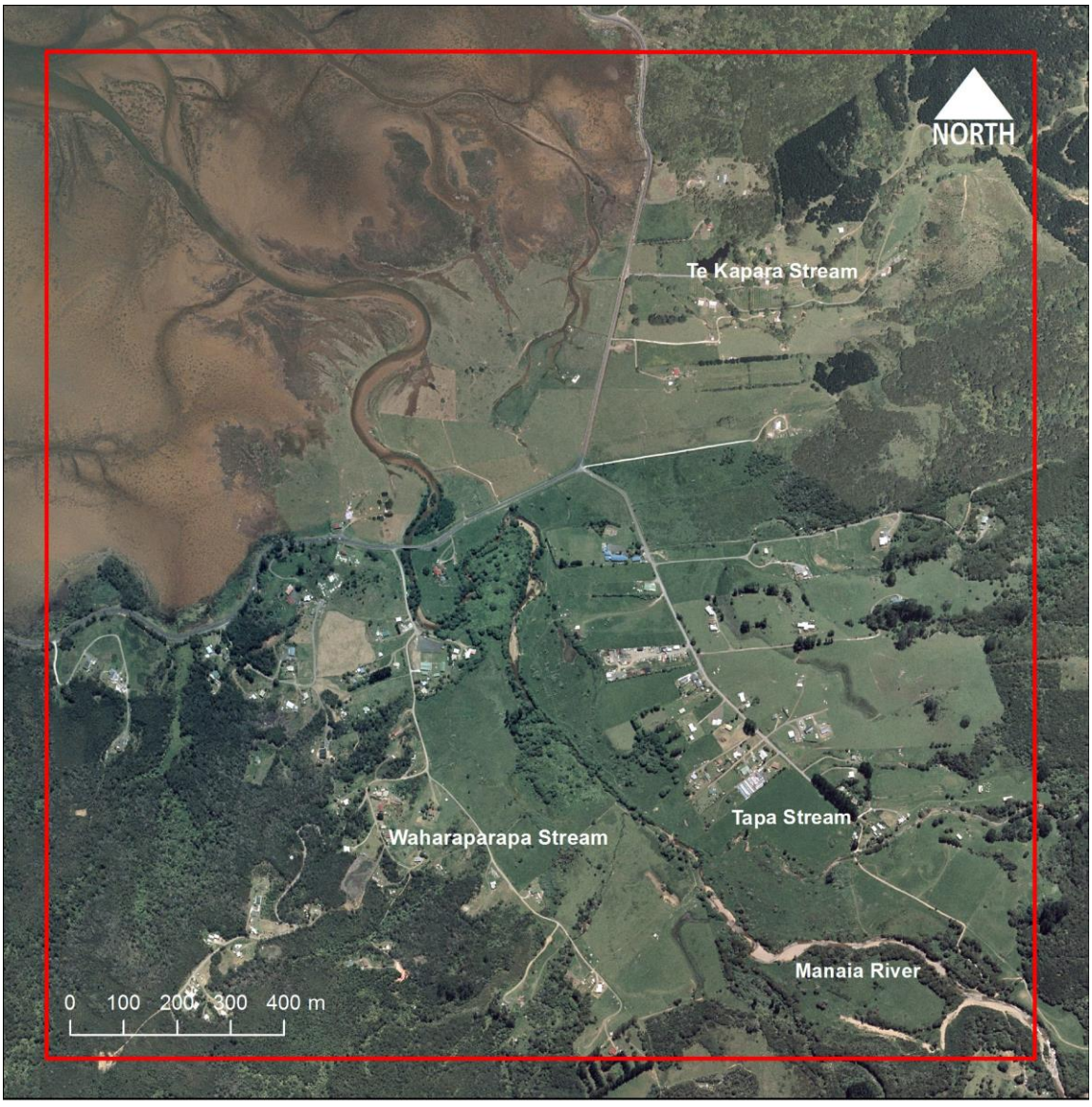

Figure 7: The red box shows the approximate extent of the flood model domain.

[35] Note that some polygons treated as homogeneous may not be so. That is, areas classified as pasture may have fences, hedges and individual trees or small groups of trees which would all increase roughness but which have not been taken into account.

Table 1: Hydraulic roughness values (z0).
Source: Smart *et al*. (2002), Smart (2004).

Cover type	Hydraulic roughness z0 (m)
Grass/meadow	0.015
River bed	0.01
Road	0.003
Town/scrub	0.05
High vegetation/trees	0.1

Incorporating baseline sea-level

The Mean High Water Spring (MHWS) level exceeded by 10% (MHWS-10) of all high tides was used as a baseline to determine the downstream water levels at the coastal-river reach boundary of the Manaia catchment[36]. This approach is similar to the mean high water spring tide level used by Environment Waikato (Environment Waikato, 2009). For the greater Thames/Hauraki area, the MSL Datum (Tararu Vertical Datum-1952 [TVD–52]) was derived from tide records during 1922-23 from a gauge off Tararu in the southern Firth of Thames and corrected with concurrent measurements from the Port of Auckland gauge[37]. Gauge Zero for the current sea-level gauge off Tararu (1992-present) is set to TVD-52. Relative to TVD-52, the MHWS-10 for Manaia based on astronomical tides for current sea-level is 1.6 m (Table 2). However, this figure was adjusted by +0.39 m (which is the offset between the Moturiki 1953 datum and the LiDAR datum) to enable comparison of the coupled modelled inundation results based on the Environment Waikato's uncorrected DEM.

Table 2: High-water tide levels for Tararu. 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 gauge zero and TVD-52 (m)	Relative to MLOS (m)	Relative to AVD-46 (m)
HAT	1.98	1.88	2.11
MHWPS	1.84	1.74	1.97
MHWS1	1.90	1.80	2.03
MHWS10	1.70	1.60	1.83
MHWSn	1.59	1.49	1.72
MHWNn	1.22	1.12	1.35

[36] This 'everyday' tide level at Manaia is governed largely by a combination of the twice-daily lunar tide (M_2) and the effect of the Moon in its perigee (N_2) as it travels in an elliptical orbit around the Earth each month
[37] Auckland Vertical Datum 1946 (AVD-46) was established as the mean sea-level (MSL) at Port of Auckland from 7 years of sea-level measurements collected in 1909, 1917–1919 and 1921–1923. MSL (AVD-46) is +1.743 m relative to tide gauge zero at Port of Auckland, which equals chart datum.

MHWAN	0.97	0.87	1.1
Min HW	0.83	0.73	0.96

Model calibration

The inundation model developed for this study was calibrated to the June 2002 flood, using eight referenced observations of flood extent and flood depth provided by local residents that were present during the peak flooding that occurred over 20-21 June 2002 (Figure 9). In short, these points were identified on the DTM and the water depths at those locations were confirmed in the model.

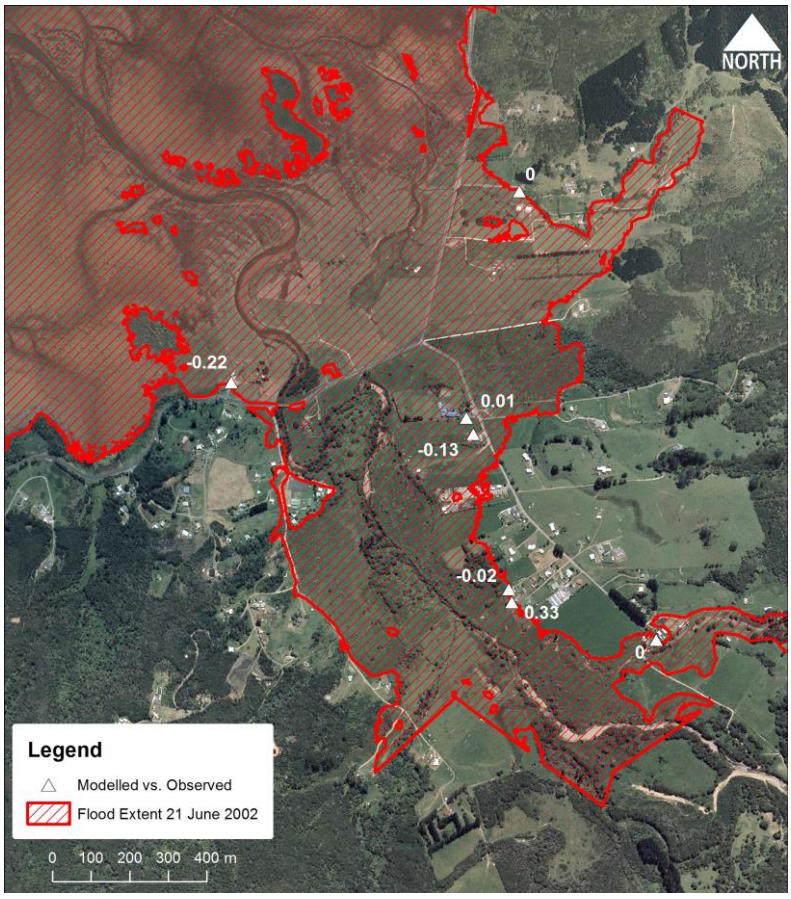

Figure 9: Calibration model results map and surveyed points across the extent of the model domain. Values on the map show differences between modelled depth and eyewitness reports. Positive values indicate points where the modelled depth was greater than the observed depth.

Note that using the hydrographs originally provided by Environment Waikato (2009) we were unable to calibrate the model to the extents and depths identified by local residents and therefore the flood flows were increased to achieve calibration (as described above). Further, this inundation model differs from the Environment Waikato model (Environment Waikato, 2009) in that the tributary to the north-east of the model domain, known as Te Kapara Stream, was also modelled to make the flooding more complete. For Te Kapara Stream the flood flows were increased in proportion to the neighbouring Tapa Stream. We are 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 authors thereby consider that the hydrodynamic model calibration is as good as can be achieved given the uncertainty in the peak flood flows and rainfall event characteristics (i.e. size, duration), the unknown quantity of debris on the bridges, and the observed flood levels[38].

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 main river and in the tributaries. There is also uncertainty about the modelled hydrograph shape as it is based on a constant rainfall intensity falling uniformly over 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 accurate LiDAR measurements, but there is uncertainty about the river bed levels for two reasons. Firstly, the LiDAR did not measure ground levels under water and secondly, the elevation data in the lower river where willows overhung the river appeared anomalous. Both issues were addressed and 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 cover types. Some polygons may not be homogeneous, e.g. areas classified as pasture may have fences, hedges and individual trees or small groups of trees which would all increase roughness but which have not been taken into account. There were no measurements of the size surface bed material in the river on which to base hydraulic roughness measurements and a uniform size of bed material was assumed. In reality bed material size would decrease between the outlet from the hills and the estuary.

(iv) Uncertainty about the ground cover at the time of the June 2002 flood as the cover was taken from recent aerial photographs. This could affect the hydraulic roughness of the flood plain through 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 Manaia River estuary 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 extensive Manaia River estuary.

(vi) Uncertainty surrounding some of the flood levels and locations as recalled by residents from across Manaia. Some recollections were based on evacuations during peak river

[38] 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.

flows in the early hours of the morning contrasted with others whom noted changes hours during daylight hours. Consequently, there is more confidence in some levels than in others regarding peak flood levels and extents.

4.4 Estimating climate change induced flooding

Downscaled climate projections for New Zealand indicate that extreme rainfalls[39] 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, sea-level rise is expected to increase base levels for coastal river reaches, and so, such a factor also needs to be considered when looking at estimations of 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)[40] 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[41].

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

Projected increases in annual maximum, mean and minimum surface temperatures for the Waikato region were obtained for 2040 and 2090 AD, for the respective A2 and B2 climate change scenarios (See: Table 2 and 3 - MfE, 2010). These temperature changes were then used to derive new climate change induced extreme rainfall figures based on a maximum 8% change in extreme precipitation for each 1 degree Celsius of temperature change (MfE, 2008a; Carey-Smith *et al*., 2010)[42]. By applying these temperature and precipitation changes, revised 90-minute duration 100-year return-period rainfall events were determined under each climate change scenario for 2040 and 2090 AD conditions. Table 3 shows the maximum, mean and minimum percentage changes in temperature (T) and rainfall (R) due to climate change for the Manaia catchment as well as the resulting peak inflows (P) for each sub-catchment for the A2 and B2 emission scenarios for 2040 and 2090 AD. The new estimates of rainfall due to climate change range from an increase of 2.4 to 37.6 % while the future peak flood flows across the four tributaries for the Manaia catchment range from a minimum to maximum increase of 1.62 to 34.7%. New hydrographs depicting future peak flood flows (i.e. the amount of water flowing in the river) for the four tributaries for the Manaia catchment for the different climate change scenarios are shown in Appendix A and B.

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

[40] The manual provides best practice information and guidance for integrating climate change into flow estimations for each region of New Zealand.

[41] 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).

[42] The current standard guidance for councils and engineers in New Zealand 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 New Zealand 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.

Table 3: Climate change induced 90-minute duration rainfall and peak flow statistics for Manaia – Waikato for 2040 and 2090 AD. Note that no return period statistics were computed for these rainfall events. T=Temperature. R=Rainfall. Min=Minimum. Max=Maximum. ↑=Increase. M=Manaia. T=Tapa. W=Waharaparapa. TK=Te Kapara.

Scenario	**T (°C) ↑**	**R (mm/hr) 90-min**	**R (%) ↑**	**Peak flow (m^3s^{-1})**				**Peak flow (%) ↑**			
				M	T	W	TK	M	T	W	TK
Current climate		77.0		570.0	183.0	113.0	53.0				
A2 Min - 2040	0.4	79.5	3.2	586.4	187.7	116.5	54.6	2.9	2.6	3.1	3.0
A2 Max - 2040	2.0	89.3	16.0	659.1	211.0	130.9	61.3	15.2	14.9	15.4	15.2
A2 Mean - 2040	1.1	83.8	8.8	618.2	197.9	122.8	57.5	7.3	7.1	7.5	7.3
B2 Min - 2040	0.3	78.8	2.4	581.8	186.2	115.6	54.1	1.9	1.6	2.1	1.9
B2 Max - 2040	1.4	85.6	11.2	631.8	202.2	125.5	58.8	10.6	10.3	10.8	10.7
B2 Mean - 2040	0.8	81.9	6.4	604.6	193.5	120.1	56.3	5.5	5.2	5.7	5.6
A2 Min - 2090	1.0	83.2	8.0	613.7	196.4	121.9	57.1	7.2	6.9	7.4	7.3
A2 Max - 2090	4.7	106.0	37.6	781.9	250.3	155.3	72.8	34.5	34.3	34.7	34.7
A2 Mean - 2090	2.5	92.4	20.0	681.8	218.3	135.4	63.4	14.3	14.1	14.4	14.3
B2 Min - 2090	0.7	81.3	5.6	600.0	192.1	119.2	55.8	4.4	4.2	4.6	4.4
B2 Max - 2090	3.3	97.3	26.4	718.2	229.9	142.6	66.8	24.7	24.4	24.8	24.7
B2 Mean - 2090	1.8	88.1	14.4	650.0	208.1	129.1	60.5	11.1	10.9	11.3	11.2

Incorporating sea level rise projections

The influence of climate induced sea-level rise (SLR) on peak flood levels and flood extents across the Manaia catchment were incorporated for 2040 and 2090 AD using mean SLR projections of 0.4 m and 0.8 m, respectively (MfE, 2008b). Again, using MHWS-10 as the baseline this resulted in future sea-levels of 2.39 m by 2040 and 2.79 m by 2090 above TVD-52 (Figure 10). 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)[43]. Please note that while large sea-level rise 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).

[43] The MfE guidance recommends for planning and decision timeframes out to the 2090s (2090–2099): (i) a base value sea-level rise 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 sea-level rise 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.

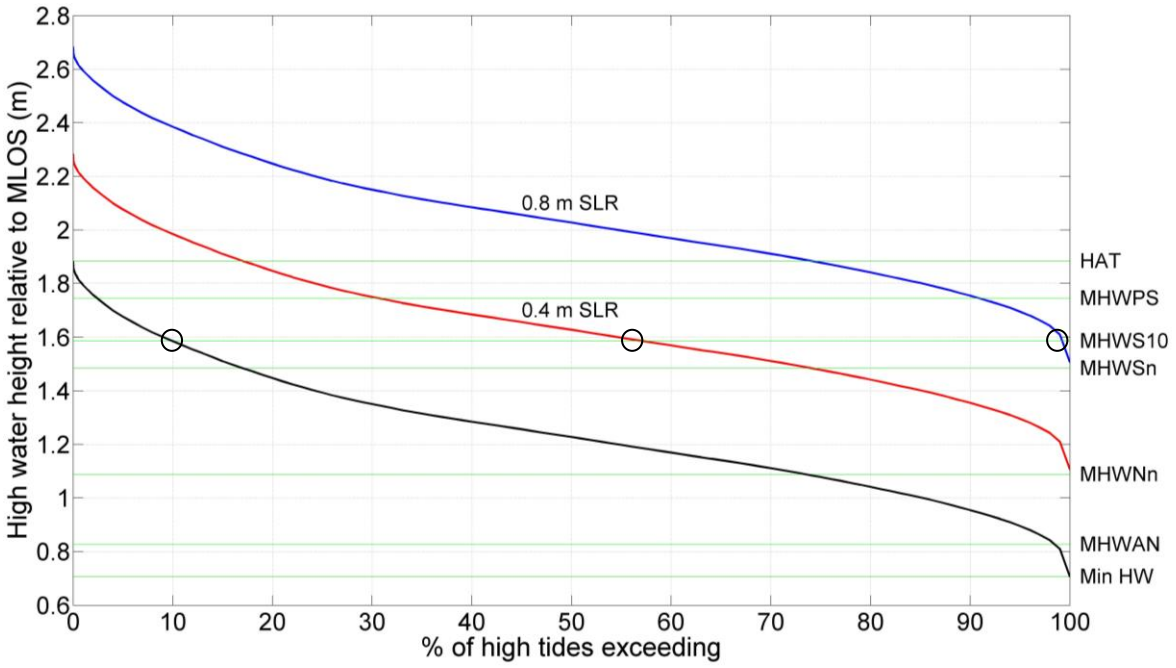

Figure 10: Cumulative high tide exceedance plot for the nearest tidal recorder at Tararu - Thames. This is based on predicted astronomical high-tide levels and excludes non-tidal components such as storm surge, wave set-up and run-up. High-water heights are relative to the mean level of the sea (MLOS). Note that the present MHWS-10 level of 1.6 m (exceeded by 10% of all high tides) would be exceeded by 57 % of all high tides with a 0.4 m SLR - see circles where it intersects the present MHWS10 line and exceeded by 100% of all high tides once sea-level rise exceeds ~0.7 m, leaving aside any long-term morphological change.

5 Projected sea-level rise and river flooding

This section presents the mapping results from our assessment of (i) projected sea-level rise impacts for 2040 and 2090 AD under mean river flow conditions, 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 surrounding the upper Manaia Harbour under current high tide levels (defined as the level exceeded by 10% of all high tides - MHWS10) as well as the corresponding sea-levels for 2040 AD and 2090 AD with an assumed 0.4 m and 0.8 m sea-level rise respectively, are shown in “time-lapse” format in Figure 11. As detailed in Section 4.3, these adjusted water levels were incorporated into a coupled river-coast flood inundation model under ‘current’ average river flows. These ‘everyday’ river flows are not expected to significantly affect tide levels or flooding, so the scenarios primarily show the effect of changes in sea-level alone. Note that a rise in river-bed level due to sedimentation near the coast that would likely accompany a general rise in sea-level was not included. Further, while large sea-level rise 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.

Under current conditions, MHWS10 tide inundation is mostly limited to local depressions and old river channels. However, it is evident that an increase in sea-levels of 0.4 m by 2040 AD would result in broader areas of coastal marsh and pasture land being inundated by the ocean more frequently (i.e. the present MHWS-10 level of 1.6 m which is exceeded by 10% of all high tides will by 2040 AD be exceeded by 57 % of all high tides. See: Figure 10). In the southern extent of the modelled domain, tide extents are projected to increase slightly between current conditions and 2040 AD with more pronounced increases indicated between 2040 and 2090 AD. Meanwhile, in the central and northern parts of the harbour comparatively larger impacts are indicated, with large areas of farm-land subject to frequent high-tide inundation by the end of the century (i.e. the present MHWS-10 level will be exceeded by 100% of all high tides once sea-level rise exceeds ~0.7 m, notwithstanding any long-term morphological change. See: Figure 10). Consequently, by 2090, the large expanse of currently stable, dry land in the lower reaches of the Manaia River would be in the future tidal zone under the scenario considered here. Furthermore, it is evident that the future MHWS10 tide extent under this scenario would propagate a considerable distance further inland and thereby reach (and possibly exceed) the current position of SH25 north of Te Kapara Stream. In summary, the most notable change from this modelling exercise is the projected gradual and on-going encroachment of coastal land – particularly areas seaward of State-Highway 25 between 2040 and 2090 AD.

Note that higher tide levels due to storm-tide conditions (i.e. the combined effect of storm surge[44] coinciding with a high astronomical tide) were not included in this analysis and therefore greater inundation extents and depths than those shown are possible. Further, no

[44] In New Zealand, changing atmospheric pressure is typically the dominant cause of storm surge, but adverse winds (westerly quarter for Manaia) can also cause a local increase in sea-level. The 1% AEP storm-tide level calculated for the present-day was 1.9 m above the TVD-52.

account has been taken of the effect of on-going coastal erosion or sedimentation on tidal extents or water depths over the next century. The interplay of these drivers of coastal change will influence future tidal extents and inundation.

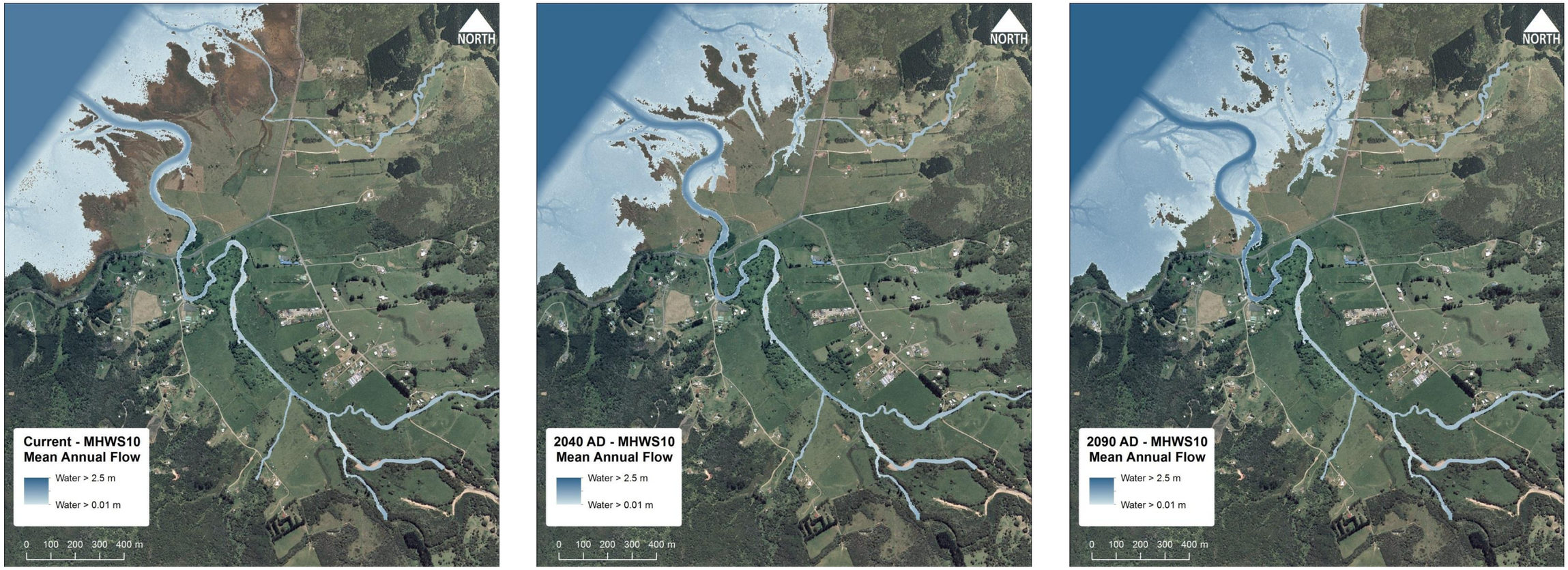

Figure 11: Mapping sea-level rise at Manaia – Waikato, New Zealand. Changes in coastal inundation depth and extent under mean annual river flow conditions are shown for current (present-day) conditions for the projected higher sea-level scenarios for 2040 and 2090 AD described in the text.

5.2 Extreme flooding

Inspection of the modelled extreme flood conditions for the Manaia coastal-river reach (which includes 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 overall minimal differences in projected flood inundation extents and extreme water levels when compared to the June 2002 reference flood event. The full range of modelled inundation extents and associated extreme water levels statistics for Manaia Bridge, Manaia School and the Manaia Mussel Depot for the 2040s and 2090's under A2 and B2 climate change scenarios are presented in Table 4.

Given the overall similarity of these results across full range of scenarios, the following analysis and interpretations are based on our modelling of the mean A2 and B2 climate change scenarios only. Extreme coastal-river-reach flood extents and depths for June 2002 and corresponding extreme flood conditions for the 2040s and 2090's under 'mean' A2 and B2 climate change scenarios for the Manaia coastal-river reach are presented in Figures 12 and 13, respectively. Additional figures of projected extreme inundation under the minimum and maximum A2 and B2 climate change scenarios for 2040 and 2090 AD are provided in Appendix C and D. Please note that while the results between the A2 and B2 scenarios indicate minimal projected differences in extreme flood extents and depths, the authors nonetheless maintain that exploring different scenarios that span different future possibilities is a valuable exercise that might result in different outcome is different locations.

The mean A2 and B2 scenario results both show that the projected inundation extents for 2040 and 2090 AD are unlikely to differ markedly from the inundation extents experienced during the ~200 year extreme flood event that occurred on the Manaia River in 2002. This outcome is particularly noteworthy because in spite of the minimal changes in flood extent depicted in Figures 12 and 13, the estimated future peak flood flow for the Manaia River for 2090 AD under the mean A2 climate change scenario was some 14 % greater than that modelled for the 2002 flood event[45] (See: Table 3). These initially perplexing results are largely due to (i) 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[46], (ii) the width of the floodway is very large and thereby any increase in extreme flood flows and associated higher water levels appear to be well accommodated by this expanse, and (iii) the scale of the map can also influence our interpretations of the overall magnitude of change as relatively small changes in flood extent can be difficult to discern on such small scales. Accordingly, Figure 14 shows a cross-section of extreme flood levels between the Marae and the northern hills behind Manaia School for the 2002 reference event and the modelled peak inundation levels for 2040 and 2090 AD under the A2 (mid-high) climate change scenario (depicted as a black dotted line in Figures 12 and 13). It is evident from this cross-section that the flood levels in 2040 and 2090 AD are marginally higher than those in 2002, although the Marae remains some 1.5 m above the highest modelled water levels, so a reasonable freeboard can be said to exist. However, on the other side of the river, the situation is quite different. Manaia School is located in an area that was inundated by more than 0.5 m of water in 2002 and it is expected that floods of corresponding character in 2090 AD will add at least another 0.1 m of depth to flood water levels.

[45] Incidentally, the estimated future peak flood flow for 2090 AD under the maximum A2 climate change scenario increased by more than 30 %.

[46] In other words, where land is flatter there are likely to be larger differences in extent between floods of different sizes and different sea-levels; and, where the terrain is steeper the changes in extent are likely to be negligible.

Table 4: Modelled inundation extents and extreme water levels for the Manaia coastal-river reach for the 2040s and 2090's under minimum, mean and maximum A2 (mid-high) and B2 (mid-low) climate change scenarios. Δ % = Percentage change from base flood June 2002.

Scenario	Inundation extent (m^2)	Δ %	Manaia Bridge (depth m)	Δ %	Manaia School (depth m)	Δ %	Mussel Depot (depth m)	Δ %
Base flood June 2002	2047192		3.47		0.65		0.33	
A2 Min - 2040	2058160	0.53	3.48	0.29	0.69	5.80	0.34	2.94
A2 Max - 2040	2079996	1.58	3.53	1.70	0.73	10.96	0.41	19.51
A2 Mean - 2040	2068740	1.04	3.50	0.86	0.70	7.14	0.37	10.81
B2 Min - 2040	2056308	0.44	3.48	0.29	0.66	1.52	0.34	2.94
B2 Max - 2040	2071820	1.19	3.51	1.14	0.71	8.45	0.38	13.16
B2 Mean - 2040	2065000	0.86	3.49	0.57	0.71	8.45	0.36	8.33
A2 Min - 2090	2089932	2.05	3.49	0.57	0.72	9.72	0.36	8.33
A2 Max - 2090	2125912	3.70	3.59	3.34	0.83	21.69	0.50	34.00
A2 Mean - 2090	2105544	2.77	3.54	1.98	0.75	13.33	0.42	21.43
B2 Min - 2090	2086284	1.87	3.49	0.57	0.70	7.14	0.36	8.33
B2 Max - 2090	2112776	3.10	3.56	2.53	0.78	16.67	0.45	26.67
B2 Mean - 2090	2098444	2.44	3.52	1.42	0.72	9.72	0.40	17.50

Notwithstanding these qualifications, small differences can still be seen in the extent of dry 'islands' around the normal shoreline and around the eastern boundaries of the model domain near to Goldfields Road. Further, the modelling for both 2040 and 2090 AD under the mean A2 and B2 climate change scenarios indicates that the river terrace on which most of the residential houses are built is well-chosen, as it is elevated above the surrounding flood plain. Similarly, the modelling suggests that the Marae would remain free from inundation for an event equivalent to the June 2002 flood in the Manaia River under both of the climate change scenarios assessed. However, flooding of the area surrounding Manaia School and the Marae could be adversely affected by backwater effects associated with the build-up of debris in and around the SH25 Bridge. Severe build-up of debris also has the potential to raise water levels, exacerbating existing erosion problems and increasing risk to these structures and people within. However, due to the wide extent of the floodplain, it is unlikely that the flood-levels will rise more than a few tens of centimetres. Results also show that lower lying properties and infrastructure (includes some occupied and unoccupied *whaanau* homes, storage buildings, fencing and sections of Goldfields Road and Manaia Road) are at greater risk of inundation and resulting flood damage under both the B2 and A2 scenarios in 2040 and 2090 AD given the expectations for slightly higher peak flood levels and possibly

increased flow rates. These heightened risks extend to farm-stock (sheep and cattle) that sometimes graze the lower plains of the Manaia.

Finally, please note that 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.

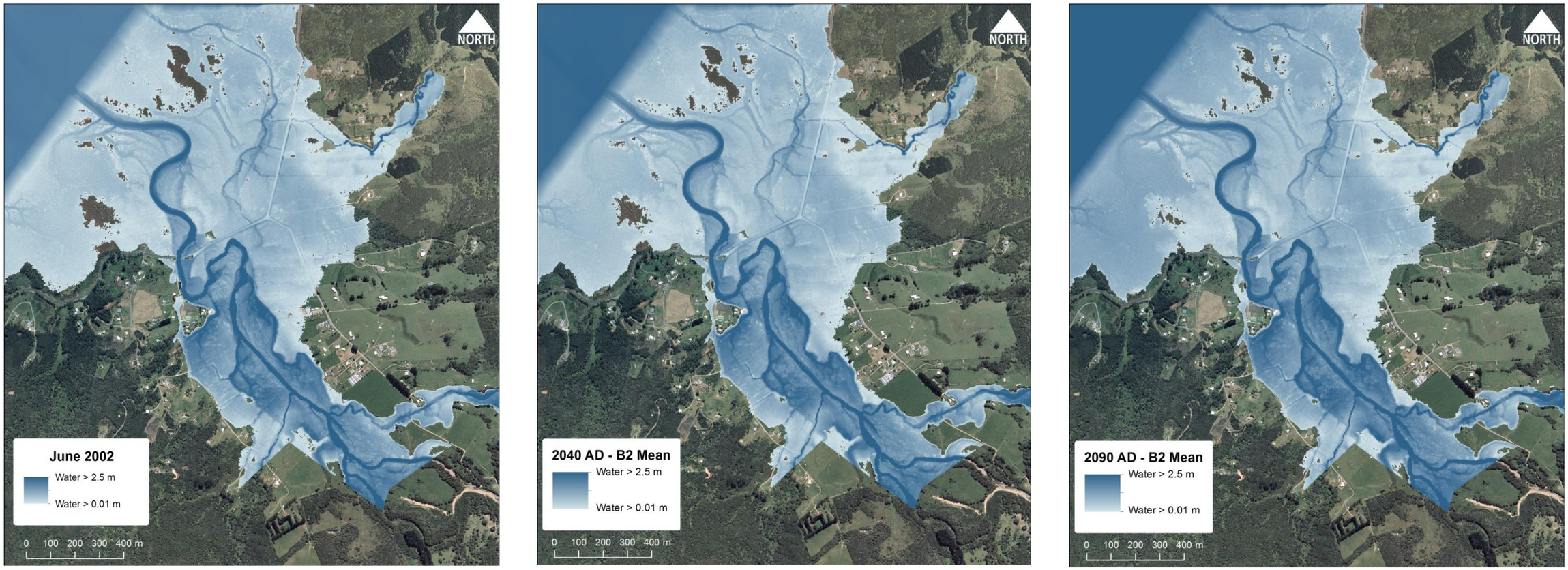

Figure 12: Modelling climate change induced coastal-river reach flooding for 2040 and 2090 AD at Manaia under the B2 ‘mean’ climate change scenario and sea-level rise scenarios as described in the text.

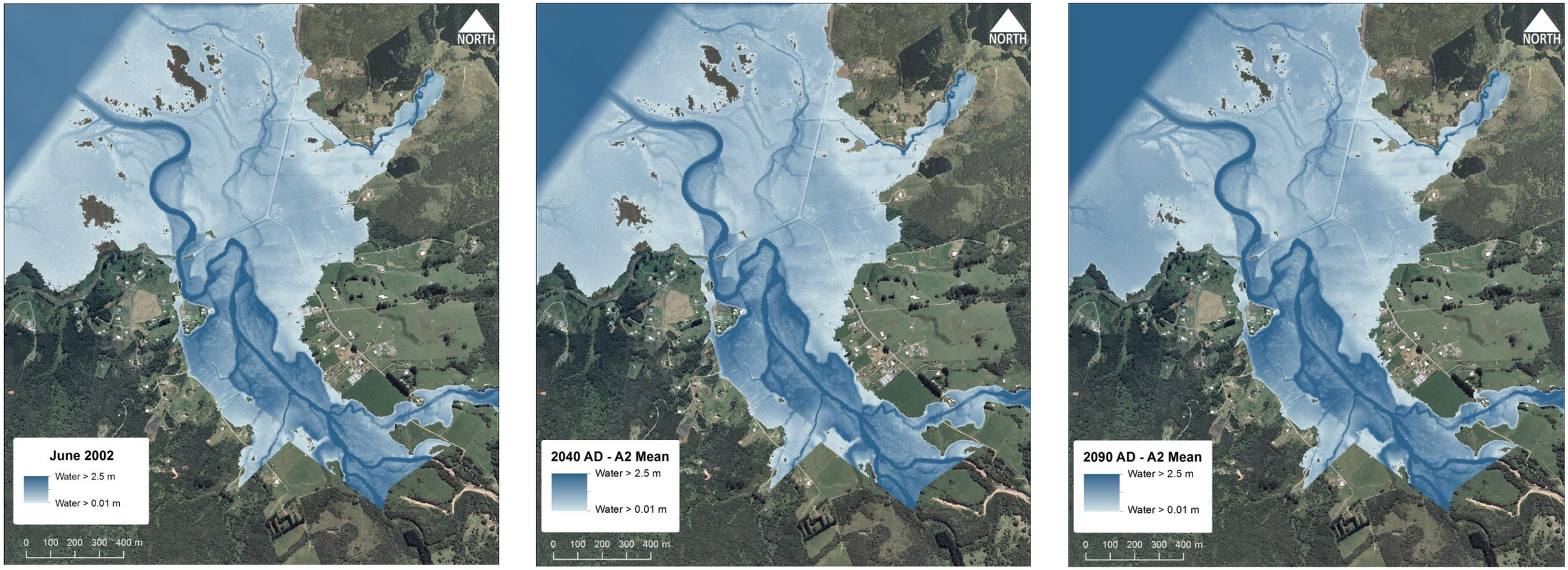

Figure 13: Modelling climate change induced coastal-river reach flooding for 2040 and 2090 AD at Manaia under the A2 ‘mean’ climate change scenario and sea-level rise scenarios as described in the text.

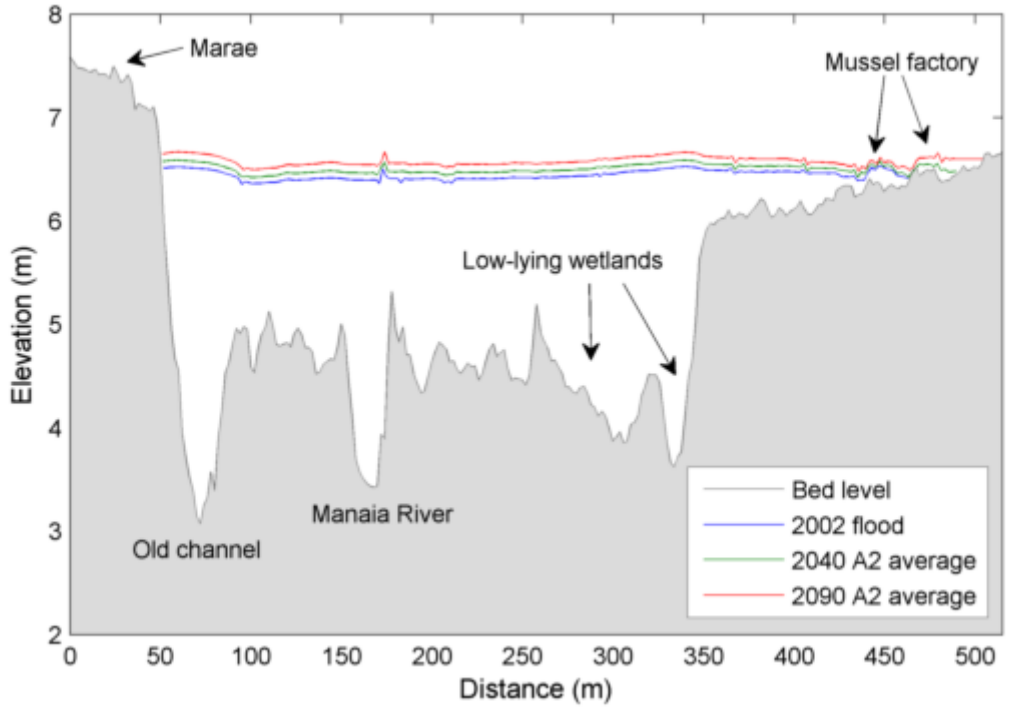

Figure 14: Cross-section of the river showing flood levels between the Marae and the northern hills behind the Mussel processing depot.

Cautionary remarks

(i) Flood flow peaks are sensitive to the rainfall intensity pattern during a storm. Subsequently, even if a storm rainfall total were the same as the June 2002 storm the flood peak could be larger if the rain were more intense.

(ii) Flood size is affected by the antecedent conditions. That is, a repeated sequence of storms over a region, which saturate the soil and fill surface depressions, can produce a flood larger than expected for a given rainfall duration and intensity.

(iii) Increases in rainfall intensity can lead to increases in erosion, and when the eroded material is delivered to the river system it may lead to changes in river channel shape and position, and consequent changes in the likelihood of inundation.

(iv) Higher sea-level is expected to produce a flatter river gradient near the coast. This would lead to a reduction in the velocity of floodwaters in the river channel, likely encourage silting and aggradation and further restrict river conveyance. Numerical modelling would be required to quantify such changes.

Please note that in spite of these cautionary remarks the scenario results are based on the best available information and provide valuable formats for considering climate-induced coastal changes and associated risks.

6 Qualitative research methods

This section provides details of the range of qualitative research methods used in the first phase of this project to gather information about the contemporary social and environmental conditions at Manaia. 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. This 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* Maaori (See: Section 3.3).

6.1 Group-based interviews

Open and semi-structured group interviews were conducted at Manaia School on the 16th October 2010. A total of 18 'home-people' were interviewed over 2 group sessions (~9 per group) – each interview session lasting between 3-4 hours. The interviewees comprised a mixture of *kaumaatua* [elders (plural) – not gender specific] and *rangatahi* [young people] – some of whom were invited by the Ngaati Whanaunga project manager and others who were self-selected following an initial project-overview meeting on the evening of 3rd September 2010[47] and a 'Nga-Iwi-FM' Radio interview to advertise the project on 12th October 2010. The interviews were guided by two facilitators and supported by two Manaia School students who transcribed participant responses.

All group interviews began with a *mihi-whakatau* [welcome speech – this included a restating of the project objective] and round-table introductions to better understand community dynamics and *whakapapa*. The interviews were guided by a broad set of vulnerability-based (includes adaptive capacity and endurance) 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[48] and themed prioritisation exercises. At the end of each session the interviewees were invited to identify any absent *whaanau* members who they believed should be asked to participate in the project. All interviews were electronically recorded and transcribed in full by a professional Maaori-English transcription service.

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 interviewees can react to ideas and build-off of each 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 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, personal characteristics. To supplement this research method, the

[47] Approximately 20 people attended this evening meeting.

[48] Interviewees were encouraged to annotate 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.

research team additionally sought to interact with key community members or residents representing different perspectives on an individual basis (see Section 4.2)[49].

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[50]. 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 conducted within the private homes of informants during the 21st-22nd October 2010 and on the 28th October 2010. A total of 14 home-people (including 3 interviewees from the group sessions) were interviewed. These interviewees comprised *kaumaatua* and *pakeke* [adults] and were selected by the Ngaati Whanaunga project manager based on inter-generational experiences and relationships with Manaia settlement. Note that most of these interviewees 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. The sessions lasted between 1-2 hours and were attended by two NIWA facilitators and the community project manager. All interviews were electronically recorded and transcribed in full. This method of data collection resulted in a considerable quantity of raw data being gathered.

A second round of semi-structured interviews was conducted on 31st May, 2012 to survey the extent and depth of flooding that occurred on 20-21 June 2002. Eight home-people shared their flood experiences (only one of whom was involved in the first round of interviews) and this involved walking the land on both sides of the Manaia River. The information provided to the team resulted in invaluable reference points to calibrate the flood modelling to the June 2012 flooding and to model future climate change induced flood scenarios.

Finally, a third round of semi-structured individual (and paired) interviews was conducted within the private homes of informants as well as within the offices of Ngaati Whanaunga Incorporated Society during the 9th–10th September 2012. A total of twelve home-people were interviewed, nine of whom were involved in the first round of interviews. These interviewees comprised *whaanau* purposefully identified by the Ngaati Whanaunga 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 interviewees during the first round of interviews as well as new questions that emerged following the analysis of specific interview transcripts.

[49] Note 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.

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

This final process permitted the research team to ensure that our interpretations had accurately captured the expressed insights and concerns of interviewees during the first round of interviews - otherwise adjustments were made. Furthermore, it provided an opportunity to deepen our understanding of *whaanau*/community realities. Interviews lasted between 1-2 hours. This visit also provided an opportunity to present maps illustrating future climate projections and possible impacts of sea-level rise and inundation across Manaia. It also afforded an opportunity to explore *whaanau* perceptions of future risk.

Overall, the individual interviews conducted in this study provided comprehensive information about 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 more potential for undue emphasis to be placed on issues specific to the individual. This realisation underpinned the decision to use multiple methods for information-gathering whereby differing techniques can complement one another.

6.3 On-land walks and observations

On-land walks and observations were made on successive visits to Manaia – 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 and river-way occurred on 31st May, 2012 during which eight whaanau shared their direct experiences of the June 2002 flood event. This included identifying flood depths and inundation extents. The information gained through this action was supplemented by field notes taken by other members of the research team. A photo gallery is provided in Appendix E.

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). 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 Manaia.

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 with *te hau kainga*. 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 *whaanau* from across the community may bias the views contained in this work is left for the reader to determine.

7 Climate vulnerability and endurance at Manaia

This section comprises the results derived from the analysis of individual, paired- and group interviews with community members from Manaia 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 in Section 2.3. 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. 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 2012.

7.1 Climate-coastal hazards and risks

Discussions surrounding the nature of climate-induced coastal hazards that *whaanau* and individuals have to deal with in and around the settlement of Manaia (includes the Manaia Harbour), were dominated by references to river flooding and associated storm events. High-winds and increasing landslide occurrence were also identified including linkages with river erosion, changing river courses and widespread sedimentation that has occurred across the entire Manaia catchment. A number of community members also acknowledged increasing coastal erosion (and land-loss) due to storm surge and large waves around the mouth of the Manaia Harbour. To a lesser extent, drought and the accompanying impacts of lower river levels, drying springs and fire risk were also identified. Contextual details are provided in the narratives below.

High rainfall and flooding

On questioning interviewees about the nature of climate related coastal hazards that *whaanau* and individuals face in and around the settlement of Manaia, there was an overwhelming acknowledgement of the danger posed to the community from high rainfall, river/coastal flooding[51] and coincident high-tides. The consistency of response in identifying flooding as the principal hazard issue facing the community (and in particular, *whaanau* living in homes located on the flood-plain) is based on a mixture of direct (and repeated) *whaanau* experience with flood impacts[52] as well as the historical effort and attention given to local flooding issues through the years (see: Section 2.3). For instance:

> *"There was a young fella up here by the side of the river. He went to open his door and the flood was up against it so his wife opened the window and they threw a blanket on the orange tree next to the window, the wife got out, in water,*

[51] When focus group interviewees were asked to "list their top four climate-coastal hazards" flooding was the only hazard to be identified by all interviewees.

[52] Such topics of conversation also prompted one *kaumātua* to reflect on how the old-people would respond to drowning: "…the home people would race around getting a fire going, that was the resuscitation method, get the smoke on and then dangle the person over the smoke and then shake hell out of them to brake the water and then take him off and have a breather, then put him back on and do it a second time" (21 October, 2010).

and the husband handed her the children and they put them on to the orange tree until he got out and he knew which side of the road to go to so he wouldn't disappear and he walked out with his kids. Now, they lost everything" (16 October, 2010).

"Flooding is a big issue for our community. From the Manaia bridge to the end of the stream - waipuke katoa [flooding everywhere]. The worst part about it, our children use the marae as a school room every day and the footpath that they've got from the Manaia Bridge to the corner is below the level of the road" (20 October, 2010).

"I would say floods - that's the worst. It takes away the banks and it brings the big trees and logs from the mountains that block up the creeks and rivers and causes big floods on the main road. It does it all the time and also blocks up all the drains. And then the tide comes in and SH 25 is covered in water. You can't get through" (21 October, 2010).

"[There is one house] …smack bang in the middle of a creek…Yeah [she's] got some good stories to tell, [she's] seen logs come right across her paddock" (21 October, 2010).

There was also consensus amongst interviewees that flooding on the flat land in and around the settlement of Manaia is a relatively frequent occurrence, with up to three to four flood events crossing SH25 each year and at least one of those flood events rising too high for large vehicles to pass. Furthermore, some of the *whaanau* interviewed considered that the frequency and magnitude of floods in the area is also changing in association with more variable and unpredictable weather and climatic conditions. Some of these exchanges are captured in the statements below:

"I grew up in Manaia…and every August we had these big floods. Now it's not August, it's anytime..." (16 October, 2010).

"All the severe storms we've had with flooding are usually from the south-east quarter… It's changed. I don't know, the wind was the south-east but now we have the prevailing winds really on the south-west side, and that's the cold bugger… That's when people get rheumatism. I know when it's going to rain. I listen to the forecast but this [rheumatism] is more accurate than that" (21 October, 2010).

"Talking about the weather pattern it has changed. I've noticed it here in Manaia… Going back about 20 years ago the rain used to come and go - but now it's happening more often" (21 October, 2010).

"I'd say that on average the floods would cross the road about 4 times a year and in that time I'd say once a year it'd be what I'd consider a high flood where you couldn't drive through with a 4WD vehicle." (28 October, 2010).

In association with these observed changes, many of the *whaanau* demonstrated an in-depth understanding of the hydrology of the Manaia River-Harbour system, with discussion ranging from rainfall/flood-flow travel times, to changes in river courses and estuarine channels, to areas (and specific people) regarded as higher risk and more susceptible to flooding. Many of the interviewees also recognised the linkage between high river levels and the tidal

movements of the Manaia Harbour (and the associated risk to people). At least half of the interviewees emphasised the importance of closely monitoring tidal movements during heavy rain, noting that the combination of high rainfall (whether in the lower or upper reaches of the catchment) and high tides will almost always result in a flood event. Some key commentaries that illustrate this understanding are conveyed in the following statements:

> *"We used to run through the paddock there. That never used to be the river" (20 October, 2010).*
>
> *"[The road was flooded] until the next day, 'til the tide went back down and it stopped raining. It rained all night. It started in the afternoon and then in the morning it was flooded, especially with the tide being high. And traffic couldn't come through to Coromandel and Thames it was blocked off for a whole day until about 8 o'clock at night" (21 October, 2010).*
>
> *"The thing with that weather bomb [in 2002] was that it hardly rained in Manaia. It rained mainly up the back [of the catchment]. And the highest flood in the 5 years prior to that was on Christmas Eve. There was no rain in Manaia [then either]. It mainly rained up in the hills" (28 October, 2010).*
>
> *You can hear the river coming…it doesn't take long to fill up. Once you have the back up of water [from the high tide] you are not going to stop any of that flooding" (9 September, 2012).*

Incidentally, the volume and density of flood waters passing through culverts that lie beneath SH25 was identified as a high risk for anybody caught in swollen flood waters:

> *"Rushing through the culverts… If you get stuck in that - goodbye. I don't know how the children in the old days kept clear of the pipes" (21 October, 2010).*

Landslides, erosion and sedimentation

In conjunction with storm events there was widespread recognition of increasing landslides and erosion taking place in the upper parts of the catchment as well as increased sedimentation and siltation in local rivers, streams waterways and upper estuarine channels. Several interviewees who regularly use the upper catchment for hunting and pest control recounted seeing evidence of more large slips than in the past. According to one long-term resident, approximately 20 large slips have occurred in the last 20 years, whereas previously there might have been only one every 5-10 years.

> *"Now if you look up the back there…15-20 years ago there were five slips up in the hills. You could look up there and see five patches of clay. You go up there now and you'll see 20 and they are bigger slips than you've ever seen. There have been some massive slips up in the catchment area that weren't there before" (16 October, 2010).*

In association with these changes, the Manaia River and local tributaries are understood to have shallowed considerably, although some scouring has occurred in other places. Across the Manaia Harbour, such aggradation is most obvious in the expansion of mangrove vegetation and colonisation of terrestrial plants covering the intertidal-flats and the formation

of large raised mud-flats[53]. Reductions in the quality and quantity of shellfish beds (*pipi, puupuu, tuangi*) affected by these increasing sediment loads and spreading mangroves were also described[54]. Some of the testimonies below illustrate the experience and exposed nature of local places and *whaanau* in and around Manaia to erosion and increasing sedimentation.

> *"The river used to be deep as - but now you can walk across it" (16 October, 2010).*
>
> *"Under the bridge it used to be about meters deep and now it's not even a meter deep when the tides out. That's how much sediment there is and it goes from there all the way to the moana [ocean, sea]. And then of course when it floods it carries more sediment down. I know further up there's a lot more that's going to come down so it's going to be a problem for a few years yet. That's only a meter from the top of the road and then that all gets washed out into our harbours" (16 October, 2010).*
>
> *"Funny thing about this, going back about 40 years ago it [Manaia River] used to be a deep river but since all the floods it's shallowed-out and you can stand up in it" (21 October, 2010).*
>
> *"Now when I look down on the river flat there, the river flats have built up probably a foot in the 10 years I was living beside the river. So what's happening is that the river-beds are filling up, the sides of the river are rising at the same time through all the siltation" (28 October, 2010).*

Added to these commentaries, some of the interviewees commented upon the increasing coastal erosion caused by storm waves, leading to loss of coastal land, *waahi tapu*[55] such as early *urupaa* and traditional *mahinga-kai* [food gathering, cultivation] areas. Although, as quick as some interviewees were to identify and acknowledge these changes, another group also explained that this was nothing to be concerned about and that such changes were 'part and parcel' of life on-going. Some of these commentaries are captured below:

> *"Some of the northern koru [bays, inlet] have experienced erosion – especially Taungatara – while others are building up with more sediment such as Mataparu" (16 October, 2010).*
>
> *"Ae – it's changed but I still get kai in the harbour and I just got to adapt and work with the changes" (16 October, 2010).*
>
> *"Everything's fine. I still use the harbour quite regularly and just adapt my activities to suit the conditions" (9 September, 2012).*

[53] The spread of mangroves is one of the most noticeable environmental changes in the Manaia Harbour. Many of the interviewees described the mangroves during their child-hood years as being located in fairly thin stands along the channel banks but now they form a thick blanket across former mud-flats and sea-grass areas.

[54] A small number of interviewees expressed that they were not concerned about the changes and that they would simply adjust how they used the harbour and its resources. In contrast, the majority of those interviewed expressed concern about the future of the harbour and how future generations of *tangata-whenua* would be able to use it.

[55] During engagements throughout this study *hapuu* members shared considerable information about the location of *wāhi tapu*. This information is regarded as private; therefore, specific details surrounding *wāhi tapu* have not been made available in this report.

High winds

The occurrence of high winds (and related tree fall) in association with storm events were identified by many of the interviewees as potentially harmful for *whaanau* living in exposed and elevated positions as well as disruptive when access or telecommunications were affected. Many of those interviewed recounted episodes of high winds and resulting damage to *whaanau* homes and power lines.

> *"For us, the 2002 one, the wind came for 2 days and it was intolerable. I had to get up on the roof and strap it down" (16 October, 2010).*

> *"When you talk about the flooding holding the traffic up for 2-3 hours, the storms and high winds can cut us off for 3 days with no power. Emergency services are out and we've got to be self-sufficient" (16 October, 2010).*

> *"[Cyclone] Bola - that's almost 30 years ago. I remember I was building my house and my windows blew out" (16 October, 2010).*

Drought and wild-fire

In contrast to the river/coastal flood hazards facing the community at Manaia, most interviewees also recognised the potential harm for *whaanau* and the wider community from prolonged periods of warmer temperatures and low rainfall - drought. This included recognition of adverse impacts from water shortages on farms, agricultural businesses operations and local ecology, as well as most local households that are dependent on rain-tanks and natural springs for domestic consumption. Heat-stresses for specific populations of the community were discussed including the threat from wild-fire in a community whereby many homes are located close to forest margins.

> *"We just about lost our water last summer the first time ever. Uncle Bunce said this river we get ours off,…has never dried up in his 80 years and he died 8 years ago and last year it went down to this wide [indicates size]" (20 October, 2010).*

> *"A lot of people on tank water at Christmas time bring in water because of low rainfall. And they run out in the winter too" (9 September, 2012).*

> *"Actually we had the fires up here too. The hazard was physical access back up onto that block over there, but the forestry fires were bad here" (20 October, 2010).*

> *"…it's not just flooding but fire hazards in the summertime, because that place is covered by bush and in the summertime it gets really tinder dry and it wouldn't take much to spark it" (21 October, 2010).*

By way of some early reflections, while all of the hazards and environmental changes above were recognised by interviewees as part of natural processes and natural systems; they were also regarded as closely linked with human activities. That is, almost all interviewees considered human interventions to be linked with the occurrence of landslides, increasing sedimentation, and general degradation of local water-ways and the current state of the wider harbour/estuary environment. Further still, interviewees spoke about the draining of wetlands, forestry operations in the upper parts of the catchment, and the construction of

roadways that impeded the natural flow of river water to the sea[56], as having amplified the community's exposure to river/coastal hazards. Increasing population and unsustainable housing developments across Manaia (and around the Harbour) were also recognised as adding to these challenges; including a lack of authority to locally manage these pressures.

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:

- Infrastructure and resourcing,
- Social-cultural networks and conventions,
- Knowledge, information and education,
- Planning, governance and competing values.

7.2.1 Infrastructure and resourcing

Consideration of how *whaanau* deal with, and are affected by, climate hazards and related biophysical changes often resulted in focussed discussions surrounding the poor state of community infrastructure (including sub-standard housing) and the connected issues of limited finances (linked to limited employment opportunities and associated low incomes) and resources to prepare for, and reduce the risks associated with, climate hazards and stresses.

The prioritisation exercise[57] undertaken with interviewees from the first round of group interviews demonstrated unequivocal concern (19/19 possible responses) about the poor state of local infrastructure and the desire for more reliable life-line services to support "healthier" living arrangements across Manaia. Many interviewees considered that upgrades to utility services such as power, water and telephone lines were needed to improve general levels of community safety. For example, disrupted electricity services were identified as a regular occurrence in Manaia with a number of interviewees frustrated by the unreliability of supply and conscious of the risks involved with having to rely on alternative sources such as gas and fire. The irregular and unreliable access to broadband internet and mobile phone

[56] "The infrastructure has made more of an impact because they've raised the roads so high the water can't get through. All these roads have risen over the years. They're like a dam in some ways" (16 October, 2010).
[57] The prioritisation exercise was carried out during the group interviews, whereby each of the interviewees were asked to list the "top four factors or barriers which made it difficult for them or their whānau to deal effectively with hazards". Interviewees were encouraged to complete the activity individually; however, some barriers were identified during the group discussion prior to this activity being completed.

reception was also mentioned - not only because of the disruption caused to those who rely on the technology for everyday jobs and lives but because of the risk posed to *whaanau* safety when dealing with a major hazard event. Subsequently, two interviewees deemed the overall quality of services provided to Manaia as substandard when compared to those offered in other areas of the Coromandel Peninsula. Some of these narratives are captured below:

> *"One of the things that happens in Manaia even in a moderate blow for some reason is that our power gets blown out all the time. I'd say that if you went through the records with the power department and you checked out how many hours Manaia has been without power compared to other communities on the Coromandel I think you'll find that Manaia has a greater outage of power than other places. And we have more instances - so that in itself is an issue for us - our people being left in the dark. It's like the time that house burnt down by the bridge. The only reason they had a candle on was because the power was off for 24 hours. Now had that power grid not failed [it is likely] the house wouldn't have burnt down" (28 October, 2010).*

> *"Come to Manaia and you'll be lucky if you can get on the internet sometimes – so broad-band deliver, rural broadband, is an issue for us here and being able to access the world out there" (9 September, 2012).*

> *"The Civil Defence headquarters [Manaia School] can't even get cell phone coverage. It's pretty ridiculous" (16 October, 2010).*

Next, the poor state of roading across Manaia and the impact this has on access and mobility was commonly raised by interviewees. In most cases, it was regarded as a safety issue, particularly when heavy rainfall, elevated river flows and high tides coincided. One interviewee described that it was not unusual for SH25 to be inundated up to three or four times a year - and as a result, access in and out of Manaia to Coromandel in the north or Thames in the south can be blocked by flood waters spilling over SH25 and secondary roads. The significance of low-lying transport routes and impeded access is widely recognised as increasing the sensitivity of *whaanau* when transport is necessary during adverse weather and climate conditions:

> *"Well the ambulance can't get through - so if there was a flood they'd have to organise some other way. And that's the main place that floods at the moment" (21 October, 2010).*

> *"Infrastructure is everything. If the infrastructure is upgraded it will take away a lot of the [problems]..." (16 October, 2010).*

A small number of the interviewees also raised concerns about unreliable drinking water and the lack of a reticulated sewage system for the valley. And linked to these issues, there were concerns about the growing numbers of *whaanau* returning to Manaia and the subsequent use and impact of septic tank discharges on local water quality, the harbour-estuary and *mahinga-kai*. Not surprisingly, many interviewees regarded the upgrading of these lifeline services as urgent.

"We still gather our kai here [pointing to map]. But, septic tanks are contaminating our water-ways. I'm not too keen on that" (9 September, 2012).

"Our concern is that sewerage system there [points to map] and it's right there by the water, and the water floods through there. And it's draining right by that creek. That creek is the one that I go down to for floundering... So that is a concern and I don't go after heavy rain just in case…" (9 September, 2012).

A select group of interviewees also acknowledged the sensitivity of some *whaanau* to adverse weather and climate conditions because of structurally inadequate or 'sub-standard' homes. A number of dwellings across the Manaia settlement are temporary structures such as caravans, house-buses, sheds and garages; as well as poorly maintained family homesteads which are at least 60-80 years old. There are also some homes within the catchment which are being built without building consent(s). General estimates of over half of the homes in Manaia being below accepted standards were given by two interviewees – with explanations ranging from poor maintenance, unreliable access to reticulated water, old or non-existent waste water disposal systems, lack of insulation and/or cases where internal cladding is missing altogether. These matters were of greatest concern when thinking about the well-being of children and elderly *whaanau*:

"And there's a couple of families in there with low-standard housing, that puts them at risk" (22 October, 2010).

"I suppose putting up flimsy structures through lack of money is the biggest risk" (28 October, 2010).

Incidentally, the acceptance of inadequate housing conditions was explained by a couple of interviewees as being influenced by *whaanau* connections with Manaia, a desire to live on (or near) their *tuurangawaewae* [home grounds through rights of kinship and *whakapapa*, place to stand][58], and to be close to *whanaunga* living in *whaanau* homesteads[59]. Due to a mix of these influences some of the *whaanau* in Manaia feel compelled to remain in poorly maintained homes and/or to build on lands located in areas (i.e. on low-lying land) which are recognised 'at risk' and susceptible to flooding[60]. Further, according to several interviewees, since the 1990s the population of Manaia has grown considerably and there are now some 60-80 households compared to less than half that number in the 1960s. However, this situation has also put significant pressure on the availability of homes and hence led to alternative living arrangements including in some cases the selection of sites for building that are located in flood risk zones[61].

Limited resourcing and finance were also often identified as key issues that influence how *whaanau* are affected by, and deal with, climate hazards and related stresses at Manaia. The general consensus among interviewees was that insufficient resourcing increased their susceptibility to hazard events, and in particular the frequent flood events which affect Manaia. Principal among these concerns was the limited employment opportunities and

[58] The notion of the land (locality or place) as home is best understood through the concept of tuurangawaewae, which literally translates as 'home, a place for the feet' (Mead, 2003). Some of the participant's interviewed regarded the land rather than the dwelling as 'home'.

[59] It is well understood that socio-cultural factors shape people's housing aspirations (Darroch Ltd, 2010).

[60] It is widely documented that physical and psychological well-being can be adversely impacted by sub-standard housing (Howden-Chapman *et al*., 2008).

[61] Many interviewees considered location (of homes) to be the most significant factor when considering those most at risk during extreme flood events. Interviewees commonly identified properties which they believed to be at risk during floods including Goldfields Road where the school and several homes are located.

associated low incomes of many *whaanau.* Many of the interviewees were employed within the primary sector (farming, horticulture, aquaculture and forestry) and tourism industry whereby jobs are invariably low paid and often only part-time or seasonal. In addition, the majority of these opportunities are located outside of Manaia based in Coromandel, Thames or even further afield. Thus, high transport costs are often features of having work, and for some, create a barrier to seeking employment. One interviewee commented on the scarcity of employment opportunities in the area, noting jobs were often limited to those who had either lived in the area for a certain length of time and/or those who had a connection or relationship with the employer.

> *"It's who you know around here eh… And if you don't really know anyone then it's hard to get a job unless you travel to Thames or Whitianga" (21 October, 2010).*

Furthermore, a consequence of the limited employment opportunities in the area is that people seeking work are frequently required to look outside Manaia for work. This highlights the importance of reliable roading for not only emergency access but also general mobility for employment and everyday activities. Some interviewees commented directly on the impact on local incomes caused by constant disruptions due to frequent flood events and the ensuing road closures:

> *"When flooding occurs in Manaia there's an economic aspect because we can't get to work" (16 October, 2010).*

Difficulty in obtaining insurance cover for *whaanau* homes was acknowledged by a number of interviewees - although most of the interviewees that raised this matter declared that they possessed some form of household insurance. However, two interviewees stated that they did not have insurance cover for their homes due to ineligibility. Aside from the barrier of cost, interviewees also referred to the complexity surrounding eligibility and the lack of information regarding the criteria. One participant described in detail the cost of being forced to contract an insurance broker in order to acquire insurance after her home had been successively affected by several flood events. Meanwhile, another interviewee declared his concern that current insurance cover for some particularly exposed *whãnau* might be at risk of termination – particularly if disasters were to increase.

> *"Luckily we're insured for that sort of thing [such as flooding]. We make sure. We've got to get a broker now to get us insurance and that's quite expensive…Oh I wouldn't feel secure if I didn't have insurance" (21 October, 2010).*

> *"Yeah well that's it, basically since that weather bomb it's very hard to get insurance for floods in those areas now and the other thing there is car insurance as well. Insurance levies go up, our people can't afford them so then they have to weigh up whether it's worthwhile getting insurance" (28 October, 2010).*

A small number of interviewees also discussed the constraints some *whaanau* face when houses do not qualify for insurance cover because of omitted building consents and failure to reach building standards. They stressed the link between these realities and the high costs involved in obtaining adequate consents and permits, commenting that a lack of funds was often what determined people's decisions and outcomes.

> *"One of the last [houses] we built the resource consents and permits cost about $7,000, [but] the house cost $50,000 to build because we built it ourselves. So*

you're looking at more than 10% of the costs went on permits, resource consents and whatever charges the Regional Councils put on the place." (28 October, 2010).

The ability to access funds through bank loans on Maaori-owned land was identified as a further obstacle to upgrading *whaanau* infrastructure across the *rohe* [area, boundary, region, district, domain]. One participant suggested changes needed to be made to Te Ture Whenua Maaori Land Act 1993 to allow for multiple-owned Maaori land to be recognised for true monetary value so that such assets can be used for security in applying for bank loans. Some commentary on the complexity surrounding the unique tenure structure of multiple-owned Maaori lands is provided below:

"For multiple-owned lands, Maaori land, banking institutions or financial institutions wouldn't even consider you because of the unknown I suppose of shareholders. There is a shift taking place where kiwi banks are prepared to consider Maaori owned lands but deliver is still limited" (9 September, 2012).

"A lot of people cannot build on the land around here because they cannot afford the cost of sewage. They want to come back but…" (10 September, 2012).

"Because a lot of us are on Maaori title land and those who are, the banks aren't so quick to provide personal or housing loans against the equity of the land or the land titles. So the situation we're in is when we need to take or would like to take an advantage such as that that would help to enhance the safety around our houses and to increase the value of our houses we can't take advantage of it because we can't go to the bank to get the money" (28 October, 2010).

Finally, a number of interviewees stated that a lack of resourcing also prevented access to specialised equipment and up-to-date technology to help deal effectively with hazard risks. The importance of having ready access to specialised equipment and machinery (e.g. chainsaws, walkie-talkies, 4WD vehicles, diggers and other equipment capable of clearing debris from properties, roads and rivers) that could help to deal effectively both natural hazards risks and impacts were all identified. In addition, one participant believed a warning system such as a siren needed to be installed to alert the catchment of an approaching hazard so that people could gather in a "safe zone" together (e.g. on high ground in the event of a flood)[62].

7.2.2 Social-cultural networks and conventions

Social-cultural networks and related conventions were often referred to when questioned about the 'things' that empower as well as prevent *whaanau* from dealing with climate related hazards and stresses. These discussions most often centred on the importance of internal relationships across the community, with a particular emphasis given to traditional ways of managing hazards and risk based on *tikanga* and therein actioned through *whanaungatanga* [relationships, familial connections]*, manaakitanga* [to support, take care of, give hospitality to visitors, protect, look out for]*, aroha* and *kaitiakitanga* [stewardship, respect, respect, guardianship]. The quality and character of external relationships (formal and informal) with the wider community, and more specifically local government organisations and authorities

[62] This conversation also prompted one *kaumātua* to recall that when he was a child the *whānau* would notify one another of a *tangi* by letting off some dynamite down by the creek "and that's how people heard that someone had died" (21 October, 2010).

for minimising the degree to which people are directly and indirectly impacted by climate related hazards and stresses, were also raised; as too was the changing structure of the community through which new community members and new values and behaviours were increasingly being seen.

The most common discussion point centred on the significance of working together and unconditional support to provide emergency as well as recovery assistance to those *whaanau* facing hardship and loss during or following extreme weather and climate episodes. Throughout these discussions *whakapapa*, *whanaungatanga* and *aroha* were identified and described as elemental parts of the tapestry that bound people across the *hapuu/iwi* to one another. Also important, in spite of different opinions and ideas held by different individuals and *whaanau* across the catchment, such standpoints were regarded as secondary when actions to ensure the safety and support of *whaanau* across the community were required.

> *"That's the strength of the village - the whakapapa connections. Whaanau just go straight down to the next household and that's what happens…" (9 September, 2012).*
>
> *"Whanaungatanga and our Maaori way is the biggest strength we've got to deal with an emergency situation…" (2 October, 2010).*
>
> *"When the hammer falls on our people, everyone switches in and tunes into the 'kaupapa' [subject, agenda, programme, theme] to deal with things" (28 October, 2010).*
>
> *"We come together as a community to deal with these things. Even if it doesn't affect us over here it's still affecting our whaanau over there. It's about kotahitanga [solidarity, unity, collective action] eh" (28 October, 2010).*
>
> *"The politics of our whaanau are the biggest problem. Although, there's no doubt that whaanau at home will pull together when required" (9 September, 2012).*

Many of the interviewees (especially *kaumaatua*) also reflected more broadly upon the importance of traditional and customary values and practices in protecting the well-being of Manaia's social, spiritual and physical landscapes. These interviewees frequently referred to *whakapapa* and the enduring responsibilities of *kaitiakitanga*, *manaakitanga* and *tau-utuutu* [reciprocity]. One participant described the use of 'land-gifting' as a traditional way to care and extend support to *whaanau* in need (as well as people not related but still considered worthy of affections) and how this 'Maaori way' had helped one *whaanau* whose family home was irrevocably damaged by extreme flood waters in June 2002[63]. Notwithstanding such conventions and practice however, a number of those home-people interviewed considered that the levels of comprehension surrounding such traditional values and ways were diminishing, unobserved by some *whaanau* and unknown altogether by others - especially those living away and/or returning to Manaia but not raised in the area.

> *"When we were growing up we had to collect kai with other whaanau. It's not collective like we were brought up. It's become more individualised…" (9 September, 2012).*

[63] According to his account – it was understood that while the land was 'gifted' to this *whānau* in need, the actual *mana* of the land still resided with those that held direct *whakapapa* to the gifted land.

The importance of internal relationships as a coping mechanism for dealing with environmental risk and hazards was also emphasised through the on-going service provided by the Manaia Volunteer Rural Fire Force (MVRFF). Located on Goldfields Road and supported entirely by *hapuu*/*iwi* volunteers from across Manaia, the MVRFF was originally established in 2002 to provide first-response services for vegetation, structural and vehicle fires[64]. However, this formal role has now widened further to also cover search and rescue operations, car accident call-outs, evacuation assistance during flood episodes and support during periods of drought[65]. This home-based initiative was thereby acknowledged by a number of interviewees as another example of *whaanau* relationships bringing people together to 'get things done'.

> *"We sort of do everything because we are the first response team. So we can be called out for anything..." (9 September, 2012).*
>
> *"We have guys on that side of the river that are part of the fire brigade and they go and check on everyone over there and we check on everyone on this side" (9 September, 2012).*
>
> *"It's been totally supported by the home-people and you can see that by the way the fire station has grown" (9 September, 2012).*
>
> *"If you go into the dry side of things - the fire brigade used to go around and top up peoples tanks for them but they were ringing every second week and we were spending more time instead of our training filling up water tanks – so then we got it down to the marae and any of our elders" (9 September, 2012).*

In spite of these commentaries, there were a few interviewees who had no awareness of the fire force and its wider functions including its linked hazard management responsibilities, systems and processes. That is, in response to questions surrounding the management of natural hazards and risks across Manaia a couple of interviewees spoke of the need for a formally structured and locally-based 'emergency response team' to deal effectively with large scale hazard events. Furthermore, while other interviewees acknowledged the 'fire brigade' – they felt they did not know enough about its activities for it to be helpful. These are important points because in spite of many interviewees recognising the positive contributions made by the MVRFF there remain opportunities to improve general *whaanau* awareness of the service and its disaster prevention and response planning activities. Some of these sentiments accounts are captured below:

> *"[We need to] set up teams like a Civil Defence so people can go out, investigate homes, check in on people… Response team[s] maybe four people, with walkie-talkies all that sort of thing. You know one at base camp – wherever that may be. Then they would have to be trained up. Chain saws all that, cutting trees…so they would be fire brigade but you need the tickets [qualifications]…" (16 October, 2010).*
>
> *"We'll need to formalise some arrangement so that the new people are gathered into the fold" (10 September, 2012).*

[64] The land physically occupied by the MVRFF is *tuku-whenua* – that is 'gifted' by a Ngaati Whanaunga *kaumaatua* to help support the on-going activities and services provided by the MVRFF.
[65] There is presently a process in place to have the MVRFF formally recognised as a Civil Defence Post in association with the *Thames Valley Combined Civil Defence Emergency Management Group*.

A number of the interviewees believed that stronger external relationships, either through strategic partnerships, new networks and/or more simply maintaining old collaborations, were important to deal more effectively with sustainability issues confronting the community including, but not limited to, catchment management and river flooding. A number of interviewees also emphasised the importance of being able to call on personnel, resources and expertise from outside the community to support *iwi/hapuu/whaanau* aspirations, business opportunities and cultural innovation. In this context, establishing and maintaining productive working relationships with external authorities, organisations, groups and individuals was seen to be a priority for the whole community.

> *"I guess it's about becoming familiar with each party's ambitions and goals and aspirations. I think the more familiar you become with one another through working together, through knowing what each of the party's strengths and weaknesses are, having a warts and all approach, will be able to provide you with a better, clearer outlook on how well you can work together. I think if you look at it like that those overcome a lot of the obstacles that you normally find when you bring different groups together with different agendas" (22 October, 2010).*

> *"…whaanau, hapuu and iwi need to work alongside and utilise the resources of outside organisations, such as territorial authorities and government agencies, to be successful in planning for future hazard events" (22 October, 2010).*

However, in the same breath there were a number of commentaries that outlined the challenges in building and maintaining meaningful and long-lasting relationships. Further, there remain considerable misgivings about what can be achieved through some external relationships. Some of the reasons for these sentiments are captured in the remarks below:

> *"We are not just fighting internal relationship issues, we are also fighting external issues and believe it or not whaanau get so frustrated that they go 'get knotted the lot of you' and then they carry on themselves. And this can lead us to lose sight of what the land is saying to us. What we need is relationships across the different levels to move forward… And we need to be strategic in how we do that". (10 September, 2012).*

> *"The local guys within Environment Waikato are good, you know from Whitianga this way, cos they know the area. When you get information from head office in Hamilton they wouldn't have a clue. The things they try and make us do and you say come on… This sewage system out the back here we stuck it on a mound, you've seen it, we told we had to get rid of it and put it at ground level... And blow me down the flood we had went half way up the mound and had it been ground level it would have flooded in and all the electrics would have been stuffed" (10 September, 2012).*

> *"An important issue is changing the mind-set of our local councils… Very little attention has been given to things Maaori. And that needs to be changed radically if we are going to have any impact on dealing with challenges like climate change... We've had a quite a lot to do with the Coromandel Blue Print and things like that but at the end of the day have people's attitudes really changed?" (10 September, 2012).*

Finally, most interviewees commented on the changing social structure of the community across Manaia, from increasing numbers of urban *whaanau* returning to their *tuurangawaewae*, to new community members (non-Maaori) and increasing resource competition, to new values and greatly altered relationships between people. The implications of these changes for community vulnerability and resilience to climate related hazards and stresses are wide ranging – but nonetheless, when reflecting on the things that either enable or make it difficult to deal with climate related hazards and stresses, commonly interviewees touched upon the tensions, challenges and opportunities arising from these phenomena that appear to have become more pronounced in recent decades.

A keenly discussed demonstration of change was the increasing numbers of urban *whaanau* returning to Manaia. Many of the interviewees explained that this movement back 'home' is mainly about affordable living arrangements and the deeper desire of these *whaanau* to know where they come from through the reoccupation of family homesteads and ancestral lands. However, in some cases there is an emerging tension between those *whãnau* who have maintained long-term residency on ancestral lands[66] and those returning. According to these accounts, most returning *whaanau* have not been raised in Manaia, and subsequently they are often unfamiliar with the physical environment, less able to support themselves through traditional activities, and by extension lacking in knowledge about local hazards and related risks. This has resulted in these *whaanau* often making poor decisions such as occupying known flood zones or being ill-prepared for unexpected conditions, thereby putting themselves and others at unnecessary risk.

> *"So it's not only the natural environment that has changed it's also the social environment for us that has changed… we've got the reversal of urbanisation now, you know how we urbanised in the '50's? We'll now there's a turn-a-round and they're all coming back" (16 October, 2010).*

> *"It's going to be an ever increasing problem the de-urbanisation and the reconnecting to the whaanau back here. Hopefully the whakapapa and the fact that they're coming back on a kaupapa Maaori basis may actually help" (22 October, 2010).*

> *"Yeah, it's like people who send their kids to training and school and then some of us know it's going to flood. And yet they send their kids to school and they get stuck. And you think well that wouldn't have happened in the old days because the old people would've said stay home it's going to flood" (28 October, 2010).*

In addition, some of the interviewees also recognised a break-down in community relationships as some recently returned *whaanau* keep to themselves, which has resulted in some *whaanau* not knowing who lives down the road and therein more individualistic and less-connected behaviours. Notwithstanding these tensions, there remains widespread support for the motives of urban *whãnau* wishing to return home – including a general hope among *te hau kaainga* that those returning would eventually also contribute to the life of the *marae*, the *hapuu* and the *iwi*.

[66] These home-people are also referred to as the a*hi-kā* as have kept the home fires burning, by maintaining residency, and preserving the physical family ties to their ancestral lands (Mead, 2003).

7.2.3 Knowledge, information and education

Consideration of how the community deals with, and is affected by, local weather/climate hazards and risks led to a number of focussed responses and discussions surrounding the loss (and significance) of Maaori knowledge (which includes traditional activities) in learning and knowing about environmental change and risk. Shortages in relevant expertise and skills to deal with increasingly complex contextual realities facing the *iwi/hapuu* were also identified as well as the need to better understand the relevance of the climate change issue for home-people today. Linked to these challenges, the importance of *iwi/hapuu* specific information as well as *iwi/hapuu* specific communicators were recognised; and the need for traditional as well as non-traditional educational opportunities that allow young people to draw from more than one intellectual tradition and thereby realise new knowledge and skills.

The loss of Maaori knowledge and accompanying decline of traditional land, river and sea-based activities, and thereby ways of learning and knowing about environmental change and risk, were identified by a handful of interviewees – all of whom had grown up at Manaia. Commonly these interviewees expressed concerns about such losses – not least of which because of the resulting links that these changes have on people's environmental awareness, understanding of ecological processes, and the potential to be able to deal effectively and make the right decisions when anticipating and/or facing environmental hazards and related stresses. Further, two elderly interviewees considered that a large number of *tangata whenua* now find it difficult to maintain a bond with the natural world and thereby the loss of this relationship and the associated loss of environmental knowledge make it much harder to engage in traditional activities such as hunting, fishing and gardening and consequently support themselves and the *whaanau* through times of adversity.

> *"We are thin on the ground when it comes to maatauranga [Maaori knowledge]…" (9 September, 2012).*
>
> *"It's the younger generation now, the ones in their 20's and 30's… Their parents were bought up away from here, they were bought up in the city, then they've moved home and it's hard for them to relate to the land. As much as they'd like to it's hard for them to pick up on it" (22 October, 2010).*
>
> *"I think what's happened is that too many of our people have completely lost touch with nature… Their minds are not in that cycle" (22 October, 2010).*
>
> *"The best thing to help us into the future is the ways of our people from the past. There's no doubt about that… Our problem is we're so far removed from those tools and that knowledge that it's hard for us to get back to them" (28 October, 2010).*
>
> *"We've been pretty good I think but the way things are going I think we need to exert ourselves, put more effort into getting our maara-kai [gardens] going which is a saving for the whaanau… and then when you've got that you can deal with the other issues better" (21 October, 2010).*

Reflecting upon these challenges, one *kaumaatua* also commented upon the paradoxical role of technology, whereby on the one hand life had become genuinely much easier for *whaanau* when compared to the days prior to the introduction of electricity and modern appliances – but, on the other hand had also resulted in what he viewed as a loss of *whaanau* endurance. Further, difficulty in maintaining a bond with the natural world was also

regarded as affecting *whaanau* awareness and attention to nature's indicators[67] thereby exposing people to greater risks not taken in the past. Notwithstanding these commentaries however, nearly all these same interviewees were also quick to acknowledge that in spite of the decline of environmental skills many of *te hau kaainga* still hold a detailed knowledge about the Manaia environment including areas of high risk. And, as already described this includes knowledge of local indicators that help to anticipate extreme conditions such as heavy rainfall and flooding as well as how best to cope with these disruptions and related stresses.

> *"…the predictable ones [storms] are from the sou'east and the westerly ones you'd see when it's an hour away at the bottom so if you're out there [on the sea] you've got an hour to get in or behind an island to wait it out. But with motorboats everyone now takes the risk and waits until the last few minutes. Most ride the rough weather now, but in our tupuna's time they wouldn't argue with Taawhirimaatea (21, October, 2010).*
>
> *"I think it's just our local knowledge eh. You know when it's going to rain hard...we keep an eye on it. You can see it eh, the water starting to rise in the creek and then you check quickly to see if the tide is coming in" (9 September, 2012).*
>
> *"Just make sure you are ready. The power might go off for 2 or 3 days. OK, we manage that, don't we? You know the powers off, so we get on with it…we just carry on" (9 September, 2012).*
>
> *"I think the thing with Manaia is that traditionally over the years we have built and lived within that risk area anyway, right beside the river, so it's nothing new to us" (28 October, 2010).*
>
> *"In this village depending on what type of weather event it is say high winds then it's better to just stay put unless you go the next one closest but yeah you are probably putting everyone at risk by going out because everyone's gotta go out and look for you…" (9 September, 2012).*

These conversations also turned to candid thoughts on the transmission of knowledge to younger generations (both traditional and contemporary) and the importance of Manaia's Kura Kaupapa in assisting the learning of both Maaori and non-Maaori intellectual traditions. The following quotes come entirely from individual interviews with *kaumaatua*:

> *"The way to do it with our young people is to use sound reasoning and to show them things. You've got to give them a living example and say 'you watch that' and when they see something happening you say 'if we did things this way this would happen' so basically it's important to teach our kids to believe in our ways for our own people's benefit (21 October, 2010).*
>
> *"We need to groom them eh? They won't pick it up by themselves… that's what's going to have to happen and it comes back to the likes of us to ensure that they're on the right track and that they value these things. What they must have is respect, if they haven't got that then that's when everything falls down. That's*

[67] This same elder referred to the blossoming of the kowhai as a signal to ready oneself for the onset of the flooding season.

how I see it anyway. Papatuuaanuku [Mother-Earth, the ecological system] and the Gods, ne? And then that is imparted to those that follow you. They've got to be aware of these things as they do the march forward. You can't ignore the other. Papatuuaanuku and Te Taiao [the living world, literally = the world of light], that's a big thing" (21 October, 2010).

"Discussing this mahi [work, activity] with the children is important because they are the ones who will be facing the changes ahead in the future. We need to make them aware of these issues…and get their input" (9 September, 2012).

"Children see what we do. So if we do the right things, they will do the same" (9 September, 2012).

Not knowing what to do during an extreme event or how to best plan for an extreme event was also raised by a couple of those interviewed. These participant's spoke of "coping as best they could", and yet reticently admitted that they were unsure what to do if they found themselves in a situation that they could not deal with on their own. Some of these commentaries are captured below:

"The homestead has never been under flood in the past, but the water was right up to the steps of the homestead this time. Quite frankly I didn't know what to do but I rang 111 and explained what had happened and they told me they couldn't get to her [my granddaughter] either... What I'm trying to get at is what local organisations are there that people need to know about in times of crisis? And that was a crisis for us. We couldn't reach her [because of inundated roads and failed telecommunication services]" (16 October, 2010).

Almost naturally, these conversations turned to considering what new skills and expertise might be needed to better deal with the increasingly complex realities facing different *whaanau, hapuu* and the *iwi*. The spread of skills and expertise identified was understandably varied; however, emphasis was often given to the need for home-people (and Maaori in general) with experience in regional planning, natural resource management, science and law. Further, there was also acknowledgment of the need for *whaanau* that possess skills and expertise that allow them to work successfully across the Maaori world and non-Maaori world. Linked to these reflections, a couple of interviewees also highlighted the critical importance of leadership and stressed that real leadership will not always follow others and nor might it always speak the Maaori language. More broadly still, there was a general consensus that that the 'right' decisions regarding the well-being of the *iwi/hapuu* and *whaanau* at Manaia will ultimately require vision, commitment, collaboration and hard-work that draws upon a wide range of skills and expertise crossing the Maaori world and non-Maaori world. Some of these commentaries are captured below:

"It's a big issue for us – having knowledge of political decision–making and legal processes... When I think about the old people and how they just sat back and let things happen. We blamed them – but it wasn't a matter of blaming them it was just that they didn't know… Then we learnt little by little to understand what the Crown was demanding" (9 September, 2012).

"The gaps are presently in environmental science, district planning, R.M.A….and more schooling in higher level management. But, expertise we can grow. The kura [school] is there to do that" (9 October, 2012).

"…If you have a look at our current leaders in the community, one of the prerequisites or qualifications of a leader is to be able to speak on the marae. So those who learn Te Reo become the leaders and more often than not they don't know what they're talking about but they can speak Maaori" (28 October, 2010).

"At the end of the day you need people who are going to be doing it. It's OK saying we are going to do this but if you don't have the project person to follow through then 'see you later alligator' – nothing ain't gonna happen" (9 September, 2012).

Importantly, a number of independent conversations surrounding this topic also made it clear that while one could always wish for more, the *hapuu* and *iwi* had very resourceful people that were capable of meeting the needs and aspirations of the community. For example:

"Well the personnel involved are suitable it's just that we have to restructure them. We have to restructure and revamp the kaupapa to make it suitable. People-wise we've got the right people; we've got the organisations in place. We just have to adapt those to meet the new requirement and challenges… " (28 October, 2010).

Almost every participant considered education and skill improvement programmes to be vital for reducing the community's vulnerability to hazards and related stresses. Subsequently, interviewees identified an array of actions which they believed would contribute to the growth and well-being of the community. These ranged from holding *waananga* to teaching *maatauranga*, *tikanga*, *kawa* (ceremony, rituals, protocols, etiquette, correct procedure]) and Maaori language; holding training courses with the opportunity to gain qualifications in the use of specialised machinery (e.g. diggers, tractors, and heavy vehicles) and emergency equipment; as well as workshops which educate people about policy and planning processes, legislative arrangements and avenues for engagement and participation in decision-making surrounding resource management.

"By empowering the community with knowledge, they can deal with a lot of things" (9 September, 2012).

Lastly – but not least, one *kuia* [elderly woman, grandmother] remarked that there was a lack of direct contact between local/regional authorities and the home-people of Manaia regarding the latest developments on local environmental issues – and that how the information was presented and who did the presenting were critically important for the actual uptake of the information. She provided an example of the adverse impact of septic discharges on local waterways and declared that the lack of appropriate information on how to mitigate that problem was actually standing in the way of effectively dealing with the issue, and thereby leaving *whaanau* vulnerable to the consequences.

Before iwi can act they've got to get all the relevant information. What is happening? Why is it happening? What do we need to do in order to stop it from happening? All that sort of stuff…" (9 September, 2012).

"Everyone goes to hui [meeting, gathering, to assemble] but it's how you get the information out. It's how you engage that people take it away" (9 September, 2012).

"It's how you adapt the information so that our people understand it" (9 September, 2012).

Similarly, another individual confirmed the need for quality information – particularly for *whaanau* intent on returning to their *turangawaewae* but unfamiliar with the risk-scape.

"We're going to have a lot of whaanau coming back to Manaia - from Auckland and Australia, with lots of money. And they are going to need well informed plans about where to invest if they're going to come back on to ancestral lands. Now if we don't identify these areas of huge concern that we know of then we're setting them up to fail. So we need to show them the areas that they need to purchase" (9 September, 2012).

7.2.4 Regulation, governance and competing values

Discussion of the factors that influence the way people are affected by, and deal with, climate hazards, risks and related stresses, led to comments about the influence of central government legislation and local government regulation (policy and plans) on *iwi/hapuu/whaanau* well-being and aspirations; to questions surrounding the roles and efficacy of different governance structures (rules, regimes, procedures, administration and decision-making within both Maaori and non-Maaori institutions), and to recognition of the on-going competition of world views and values regarding the use, management and care given to natural resource and ecological systems.

The influence of central government legislation and local government regulation (policy, plans and strategies) on community well-being and *whaanau/hapuu* development aspirations was raised by a number of those interviewed – particularly those members of the community involved in direct iwi representation and/or participation in local planning and resource management matters. Most of these interviewees considered that Maaori were unfairly impacted by restrictive legislative policies and rules surrounding how Maaori land assets (registered under the Maaori Land Court) can be developed and used. More specifically, constraints were identified surrounding multiple-owned Maaori land in Manaia which is subject to Te Ture Whenua Maaori Act 1993[68] (The Maaori Land Act). This land tenure and asset management system is characterised by a number of unique legal and institutional attributes that some interviewees regarded as overly restrictive and thereby a barrier to *iwi/hapuu* development and resilience. Some of these commentaries are captured below:

"…Maaori land is basically legislated out of the economy. If we keep in mind that the economy is based on the use of a square meter of land with a dollar value attached then if you look at Maaori land under Maaori title, we cannot attach a commercial or equity value to those lands. Therefore we can't use those lands in the economy. So by virtue of the fact that it's under Maaori title it disqualifies our land from participating in the economy… So what we need to do is structure or rework the Ture Whenua Maaori Land Act so that we can somehow or other use our land in the economy as security for a loan at the same value as general title" (28 October, 2010).

[68] The Preamble of Te Ture Whenua Maaori Land Act 1993 states that: "…land is a taonga tuku iho of special significance to Maaori people and, for that reason, [the Act was established] to promote the retention of that land in the hands of its owners, their *whānau*, and their *hapuu*, and to protect *wāhi tapu*: and to facilitate the occupation, development, and utilisation of that land for the benefit of its owners, their *whānau*, and their *hapuu*: And whereas it is desirable to maintain a court and to establish mechanisms to assist the Maaori people to achieve the implementation of these principles."

"A lot of us are on Maaori title land and those who are, the banks aren't so quick to provide personal or housing loans against the equity of the land or the land titles. So the situation we're in is when we need to take or would like to take an advantage such as that that would help to enhance the safety around our houses and to increase the value of our houses we can't take advantage of it because we can't go to the bank to get the money. So these are all the things that impact on us in terms of being able to get finance to get ourselves in a position to deal with effects of climate" (16 October, 2010).

A number of these same interviewees also considered that many *whaanau* were unfairly impacted by local zoning restrictions - particularly the development of land assets in the coastal zone. Such local government rules were considered to reduce the capacity of some *whaanau* to make better use of their resources - particularly those with large acreages of property who desire to use the land to provide improved housing for extended *whaanau* but are formally restricted from doing so:.

"If one whaanau want to build and they have shareholding, a couple of acres, why wouldn't people be willing to allow them build. The issue is: 'I have land, I want to build, I want to come home'. We can all do the pro's and con's why you shouldn't come home but I'm not surviving anywhere else" (9 September, 2012).

"Another thing that happened under the Ture Whenua Maaori Land Act is the reclassification of Maaori lands to what they call Maaori Purposes or General Purposes land. That basically wiped out the prior status of the land and applied a new status and the other thing that happened at the same time was they bought in that 1 km Coastal Zone which bought us into the Coastal Zone and the simple thing in that, if you're 1 km away from the coast and you want to do some earthworks legally your permit consent process would cost you about $700, once you do anything within the Coastal Zone the consent process automatically goes up to say $5,000-$7,000, simply because they've classified Maaori land or households in that Coastal Zone" (16 October, 2010).

"The issue for us isn't getting loans from Maaori land but being able to develop infrastructure onto the land and whether it goes into coastal zoning or residential zoning. So, the District Plan here for the Coromandel plays a big issue moving forward, irrelevant of climate changes" (9 September, 2012).

At the same local level, although interviewees acknowledged the need for the construction of safe and robust buildings, some building regulations and consent procedures were also identified as excessively restrictive and costly to the point that some *whaanau* are feeling little alternative but to construct illegal dwellings and structures. For example:

"One of the last ones we built resource consents and permits cost about $7000. The house it cost $50,000 to build... So you're looking at more than 10% of the costs went on permits, resource consents and whatever charges the Regional Councils put on the place. One of the charges was a $4000 contribution and their explanation is that you and your children use the parks and public facilities in the Coromandel area so when you live here you make a contribution. Our response to that was that all of the parks and roads you're talking about were contributed by our people, either involuntarily or voluntarily" (16 October, 2010).

Linked to these discussions, the role of institutions (both Maaori and non-Maaori) and the governance/decision-making that occurs within were identified by a number of interviewees as critical for enabling as well as constraining the capacities of *whaanau* (and the wider *iwi*) to deal with social-ecological risks, changes and stresses. Formal Maaori institutions such as Ngaati Whanaunga Incorporated Society and Ngaati Whanaunga Environment Unit[69] were acknowledged as currently providing important formal structures for engaging with external institutions such as local and regional government authorities over planning and protection of Ngaati Whanaunga ancestral lands, waters and other significant places. Further, such governance structures are well-recognised to have increased the capacity of the *iwi* to negotiate with central government and other *iwi* authorities over Treaty of Waitangi settlement issues. This in turn has provided the community with new expertise and pathways which they hope will accelerate *iwi/hapuu* development.

> *"My focus is on protecting our whenua and moana from an ever increasing pressure to develop our significant places, in particular our coastline and other outstanding landscapes. We need to increase our participation in those decisions that impact upon us, by both local and central government" (28 October, 2010).*

> *"What Aunty Betty's done in the past is she's promoted a community plan and basically from the angle that there's many iwi, many hapuu, and it was seen as a document that would help feed back up into the district plan…in one respect [this] could almost be identified as the iwi plan" (10 September, 2012).*

> *"The important thing is to be able link community-based decision-making to local government and central government processes so that people in political positions can make better decisions for whaanau [and] more importantly so you don't have a disjoin" (28 October, 2010).*

But, in spite of the work taking place at these levels a number of interviewees maintain a level of scepticism regarding their ability to have effective influences over those decisions that influence the treatment and management of ancestral lands, waters and significant places of interest – which are widely recognised as interconnected with the general health and well-being of the *iwi/hapuu* and *whaanau.* Criticism typically pinpointed consents which had been granted for activities that they saw as unsustainable such as the siting and building of the Manaia School. A number of these interviewees commented that such development and treatment of resources was short sighted and poorly informed, thereby increasing vulnerabilities across the community. Consequently, having greater control over the decision-making surrounding local resource management and land-use zoning was considered of paramount importance, as demonstrated in the following comments:

> *"People would've known that was a flood zone for 100 years. What sort of decision making was made so that they'd put the school and children's risk in a flood zone?*

[69] The Ngāti Whanaunga Environment Unit focusses on resource consents processes, and influencing statutory plans, under the Resource Management Act 1991. Working on a voluntary basis, it seeks to be proactive in protecting *iwi* interests through involvement in Council and Crown plan drafting, revisions, and reviews, to ensure that plans provide Ngāti Whanaunga with effective tools with which to protect Māori values and interests. It also involves *whānau* in planning processes and advocates on their behalf. In order to do this the Unit tries to identify which families are affected by proposed activities, talk with them, and either with them or on their behalf write Māori Values Assessments (MVAs), and make formal submissions as part of resource consent applications and other planning processes. Where the Unit fails to secure protection of iwi values and interests the Environment Unit, supported by the Ngāti Whanaunga Incorporated Society, it has previously lodged appeals or provided evidence before the Environment Court and other courts.

And then having to put the road there to be able to get to and from the school which means that if there's flooding while the schools in, parents can't come and pick their kids up. Rescue and safety services will have difficulty getting in and out of that area". (10 September, 2012)

"We've got this building right in the middle of the flood zone is really annoying to me because what we didn't do at the time was view it for what it was. Of course there was a discussion to locate it to higher ground but there was also an urgency coming not only from some of us in the awa-awa [river, waterway] but from the Ministry as well in terms of funding and politically at that time. As a result we dumped our kura in the flood zone" (10 September, 2012).

"I think community level decision making is vital, crucial in terms of our survival and ability to be resilient going forward because we can get together and decide where the areas are safe, whether we want to put ourselves at risk from whatever hazards or dangers, and also in terms of resource use in those areas. How much are we going to tax this water supply that we've got here when sometimes you get 'teaspoonful's' a day in the summertime when in the wintertime there's tons flowing down from the catchment" (28 October, 2010)?

Importantly, many of the interviewees considered that future *iwi* development and management of social-ecological risk (and by extension climate change) would come from not only greater Maaori involvement in local, regional and central government institutions, but also from the existing (as well as creation of new) tribal institutions and governance structures. For example:

"Through the work of the Hauraki Collective and the Tamaki Collective one of the outcomes will be that these iwi organisations will be stronger, more organised because they have to be in order to receive those settlement funds and to deal with all of the opportunities that will come out of the settlement" (10 September, 2012).

"I think the biggest leverage we've got is in this Treaty negotiations process… One thing that's happened with the Treaty Settlements process it has brought everyone together. [Ngaati] Pukenga is working with Whanaunga, Ngaati Maru and all the rest at the Hauraki collective table. At that table we have the Chairpersons of almost every iwi body in Hauraki. So from that we'll make sure we form these relationships and we improve and maintain them. This Treaty negotiation settlement has actually been a fix-it for a lot of problems that have existed within the iwi dynamic" (10 September, 2012).

"Iwi plans, is where it needs to happen. Those iwi plans need to be written alongside the rangatahi and understood by the rangatahi because at the end of the day the rangatahi have got to get on with the work and make it happen" (10 September, 2012).

"With the approaching settlement of our Treaty Claims it is my hope that we will have the wisdom to buy back our whenua tuupuna [ancestral lands and places], and to use these new resources to build up our hapuu and whaanau, and to assert mana whenua to influence decisions about our environment and the future of Ngaati Whanaunga as a people" (10 September, 2012).

Finally, a small number of those interviewed referred to an on-going competition of values[70] (and ethics) underpinning all of the discussions above. More often than not these discussions were framed by reference to *Papatuuaanuku*, a lack of recognition of her intrinsic value and integrity, and the wider societal pathways of development, government policy and linked regulatory regimes for natural resource use and protection. Linked to these discussions, a number of interviewees acknowledged that the increasing pressures being placed on *Papatuuaanuku* were actually raising the sensitivity and likelihood of harm to *whaanau* from the direct and indirect impacts of weather and climate extremes.

> *"To avoid fragmenting strategies that deal only with human concerns, human values must be considered within the total framework of safeguarding the values of the Earth, Papatuuaanuku, first" (16 October, 2010).*

> *"We are preoccupied with devising adaptation techniques that will safeguard our commercial interests, thus neglecting to firstly formulate strategies to revitalise natures 'mauri' [life principal, entity]* [71]*, natures life-force" (16 October, 2010).*

> *"How you balance up economic interests with cultural interests and try to make them work out is very, very difficult. On the one hand you've got the legislation to allow that to happen, but in reality it doesn't provide very well I think for the cultural values to be considered" (16 October, 2010).*

> *"We are dealing with a very powerful capitalist system and I think that has got to change. I recognise that but I don't know how to do that…" (8 September, 2012).*

> *"For Ngaati Whanaunga the physical and spiritual well-being of the whenua and moana is linked to our own spiritual and physical well-being" (8 September, 2012).*

Importantly, these same interviewees also spoke of the importance of kaitiakitanga and how it is vital to sustaining a healthy environment and people. Interviewees often framed these discussions by talking about their responsibilities to sustain, protect, and care for the environment for future generations. These responsibilities were further described as intrinsic, linked through *whakapapa* and not a matter of choice. In this way, most interviewees expressed an emotional bond to Manaia, regarding the *whenua* and *moana* as *tuurangawaewae* which encompasses identity, belonging and *whaanau* origins. Given such connections there was an overwhelming sense of responsibility and obligation to be directly involved in decision-making related to the management and use of environmental resources.

> *"Maaori spiritual philosophy has taught me that everything in creation is interconnected by whakapapa and that our survival is dependent upon maintaining the whakapapa connections, whakapapa integrity and whakapapa strength…" (16 October, 2010).*

[70] The word value means worth and relates to things that we care about. It also refers to an ethical position on which we base our behaviour. Values are shaped by the culture and which we live and by our experiences, so they differ amongst cultures and individuals. This can of course lead to tensions and conflicts especially when the values of one culture (and their associated use-behaviours) are imposed on another culture (Mitchell, 2002).

[71] '*Mauri'* is a central feature of Te Ao Maaori that reveals much about the health and well-being of human and non-human entities. It is often translated as "life principle or life force" – it generates, regenerates, upholds creation and binds the physical and spiritual elements of a resource to together. If the *mauri* of natural world is compromised then it is thought that people will also suffer and their health well-being will be compromised. Conversely if the *mauri* of the natural world is enhanced and/or improved then the health and well-being of the people will also be enhanced (Mead, 2003).

"…because of our whakapapa to the whenua, to Tangaroa [Deity of the sea/ocean], we cannot break that whakapapa. Whakapapa provides the passageway for the mauri to come from Te Kore down to us and the rest of creation and it's keeping that whakapapa connection intact that's important" (16 October 2010).

"As a Maaori, the vision for the future is to restore and maintain the integrity of 'nga taonga o Papa raua ko Rangi' [the treasures of earth and sky], that is to restore and maintain the mauri of all natural treasures from the sky to the core of the Earth. This vision arises from the Maaori spiritual philosophy that we are an integral part of the Universe. We are all connected by whakapapa" (16 October, 2010).

"[We need to consider] the values of land and what it means, what it's for and that it's your lifeline and it isn't your right to abuse it, your role is to look after it and your whaanau, your community [need to be] into that as well" (22 October, 2010).

Added to these beliefs and practices, the diminishing relationship between people and the environment was again raised. These concerns were outlined through reference to intrinsic responsibilities, to needless consumption and unsustainable living arrangements across the community (and beyond), and to the diverse barriers impeding 'right' relationships and practices. Many of the *kaumaatua* who were interviewed believe that this relationship is fundamental to the resilience of the human–environment system as a whole.

7.3 Climate change induced coastal flooding and future risks

Each year there are weather and climate related events that represent risks to people and activities. These risks arise from 'normal' day-to-day, seasonal, and year-to-year variability in climate. As already confirmed, the community at Manaia have a range of informal and formal practices and strategies in place to deal with the effects of routine climate variability. However, when dealing with climate variability in the future, *whaanau* cannot simply rely on the assumption that the prevailing climate will be more or less the same as it has been over the past 50 or 100 years. Rather, effective coping and adaptation will need to be based on an awareness of the risks posed by climate change and, importantly, an understanding of the significance of those risks. This sub-section considers the implications of the different climate change scenarios modelled in this study, and the impacts and future risks likely to be faced by the home-people of Manaia. These results are based upon direct feedback provided by selected community members during the final round of interviews in May 2012 and supplemented by material gathered by the author team. Please note that those 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

As described in Sections 4 and 5 and illustrated in Figure 11, the scenario results produced from our examination of projected high tide levels (MHWS10) indicated that by 2040 AD much broader areas of coastal marsh and pasture land on the seaward side of SH25 will be inundated by tidal waters on a regular basis. A further creeping of the tide between 2040 AD and 2090 AD is also expected, with comparatively larger inundation extents indicated in the central and northern parts of the upper harbour by the end of the century. It is also likely that the MHWS10 will propagate further landwards during coincident periods of higher river flows

and thereby reach (and possibly exceed) the current position of SH25 north of Te Kapara Stream. Many low-lying areas are thereby expected to transform into coastal marsh and eventually become a permanent part of the harbour/estuary system.

In response to questions surrounding the possible consequences of such changes upon *whaanau/hapuu/iwi* assets, activities and things of value, most interviewees were generally surprised that the projected MHWS10 levels for 2040 and 2090 AD were not greater - regularly commenting that these mapped scenarios were already frequently occurring. Notwithstanding these observations and subsequent qualifying discussions about the critical role of the river in modulating the actual reach of high tides in the upper part of the harbour/estuary, *whaanau* then proceeded to consider the potential impacts and associated risks for different activities, groups and *whaanau* across the community. Although, one *kuia* wished to emphasise that while she appreciated the rationale and value behind identifying potential climate change impacts and risks, that such an approach was also limited because it was focussed solely on safeguarding human social, economic and political values and needs in relation to climate change, rather than considering human values and needs within the total framework of safeguarding the values and needs of the Earth, *Papatuuaanuku*. Such considerations are considered further in Section 8.1.

The risk of damage to *whaanau* homes on the seaward side of SH25 was frequently identified by interviewees – including recognition that these *whaanau* would eventually have to move and/or build homes that could accommodate higher water levels. This was followed by identifying the potential loss of currently stable, dry-land and paddocks due to excess water build up and the problem this would cause for *whaanau* who use these areas to principally graze and rotate cattle. Further potential impacts identified included potential water intrusion into septic tanks and the risks that such impacts could pose for local ecology and *whaanau* health – particularly those that still utilise these areas as *mahinga-kai*. Higher water levels and the likely destabilisation and/or damage to key infrastructure such as roads, bridges, storm-water pipes and channels, and Manaia School were also acknowledged. The costs of maintenance, repairs, and redesigning such infrastructure to cope with such changes were thereafter identified including the anticipated higher burden that would be placed on particular pockets of the community. Degradation of *paa, waahi-tapu* and other cultural symbols were also identified and this led to consideration of the harmful impacts this would have on *whakapapa* connections and *hapuu/iwi* identity. The potential impacts and risks from climate change induced sea-level rise for the Manaia community are summarised in Box 2. Note that possible response and adaptation options identified by interviewees 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 sea-level rise

- Increased risk of coastal flooding from rising sea-levels and extreme weather events;
- Permanent inundation of low-lying coastal areas including salt water intrusion (salinization) into fresh water resources and farm paddocks;
- Structural damage to privately owned buildings and key infrastructure such as local roads and Manaia School from higher water levels and periodic storms;
- Degradation of sacred places and sites resulting in loss of identity and *whakapapa*;
- Loss of *hapuu*-owned farm-land resulting in loss of economic opportunity;
- Increased coastal erosion and destabilisation of coastal slopes from rising sea-levels and storms;
- Adverse impacts on ecology from erosion, sedimentation and pollution from destruction of septic tanks and sewer lines;
- Danger of injury and loss of life in the case of extreme flooding events;
- Rising costs surrounding the maintenance, repair and re-design of *whānau* homes and vital infrastructures to cope with such changes.

Coastal flooding from climate-induced changes in river flows and sea-level rise

The scenario results produced from our examination of extreme coastal-river-reach flooding for 2040 and 2090 AD under A2 and B2 climate change scenarios both show inundation extents that are comparable to those observed on the Manaia River in 2002. As described in Section 5.2 this outcome is largely due to the relatively steep land around the edges of the flooded area where the water level can change substantially without much corresponding change in the extent of flooding. Notwithstanding these modelled outcomes, higher future flood levels are also indicated thereby increasing the potential risks for some community assets, activities and things of value.

Small inundation differences can still be seen in the extent of dry 'islands' around the normal shoreline and around the eastern boundaries of the model domain near to Goldfields Road. The modelling for both 2040 and 2090 AD under the full range of B2 and A2 climate change scenarios also indicates that the river terrace on which most of the residential houses are built is well-elevated above the flood plain – although obstructed road access due to flood waters remains a significant risk for SH25, Goldfields Road and Marae Road. Also notable, is the heightened exposure of Manaia School to flood waters which is located in an area that was inundated by more than 0.5 m of water in 2002. Based on the modelling conducted in this study, it is expected that floods with corresponding hydrological characteristics in 2090 AD will add at least at least another 0.1 m of depth to flood water levels in this vicinity. Uncertainties surrounding the build-up of debris in and around the SH25 Bridge could result in quite different inundation extents and flood exposures, however – particularly for the land surrounding Manaia Marae which faces existing erosion and scour problems. Recognising that members of the community have varying interests in the lands, infrastructure and natural

features that are part of the Manaia landscape, there are a number of distinct risks facing different groups, activities and *whaanau* across the community.

In response to questions surrounding the possible consequences of coastal flooding from climate-induced changes in hydrology and sea-level rise upon *whaanau/hapuu/iwi* assets, activities and things of value, interviewees identified a range of potential impacts and risks facing different *whaanau* and groups across the community. Foremost in the minds of those questioned were deep concerns about the endangerment of children at Manaia School due to projected higher flood flows and road networks being impeded into, and out from, Manaia. Linked to these concerns interviewees also recognised the implications of obstructed road access for emergency services such as the MVRFF – including the disruption to wider road users and the community during, and in the aftermath of, such an event. Other potential impacts and risks for transport and storm-water infrastructure identified included the blocking of drainage storm-water pipes and drains by flood debris and sediment, and the scouring (as well as washout) of unsealed and sealed road foundations.

The risk of damage to *whaanau* homes and buildings (external and internal) was also widely recognised, 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. Some *whaanau* homes and buildings were recognised as particularly exposed to these risks. Any increase in the frequency of extreme flood events was also viewed as possibly leading to the insurance industry withdrawing coverage altogether for some *whaanau* and/or increased premiums which would intensify the challenges already facing particular *whaanau* in dealing with future flood risk. Further, a couple of interviewees commented that projected future impacts and risks facing the community might be also aggravated by the return of city *whaanau* 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.

There was also recognition of the potential failure of household sewerage systems and the risk of faecal contaminants entering waterways and drinking water supplies which can in turn lead to the spread of various water–borne diseases. Adverse impacts from pollution and destruction of septic tanks and sewer lines on *mahinga kai* were subsequently identified including recognition of such impacts on community recovery following an event. Further potential impacts and risks identified by interviewees included damage to vehicles, disruption to businesses due to interruption or damage to transportation, postal and telecommunication networks, and compromised safety for stock (sheep and cattle) grazing the lower lying areas of the settlement. Adverse impacts on coastal sacred sites such as traditional *paa* and burial grounds were also acknowledged and this was of deep concern to many of those interviewed - particularly from the point of view maintaining cultural heritage, *hapuu*-identity and *whakapapa* to place. The potential impacts and associated risks from climate change induced river flooding coincident with projected sea-level rise for different *whaanau* and groups across the community are summarised in Box 3. Note that the identification of possible response and adaptation options by interviewees and the author team are considered and discussed separately in Section 8.2: Managing future climate vulnerability, endurance and adaptation.

Lastly, even if the probability and intensity of hazard activity were to remain constant, continuing population growth and economic and infrastructure development across Manaia

and the wider Hauraki-Waikato region is expected to result in an increase in the potential magnitude and significance of loss and disruption associated with hazard activity, and consequently, risk.

Box 3: Potential impacts and risks caused by climate induced river flooding

- Danger to life in the case of extreme flood events - particularly for elderly residents living alone and school children at Manaia School;
- Damage or destruction of lifeline infrastructure such as roads, water, gas, sewerage, power, communications;
- Costs from service disruption to water, power, gas, communications;
- Road access is likely to be impeded for certain whānau/households living on Goldfields Road and Marae Road;
- Damage to homes, machinery and equipment as well as community buildings such as the marae, school, health clinic;
- Loss of household contents and family records/heirlooms;
- Costs of clean-up, construction and maintenance of protection structures;
- Households may find it more difficult to access adequate insurance cover in the face of increased flood risk;
- Altered river flows in association with newly configured rivers and streams;
- Loss of land-holdings and farm-stock as well as related economic opportunity/income;
- Destabilisation of properties and surrounding lands from flood runoff and erosion;
- Adverse health impacts: injury, stress, trauma and sickness;
- Damage and loss of sacred sites/places resulting in loss of identity and *whakapapa*;
- Adverse impacts on ecology from erosion, sedimentation and pollution from destruction of septic tanks and sewer lines;
- Increased pressure on formal and informal *whānau*-based support systems;
- 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 Manaia to climate-induced coastal changes. The aim here is to summarise the context within which the vulnerability and adaptability of the community at Manaia 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/hapuu/whaanau* 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 experiences, perceptions and sensitivities, even deeper complexity is often the result. 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, *whaanau* and groups within the community experience and respond to on a daily basis.

Infrastructure and resourcing

Infrastructure and resourcing feature repeatedly in domestic and international studies of vulnerability to climate hazards and risk, with connections often made between these contextual drivers and resulting outcomes for different sectors, systems and groups (Cooper and Brooking, 2001; Waldegrave *et al*., 2006; Tribbia and Moser, 2008; among others). Such being the case, there is a corresponding recognition that future decisions surrounding key infrastructure and housing will need to take account of new climatic conditions such as higher sea-levels and altered hydrological regimes. Thereafter, actions to refurbish, upgrade, and/or replace buildings, transport structures, energy services, telecommunications and water networks will be shaped by current planning processes, statutory limitations, political will, capacity and funding deficits, as well as reliable information and communication about risk probabilities (Manning *et al.,* 2012).

Unreliable and aging lifeline infrastructure (including substandard housing arrangements) were recognised by a number of the home-people from Manaia as an important and existing community issue that compromises the health, wellbeing and endurance (resilience) of some *whaanau*. Many interviewees also acknowledged that such circumstances and living arrangements make it harder for these *whaanau* to be prepared for adverse climate conditions and that these conditions actually exacerbated the sensitivity of different *whaanau* to weather and climate related variability and extremes. Such impressions are consistent with the work of a number of commentators including Waldegrave *et al*. (2006) who found that a lack of affordable and quality housing in New Zealand is faced by disproportionate numbers

of Maaori and that this situation compounds challenges for those *whaanau* who are exposed to climate hazards and their risks. Furthermore, the modelling work undertaken in this study has also shown that future planning for vital infrastructure such as Manaia School must take into account the location of buildings, preferably outside flood plain areas and away from coastal spaces that are vulnerable to flooding and erosion.

Linked resourcing issues are 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 indicates that the financial capacity of many *whaanau* within (and connected to) the Manaia 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 conditions are limited at best. Economic hardship and resource limitations means that for many *whaanau,* 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 *whaanau* who face significant financial constraints were able to minimise such hurdles it would contribute enormously to the capacity of these *whaanau* being able to better respond and plan for adverse climate consequences and related stresses when they arise. 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 community (e.g. *iwi*-scholarships for education and business innovation).

A further Maaori-specific issue related to housing and resourcing is that there are major differences between Maaori home ownership on Maaori land and general home ownership on individual title. That is, on Maaori owned land *whaanau* homes cannot be traded in the same way that homes can be under mainstream property arrangements. This situation thereby locks *whaanau* in when they decide to build on Maaori land and can discourage capital investment when *whaanau* have limited resources. Perhaps new initiatives, such as the availability of financial grants through the Government's Social Housing Unit to assist building new housing stock on Maaori land, might assist these challenges. According to Wixon (2008) the initiative is probably best for *whaanau* 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 Maaori need to come to terms with in order to realise housing projects on Maaori 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 *whaanau* in accessing and maximising their assets and resources as Maaori and as individual citizens of New Zealand is critical to strengthening *whaanau* 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). While there is value in such actions – particularly from the point of view of setting objectives, the reality is that for some of the *whaanau* 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 *whaanau* at present. More equitable policy interventions that can provide resource assistance through subsidies and technical support to *whaanau* 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.

Social-cultural networks and conventions

Social-cultural networks and related cultural conventions and values are widely recognised as central to the long-term health, well-being and resilience of *whaanau/hapuu/iwi* and associated Maaori communities to deal with adverse or unexpected socio-ecological challenges (Durie, 2005; Panelli and Tipa, 2007; Moewaka-Barnes, 2010; Mikaere, 2011; King *et al.*, 2012, among others). 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 (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 *whaanau* and *hapuu* 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*. According to Durie (2005) these values, conventions, rules and behaviours are all important indicators of Maaori endurance (resilience), bringing people together to support and share in times of abundance and adversity. However, he also argues that access to *Te Ao Maaori* is integral to Maaori endurance - as the separation of Maaori from their 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 Maaori. Mikaire (2011) also points out that while Maaori society is open to change it is nonetheless protective of these fundamental norms and principles[72].

Notwithstanding these clarifications, a number of home-people considered that the levels of comprehension surrounding such traditional values and practices were diminishing, unobserved by some *whaanau* and unknown altogether by others. Analogous challenges and transformations have been identified in place-based studies with Inuit communities

[72] 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.

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 thereby 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. More specifically, a central task ahead for Maaori leadership is 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 Maaori world views are endorsed.

Knowledge, information and education

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; Kral, 2003; 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 Manaia centred around the diminishing relationship *whaanau* have with the natural world, and the subsequent recognition that such changes have implications for not only the supplementing of household food supplies and linked self-reliance but also tribal identity and custom.

Explanations for these changes are not entirely different from those offered by other groups and commentators - and mainly include references to fewer *whaanau* remaining active on local lands and water-ways; more time spent away from the area by many *whaanau* (particularly younger members of the 'community'); and a number of city *whaanau* returning to live at Manaia but with little experience of hunting, fishing and gardening. The authors were also reminded by a number of elders in the community that the increasing reliance by some of the *whaanau* on technology can also lead to reduced self-sufficiency and less flexibility, which are regarded as crucial qualities for dealing with adverse environmental conditions. 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. These changes are recognised as limiting 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 *whaanau* 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. Issues of catchment management and high-risk flood areas were recognised by many interviewees, as too was detailed understanding of hydrological processes such as the role of tides in governing the timing of extreme flood episodes at Manaia. Some *whaanau* 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 apologetic comments by some *whaanau* who admitted that they no longer possessed such knowledge. Notwithstanding this, in combination with collective-based values and conventions, these insights and skills were commonly recognised as the 'Maaori-way' of managing risks and thereby mitigating harms.

Similar conclusions have been drawn by Durie (2005) and King *et al*., (2007), whom have argued that Maaori 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. Incidentally, 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 purportedly 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 Manaia are regarded as central to ensuring that Maaori lifeway's continue and that *whaanau* are in turn able to minimise risk and sustain themselves in the future.

New interactions and the development of new skills and expertise by *whaanau* spending more time away from Manaia for work and education as well as the return of 'city-whaanau' wishing to reconnect with their *turangawaewae* 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. For example, 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 *et al*., 2006; Gearheard *et al*., 2006).

Planning, governance and competing values

The importance of central and local government planning and its influence on indigenous development (and related endurance to face adversity and stress associated with social-ecological changes and risks) is widely acknowledged (Berkes *et al*., 2005; Matunga, 2006; King *et al.,* 2010). Many Maaori communities and populations have also identified local planning arrangements as critical factors that facilitate and/or 'stand-in-the-way' of better outcomes for Maaori including the management of risk associated with natural hazards and environmental changes (MfE, 2007; King *et al*., 2008; King *et al.,* 2012). For instance, many members of the Manaia community involved in direct iwi representation and/or participation in local planning and resource management matters commonly discussed 'prohibitive' policies, plans and processes that restricted how Maaori land assets could be developed and used. Durie (2005) reminds us that successful Maaori endurance requires Maaori participation in mainstream planning in order to realise and convert vision and possibility into sensible realities.

Iwi management plans recognised through the 2005 Resource Management Act (RMA) amendment have partly assisted Maaori 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 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? More specifically, Maaori 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 Maaori are actually grounded in Maaori community realities, aspirations and goals (Matunga, 2006).

Climate change planning for Maaori 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). Reducing sensitivities and enhancing adaptive capacity will only be successful however when they are integrated with other policies such as land-use planning, environmental conservation, coastal planning, disaster preparedness and national plans for sustainable development. Such development and implementation of such policies will therein require institutional awareness, vision and perhaps even the creation of new institutional and governance arrangements whereby Maaori are represented and participate as citizens and as *tangata-whenua*.

Future iwi development and management of social-ecological risk (and by extension climate change) will not only come from greater Maaori involvement in local, regional and central government institutions, but will also demand the strengthening of existing (as well as the creation of new) tribal governance structures. For example, the HMTB is charged with providing formal structures for dialogue at the *hapuu* and *iwi* level, as well as linkages with external organisations such as local and regional authorities[73]. Such institutions have increased formal access for *iwi* to high level regional management discussions and decision making processes, as well as provided the community with expertise and information that contribute to *hapuu/iwi* development and capacity[74]. Furthermore, the growing maturity of the Crown-Maaori partnership relationship provides a framework not only for the on-going settlement of Treaty claims, but also for accelerating tribal and inter-tribal development and global opportunities.

Finally, a significant challenge identified by mostly older interviewees related to the on-going ‘competition of values’ that is occurring. This ‘competition’ was articulated in terms of

[73] A new chapter has begun in the relationship between Ngāi Tahu and local authorities in the Otago region. A governance charter signifying the creation of Te Roopu Taiao Otago was recently established to act as a forum between Ngāi Tahu and local authorities to facilitate better mutual understanding, improve iwi engagement and resourcing for council-oriented business, and foster and grow iwi capacity in local government (Otago Regional Council, 2012).

[74] Interestingly, Baker (2010) identifies that from the 1980s, there has been an apparent paradox in the actions of Māori organisations and iwi groups, versus the experience of Māori as individuals. That is, Māori organisations and iwi groups began (and continue) to seek Māori-led development and solutions through innovation, enterprise, leadership and enhancing *whānau* capacities. In contrast, Māori as individuals were significantly impacted upon by the economic reforms of the 1980s.

government policy directions, wider societal development paths and linked regulatory regimes which conflict with traditional Maaori views about the intrinsic value and integrity of *Papatuuaanuku* [Mother-Earth, the ecological system], as well as neglect of the inherent duties, obligations and responsibilities to safeguard the living options for future generations. The 'competition' was also described by reference to increasing examples of individualistic and materialistic behaviours wherein economic activities appear to be driven more by want and self-interest rather than need and notions of collective responsibility. Taken together, these perspectives reveal sharp tensions about the philosophical basis underpinning Maaori and non-Maaori environmental ethics[75], the resulting management of natural resources (including the solutions proffered to adapt to climate change), the role of the Treaty of Waitangi and the related authority and responsibilities of government and Maaori, as well as other spheres of influence which determine human behaviour, choices and actions.

Things do not have to remain the same however, rather, changes can occur if the wider institutional, governance and policy settings in which Maaori act also change to take more meaningfully account of Maaori and non-Maaori and values whereby both are treated as equally important. Progress for Maaori will likely require the establishment of new kinds of relationships, between Maaori and Maaori, and between Maaori and the Crown. Such fundamental shifts will play a key role in helping to distinguish and develop new transformative societal governance, identity, culture, operations and responsibility across wider Aotearoa/New Zealand.

8.2 Managing future climate vulnerability, endurance and adaptation

In this penultimate section, 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 Manaia, 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, are presented. 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[76]. Such options are based upon direct feedback from the community at Manaia to projected climate change impacts and risks, the draft results of a working party to develop a 'community plan' for Manaia, as well as national and international assessments of adaptation practices and options.

Before proceeding further, it is important to acknowledge that the coping and adaptation strategies and actions identified below are based upon fundamental risk management principles which 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 recognises four key components in managing societal risk from natural hazards: reduction, readiness, response and recovery. Together these four R's contribute to limiting impacts and supporting adaptation (MCDEM, 2004). Given the inherent complexities of the climate system, and the

[75] Environmental ethics is concerned with the moral relations that hold between humans and the natural world. The ethical principles governing those relations determine your duties, obligations and responsibilities with regard to the natural environment and all that inhabit it.

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

many social, economic, and technological factors that determine impacts, future adaptation will need to be iterative where risks and possible response options are revisited over time taking advantage of new knowledge, information, and technological capabilities.

Reducing exposure to coupled sea-level rise and river flooding

In varying ways and degrees, future projections of sea-level rise[77] and coupled river inundation (along with concomitant transformations in living arrangements) are expected to challenge how different *whaanau* and activities across the community at Manaia 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 actions (or entry points) to help limit projected impacts, support coping strategies and facilitate adaptation decisions and activities. Some of these options were previously identified in Section 2.3.

(i) Future-proof existing infrastructure and buildings.

This option recognises the existing exposure of key access roads (i.e. SH-25, Marae Road and Goldfields Road), high-value infrastructure (i.e. Manaia School and Manaia Marae) and private *whaanau* homes (among other structures), to flooding in association with high rainfall and elevated levels in the Manaia River coincident with high tide conditions in Manaia Harbour. Options include raising the lowest lying sections of SH-25, Marae Road and Goldfields Road which when flooded can prevent access in and out of the Manaia Valley area. Construction of a formal spillway over SH-25 between Manaia Bridge and Goldfields Road was also previously identified by Environment Waikato (2009) to limit waters to only one part of the road. Other related options include elevating existing homes (many *whaanau* identified building on poles) and raising floor levels for buildings in areas close to rivers and the sea. Note that 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 surface waters. This practice is currently employed at Manaia School - although a reliable flood-warning system is critical to the provision of sufficient lead time.

(ii) River maintenance and modification.

Removal of gravel and sand build-up and debris along the Manaia River would help to minimise the risk of erosion and flood waters spilling onto higher ground. It is also important for debris caught under structures such as bridges which can result in flood-waters backing up and being dammed behind such obstructions. This option effectively increases the channels capacity (either by widening or deepening the channel) to carry and confine higher flows of water to the main river channel during flooding. However, the success of any such strategy would depend on a corresponding widening of the river channel in the vicinity of Manaia Bridge (Environment Waikato, 2009). Such strategies are a part of many river management practices, which require regular work and maintenance to be carried out. Other

[77] 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 (MfE, 2008b).

options include willow removal, native planting of riparian areas and the fencing of stream banks to prevent damage from wandering stock. A further option identified by Environment Waikato (2009) comprises the straightening of the path of Manaia River in the lower reaches near to Manaia Marae. This would decrease the length of the river in the last reach, and likely 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 issues surrounding the stability of such a channel and on-going maintenance, heightened risks associated with faster river flows, unknown biophysical environment effects and the likely requirement of a new bridge due to the change in channel location.

(iii) 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 the coastal waters. Homes next to the Manaia Bridge and the relatively recent relocation of a dwelling to the Manaia flats area on the seaward side of SH-25 are particularly exposed to coastal-river reach flooding. Decisions to further develop such areas should be based on precautionary approaches that involve a combination of *risk-avoidance* and *risk-reduction* considerations. Note that 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 in the district plan are in controlling subdivision, use and development activities in coastal hazard areas. Perhaps even more important the effectiveness of plans depends on the degree to which compliance with the district plan is monitored and enforced. Such being the case, land-use rules can be made more effective through community defined standards that in the case of Manaia are designed to preserve community well-being, history and identity, and the integrity of Te Taiao. A popular planning option identified by a number of home-people included flexible land-use practices which would allow rotation of cattle and horticultural activities on areas that are currently recognised as high flood risk.

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

Given the cost of physically relocating lifeline infrastructure and *whaanau* homes this option is likely to be very expensive - even if restrictions surrounding the number of dwellings permitted on Maaori reserve lands were lifted and/or more traditional conventions such as 'land-gifting' were possible and acceptable. Aside from resourcing constraints, moving from some ancestral areas, sites and *whaanau* homesteads is likely to be unacceptable for some of the *whaanau*. On the other hand, a number of interviewees emphasised that pragmatic decision-making and *iwi* led planning around risk avoidance and the movement of people away from high risk areas would be easier for *whaanau* to accept. There may be deep heartache involved, long-running debates and even people who will never agree to such a proposition, but moving from highly exposed sites in the interests of *whaanau* health and well-being is not unprecedented. It has happened before and it will happen again[78].

[78] 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.

(v) 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 Maaori perspectives, such an approach provides for a greater account of 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 harbour edges and creeks to assist the capture of silt into rivers and the harbour, among others. Note that a popular community vision for the catchment includes lining the streams with native tree and plant species, restoring stream/river water quality for wild-life and other human resource values and activities, and closer working relationships between landowners, Landcare groups and local authorities to support the improved care and use of natural resources within the ecological system. Recent steps have been taken to enhance the area in the front of the *marae* with wetland plantings.

(vi) Encourage sustainable infrastructural development.

Major long-life infrastructure (such as roads and causeways) will likely need climate change factors incorporated into future design, planning and construction; and improvements in house-hold water, energy and sewerage services (among others) will assist *whaanau* to reduce climate risks and thereupon face adverse conditions caused by climate extremes. Other gains from sustainable infrastructural development include more secure domestic energy supply, reduced pollution and healthier social systems. Throughout the course of this work, most of the home-people interviewed shared aspirations of becoming more self-sufficient relying on renewable energy from local renewable sources; operating alternative systems to septic tanks (e.g. composting toilets), and seeking other alternatives for grey water disposal; promoting the use local building materials such as mud bricks and wood from native/exotic trees on Maaori owned lands; and more simply providing footpaths for children to walk to school on. Another important sustainable infrastructural development issue for the community at Manaia includes the future development of healthy and affordable housing. At present there are a number of barriers to building homes on *whaanau* land however; including among others the high cost of permit and resource consent fees. Such challenges highlight the co-dependency (as well as co-benefits) of exposure-sensitivity-adaptive-capacity realities facing Maaori communities. 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 low income families who have *whaanau* land and wish to develop this for *whaanau* housing is crucial. Actions across many of these sustainable infrastructural development options would likely lead to employment creation for local people.

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 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 *iwi/hapuu/whaanau* awareness of climate change risks, mitigation and adaptation; as well as the linkages with sustainability and natural hazards management requires making available, and promoting, information and education. Transmission pathways might include programmes and learning through *marae*, *waananga*, *kura*, *whaanau* workshops, websites, public talks, Maaori radio and television, as well as more traditional pathways through first-hand experience on-land or on-sea. Perhaps new ways of story-telling might also help to build awareness and therein assist the up-take of new (as well as time-honoured) messages. In order to achieve the massive social shift that is required to ensure that we live within the earth's capacity to sustain life, education must be central to all learning, from early childhood through to tertiary level and also in non-formal education. More specifically, encouraging Civil Defence procedures and capabilities would help to promote awareness - particularly given that some of *whaanau* communicated that they did not know about the considerable work being undertaken by specific community members to have the Rural Fire Service formally recognised as a Civil Defence post for the Manaia settlement. An improved forecasting system supported by local rainfall and river flow information to deliver advance warning of extreme climate events would also be beneficial – particularly in terms of providing sufficient lead time to reduce potential harm to people, buildings and their contents (especially those contents that can be easily shifted). Improved and reliable broadband internet access and cell phone coverage would greatly assist such an initiative. There are also ways of raising public awareness through statutory mechanisms, such as incorporating hazard and risk information in regional and district plans, and other planning documents such as Long-term Plans. Finally, 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 also assist the opportunities above.

(ii) Reaffirm human-environment relationships and Maaori ways of knowing.

Together with learning new strategies and practices, the reaffirming of human-environment relationships through *whakapapa*, *tikanga, kaitiakitanga* and related Maaori ways of knowing and being was widely acknowledged as critical to realising a more sustainable future for the community and society more widely. Accordingly, prosperity and well-being are viewed as dependent upon the balance between social, cultural and economic development and the strengthening of *Te Taiao* by minimising damage to *Papatuuaanuku*. Consequently, there is a deep desire among the home-people that their children know their cultural heritage and identity, as well as understand fundamentally that socio-cultural, environmental, and economic realities are inextricably linked. From these beliefs, ethics and values - traditional behaviours and life-ways based on *iwi, hapuu and whaanau* networks and cultural conventions are expected to be uplifted. In no particular order actions might include: promoting the well-being and protection of *Te Ao Wairua me Te Taiao* [the spiritual and physical environment]; conducting *marae*-based *reo* and *tikanga waananga* to teach the

young to strive for balance and harmony in their lives [offering alternatives to drug and alcohol culture]; being usefully and gainfully employed, or alternatively being able to support oneself by living off the land and sea; and more specifically, establishing an education and communication strategy aimed at informing locals and non-locals about appropriate or inappropriate behaviour related to the use of the water-ways, the harbour and other culturally important sites and places. Note however that reaffirming of the human-environment relationship is largely dependent upon *tangata whenua* being able to exercise their authority as *kaitiakitanga* over their *whenua*, harbour and waterways. Shared norms and clear vision provided by astute leaders will also be key, based on a vision of inheritance for future generations.

(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 Maaori 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. Finally, it is notable that the work and results produced through this study are based upon a formal collaboration between Ngaati Whanaunga Incorporated Society and NIWA as a science provider, which is expected to assist the community at Manaia in identifying future climate change impacts, risks, adaptive strategies and opportunities.

(iv) Leverage economic support and technological resource pathways.

In most instances, economic support will be required to assist on-going flood risk reduction, emergency preparedness and adaptation to new climate conditions. Given that the vulnerability and endurance of communities like Manaia are strongly shaped by financial conditions, assistance will be required to assist any modifications, improvements and/or maintenance of lifeline services, key community infrastructure and *whaanau* housing, among other activities. Linked to these needs, financial support is also required to assist more sustainable land-use practices. Financial measures can be provided by the council (e.g. rating relief or grants – which may include land management agreements), by organisations such as Queen Elizabeth II National Trust (encouraging rural landowners to maintain undeveloped coastal areas and/or to assist with land management for conservation purposes), or by the government (e.g. through reserves). Fostering partnerships with government bodies, companies, community organisations, and neighbouring councils might also yield funding opportunities for important research and development.

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

There are likely to be opportunities to consider climate change adaptation planning in wider *iwi/hapuu* planning efforts. These might include integrating disaster preparation, flexible resource management regimes, and environmental conservation into *hapuu/iwi* plans for sustainable development. It might also comprise formally supporting the protection and enhancement of ecological systems such as streams, wetlands, estuarine and harbour areas linked with Land-care groups, science providers and Council initiatives. 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 Maaori political participation and involvement in broader societal decision-making processes and institutions, including formal recognition and provision of *hapuu/iwi* management plans, principles, practices and values by relevant territorial authorities, will be crucial to the implementation of *iwi/hapuu* and *whaanau* aspirations, health and well-being. Further, community-based strategies more generally 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, as well as greater understanding of the relationship between past and present variations in climate and the performance of economic, social and environmental systems. New systems for collecting and sharing information can also help to ensure that climate-related decisions are informed by the best available knowledge and analyses, and can moreover help to evaluate the effectiveness of actions taken. Incidentally, the development of the Estuarine Monitoring Toolkit alongside the community at Manaia is particularly helpful for tracking the state and character of certain environmental indicators – from the monitoring of sedimentation rates and river flows, to the abundance and distribution of *kaimoana* [shellfish, sea-food] species and their relationship with exotics and land-based activities, to identifying sources of pollution entering water-ways and harbour system. Such locally embedded scientific tools provide an invaluable opportunity to understand scientific techniques and processes as well as positive examples of working alongside scientific and academic agencies.

Lastly, in the context of climate change the Manaia community's management of risk in the future will be about drawing upon the best available information to determine the likelihood of climate impacts and the secondary or flow-on effects of their consequences. Along with precautionary approaches to planning new development, infrastructure and services to *avoid* coastal hazards, this information will provide the basis upon which to select and implement adaptation options that will minimise climate risk and therein help to avoid potential harm or loss. Please note however that risk management measures will never completely remove coastal hazard risks. That is there will always be some remaining risk (referred to as the residual risk), which involves living with accepting risk. Any associated consequences can thereafter be dealt with via emergency management plans and by signalling risk through the insurance process. Taken together these strategies are likely to lead to greatly lessened community vulnerability to the risks from climate variability and extremes.

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 Manaia. 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 *whãnau* and groups across the community as well as begin to understand the factors and processes that constrain and facilitate *whaanau* 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.

Mapping results from our assessment of projected sea-level rise impacts for 2040 and 2090 AD (under mean river flow conditions) indicated that an increase in sea-level of 0.4 m by 2040 AD will result in broader areas of coastal marsh and pasture land being inundated by the ocean on a regular basis. In contrast, by 2090 AD an increase in sea-level of 0.8 m indicated that a large expanse of currently stable, dry land in the lower reaches of the Manaia River will be in the future tidal zone. Blocks of this coastal land remain in communal and private Maaori ownership and are used predominantly for housing and cattle grazing. Such land-use activities are expected to be impacted and disrupted more frequently under such scenarios, particularly as permanent inundation occurs. It is also likely that the high tide will propagate further landwards, periodically reaching, and eventually exceeding the current position of SH25. Less is known about the direct and indirect impacts of such physical changes on local ecosystem services and related wild-food availability; however, potential adverse impacts from flood debris, saltwater intrusion and septic tank leakages are possible.

Next, our assessment of future extreme river flooding coupled with increases in sea-level rise across the Manaia coastal-river reach indicated for both the A2 and B2 climate change scenarios that the projected inundation extents for 2040 and 2090 AD are unlikely to differ markedly from the reference extents experienced by community members during the extreme flooding of June 2002. This outcome is principally due to the relatively steep edges of the valley sides where heightened water levels can change substantially without much corresponding change in the extent of flooding. Notwithstanding these modelling results however, considerable infrastructure is at greater risk of inundation and flood damage due to increased flood levels under both the A2 and B2 scenarios in 2040 and 2090 AD. Notably, Manaia School and some *whaanau* homes are located in an area that was inundated by more than 0.5 m of water in 2002 and it is expected that corresponding flood conditions in 2090 AD will add at least another 0.1 m of depth to flood water levels in this vicinity. Heightened risks are also likely for some occupied and unoccupied *whaanau* homes, storage buildings and sections along Goldfields Road and Manaia Road. Note that while the frequency of extreme flood events comparable to June 2002 reference event 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. Further work would be required however to translate changing rainfall frequencies into future flood frequencies.

Concurrent with the quantitative methods and results produced through this work, in-depth semi-directive interviews (including many informal discussions and land-walks) were carried out between October 2010 and September 2012 with a total 46 ‘home-people’ who reside within, and/or live in close proximity to, Manaia settlement. During these group, paired and individual engagements, the interviewees shared their experiences of climate and coastal hazards (and associated environmental changes) in and around the settlement of Manaia – including specific knowledge of local hydrology, areas susceptible to flooding, and importantly a range of ‘things’ or matters that enable as well as obstruct *whaanau* from effectively ‘dealing with’ climate related impacts, risks and stresses. Subsequently, analysis

of how *whaanau* and different *iwi/hapuu* 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 include: (i) Infrastructure and resourcing, (ii) Social-cultural networks and conventions, (iii) Knowledge, information and education, and (iv) Planning, governance and competing values.

The poor state of local infrastructure and housing, as well as insufficient resourcing and finances to adequately reduce risk and exposure to potential impacts, dominated many discussions and conversations. Many interviewees acknowledged that it was harder for *whaanau* to realise "healthier" living arrangements under such constraints and that these conditions exacerbated the sensitivity of different *whaanau* to weather and climate related variability and extremes. While it is accepted in general terms that community members rarely have all the resources they require to achieve their goals, more needs to be done to support *iwi/hapuu/whaanau* to take greater advantage of their natural, social and cultural capital. In addition to these challenges, institutional and legislative influences are also recognised as having a determining impact on *iwi/hapuu/whaanau* well-being and development. These include questions over equitable representation in local planning and resource management arrangements, to the nature of participation afforded to the community in social as well as environmental policy development and decision-making, to the even deeper challenge of competing human-environment values, beliefs and behaviour which are inseparably linked to ethics surrounding the integrity of life and the responsibility to future generations.

The importance of social-cultural networks and elemental cultural values and approaches centred around *tikanga*, *whanaungatanga, kotahitanga* and *aroha* were also recognised as fundamental to being able to manage and 'deal with' climate related hazards and risks as well as wider human-environment well-being. This depends not only on the relationship between *whaanau* and *hapuu* however but also the relationship between people and the environment – which is necessarily supported through regular interaction and the complementary principles of *rangatiratanga* [control and jurisdiction] and *kaitiakitanga.* The changing nature of the community however has had a serious effect on such 'relationships', thereby diminishing the effectiveness of such approaches. Linked to these insights and transformations, the loss (and significance) of Maaori knowledge (which includes traditional activities and practices) and knowing about environmental change and risk was also regularly pointed to – including the importance of traditional as well as non-traditional educational opportunities that allow young people to draw from more than one intellectual tradition and thereby realise new knowledge and skills. In recognition of these aspirations, ways must be found to promote 'walking the land' and connecting *whaanau* with those who have gone before, while simultaneously embracing new knowledge, skills, information, relationships and collaborations.

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 Manaia 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, *whaanau* 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 *iwi* leaders and decision makers across a range of scales and institutions, as well as *te hau kaainga* on the ground 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 Manaia thereby recognised the need to strengthen the social, cultural and economic capacities of *whaanau* and groups across the community to 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, *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, *whaanau* 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 difficult and most important "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 Maaori 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 Maaori 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 Maaori communities interested in examining in their own climate change challenges it is important to emphasise that consideration of community vulnerability and resilience 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. 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 *whaanau/hapuu/iwi* development and social-ecological well-being.

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11 Glossary: Maaori language

A	
Ahi kaa	Whaanau who maintain residency on ancestral lands, burning fires of occupation – title to land through occupation
Aroha	Sincerity, mutual-respect, love
Awa-awa	River, waterway, valley
H	
Hapuu	Sub-tribal kin group
Hau-kaainga	Home-people
Hiikoi	Land-walks, to step, stride, march, walk, field-trip
Hui	Assemble, meeting, gathering
Hura koohatu	Unveiling – a ceremony at the graveside to unveil the headstone
I	
Iwi	Tribal kin group
K	
Kahawai	Inshore pelagic fish
Kaainga	Home, village, settlement, habitation
Kai	Food, to eat, consume
Kaimoana	Shellfish, sea-food
Kaitiakitanga	Stewardship, respect, identity, guardian
Kanohi kitea	Seen face, in person, literally means ‘face to face’
Kapahaka	Traditional performing arts
Karakia	Prayer, incantation
Kauri	Native coniferous tree
Kaumaatua	Elders (plural) – not gender specific
Kaupapa	Topic, policy, matter for discussion, plan, scheme, agenda, subject, programme, theme
Kawa	Ceremonial rituals, protocol, etiquette, correct procedure
Kina	Sea urchin
Koru	Bay, inlet
Kotahitanga	Solidarity, unity, collective action
Kuia	Elderly woman, grandmother
Kura	School

Kuutai	Mussel
M	
Maahaki	Humility
Maaori	Indigenous peoples of Aotearoa/New Zealand
Maatauranga Maaori	Maaori knowledge – the body of knowledge origination from Maaori ancestors, including the Maaori world views and perspectives, Maaori creativity and cultural practices
Mahi	Work, employment, practice, activity, excercise
Mahinga kai	Food gathering, cultivation
Mana whenua	Territorial rights, power from the land - power and authority associated with possession and occupation of the tribal land.
Manaaki	To support, take care of, give hospitality to visitors, protect, look out for
Manaakitanga	Hospitality, kindness
Marae	Meeting house and surrounding area
Mauri	Life principal, entity
Mihi whakatau	Formal welcome speech
Moana	Ocean, sea
P	
Paa	Traditional settlement
Pakeke	Adult (plural), difficult
Papakaainga	Habitation, village
Papatuuaanuku	Mother-Earth, the ecological system
Paatiki	Flounder
Paaua	Abalone
Pipi	Clam, endemic mollusc
Pito	Umbilical cord
Poroporoaki	Farewell speech
Puupuu	Whelk, sea snail
R	
Rangatahi	Younger generation, youth
Rangatiratanga	Control, jurisdiction, authority
Rangi	Sky-Father
Reo	Voice, language
Rohe	Area, boundary, region, district

T	
Taamure	Snapper
Tangaroa	Deity of the sea/oceans
Tangata whenua	Home people, people of the land, locals, residents, hosts
Tangi	Funeral, grieve, cry
Taonga	Treasure, asset, artefact
Tauututu	Reciprocity
Tikanga	Maaori conventions, culture, custom, correct procedure, lore
Tio	Pacific oyster
Tuangi	Cockle
Tuna	Freshwater eel – *Shortfin eel (Anguilla dieffenbachia), longfin eel (Anguilla australis)*
Tuupuna	Ancestors, forbears
Tuurangawaewae	A place to stand, home grounds through rights of kinship and *whakapapa*
U	
Urupaa	Burial site, sanctuary
W	
Waahi tapu	Sanctuary, sacred area, shrine
Waipuke katoa	Flooding everywhere
Waananga	Seminar, forum, to meet and discuss
WH	
Whakaraapopotonga	Executive summary
Whaanau	Extended family, born
Whakapapa	Ancestral and kinship linkages to people and place, genealogy, literally means ‘to place in layers’
Whakapiki tangata	Empowerment
Whakatuia	Integration
Whakawhanaungatanga	Kinship, process of strengthening relationships
Whanaungatanga	Relationships, interconnection, birth
Whenua	Land, placenta

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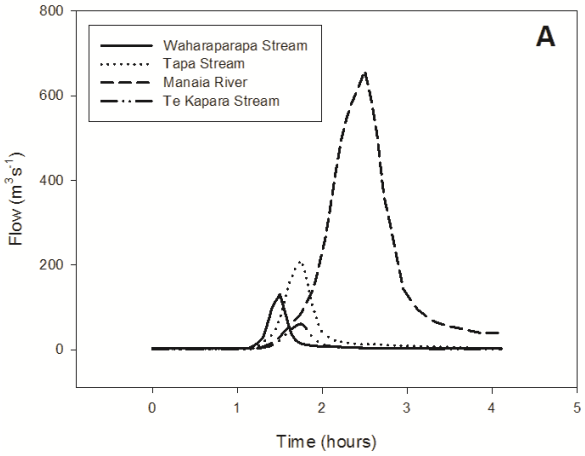
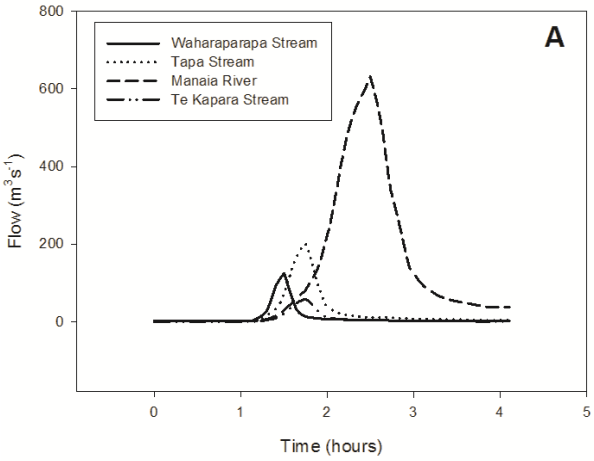
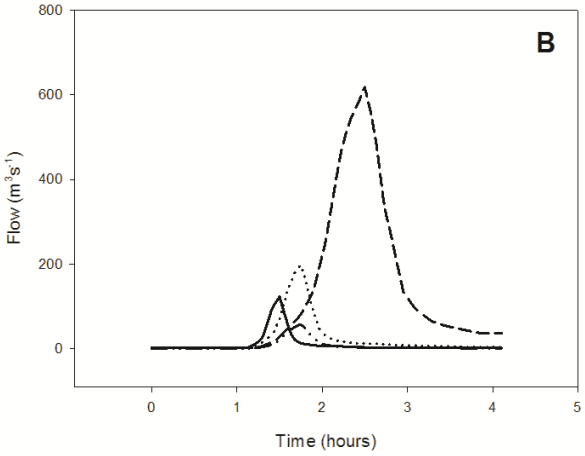
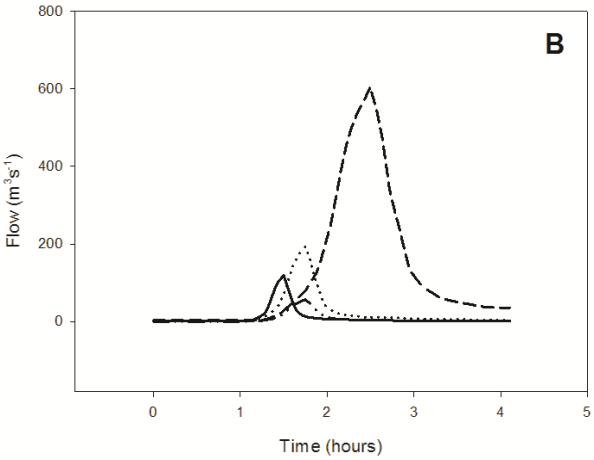
Appendix A Flood flow hydrographs – Manaia 2040 AD

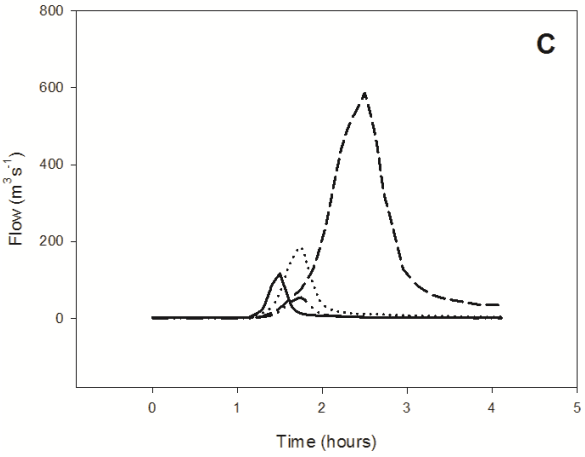
This appendix contains flood hydrographs for Manaia for 2040 AD under the A2 (left column) and B2 (right column) climate change scenarios for maximum (A), average (B) and minimum (C) emissions.

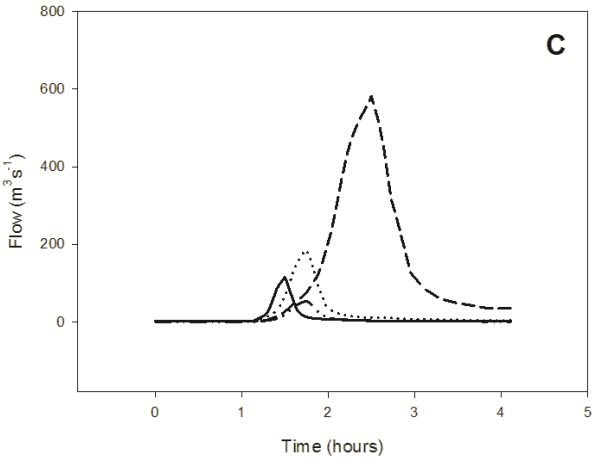






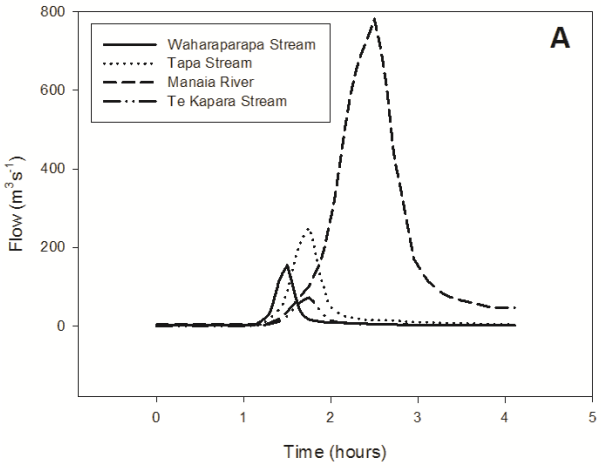


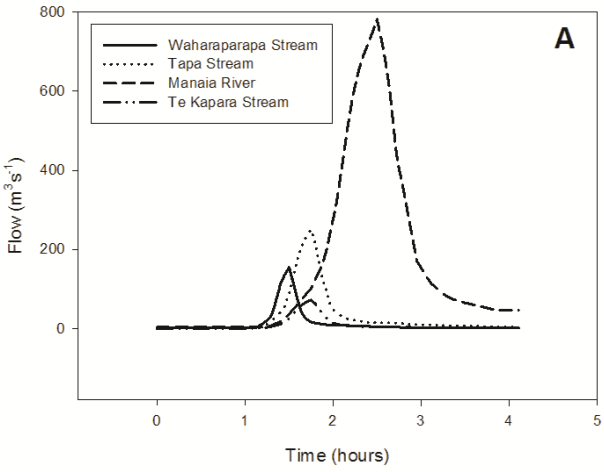


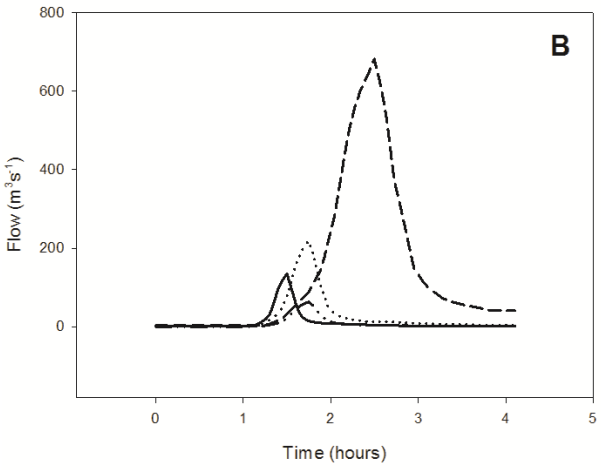


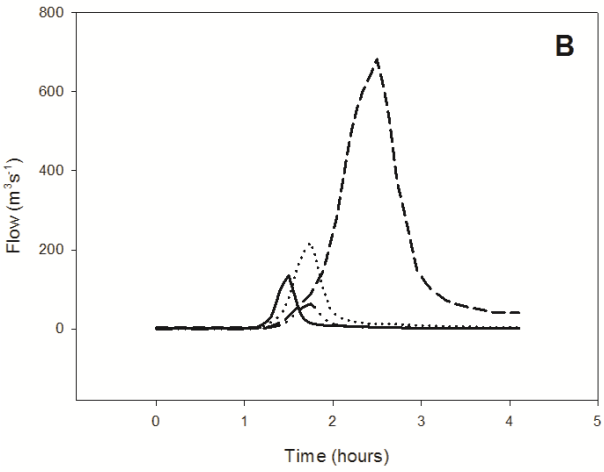
Appendix B Flood flow hydrographs – Manaia 2090 AD

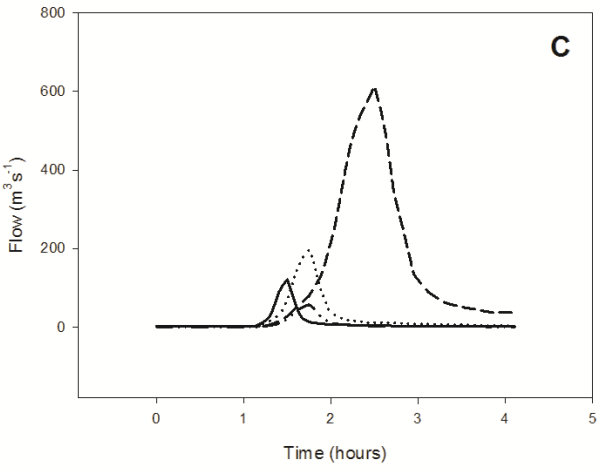
This appendix contains flood hydrographs for Manaia for 2090 AD under the A2 (left column) and B2 (right column) climate change scenarios for maximum (A), average (B) and minimum (C) emissions.

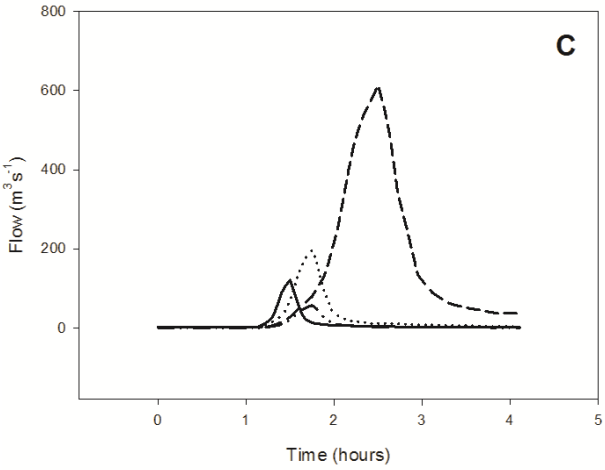






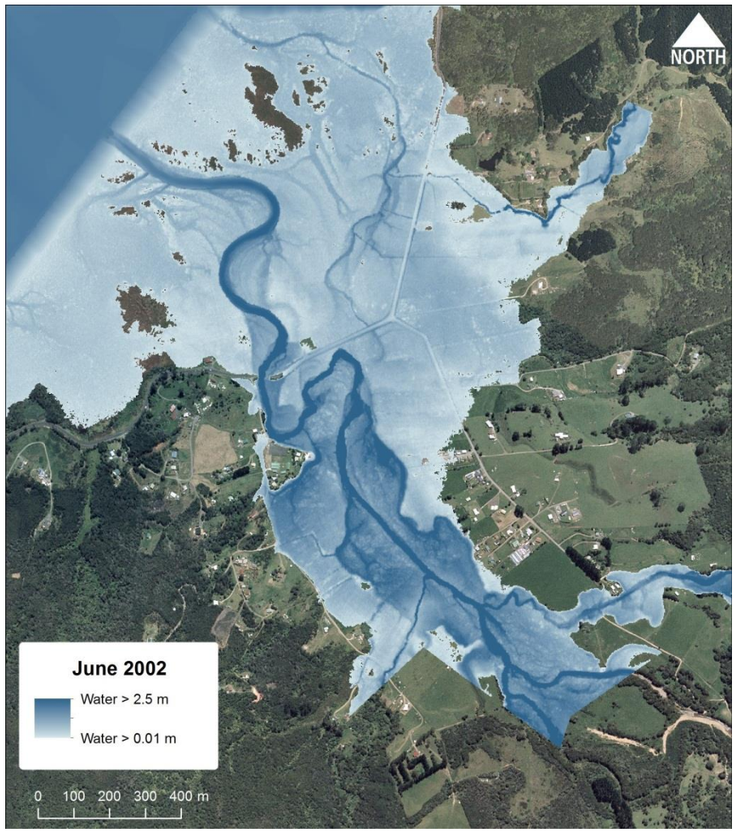


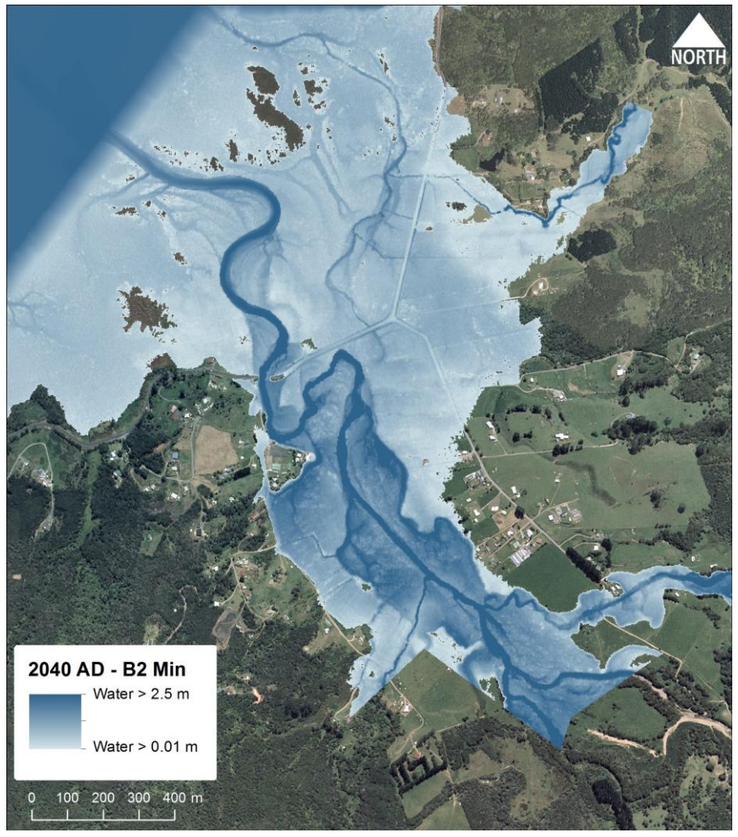


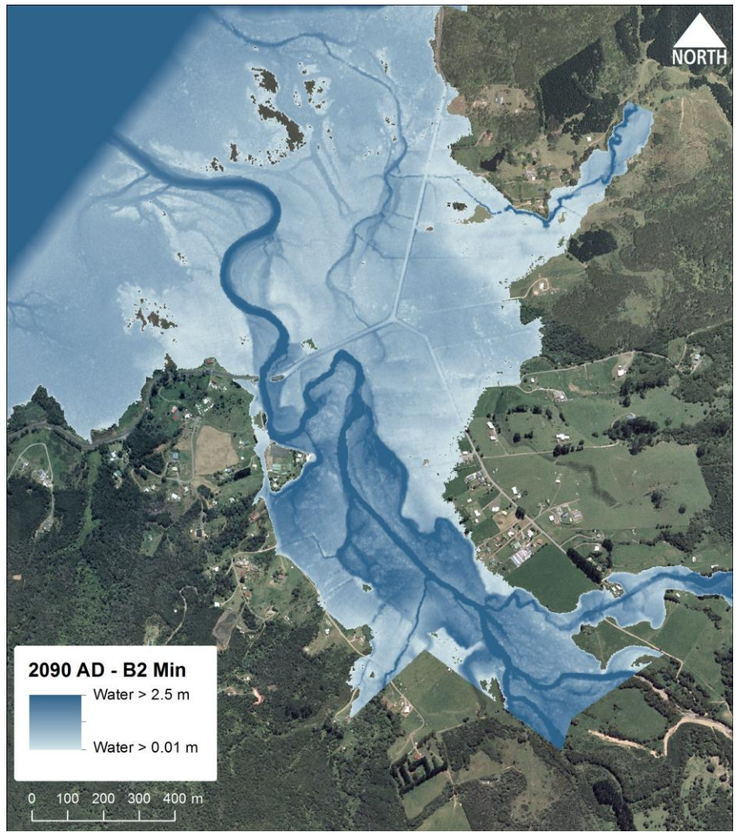


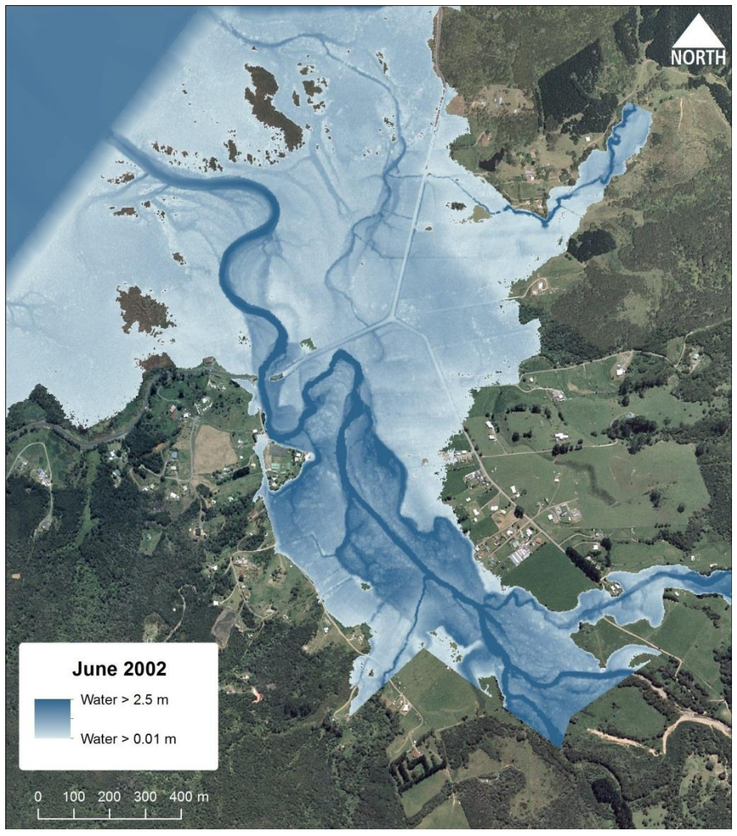
Appendix C Extreme flood scenarios at Manaia – B2 climate change scenarios

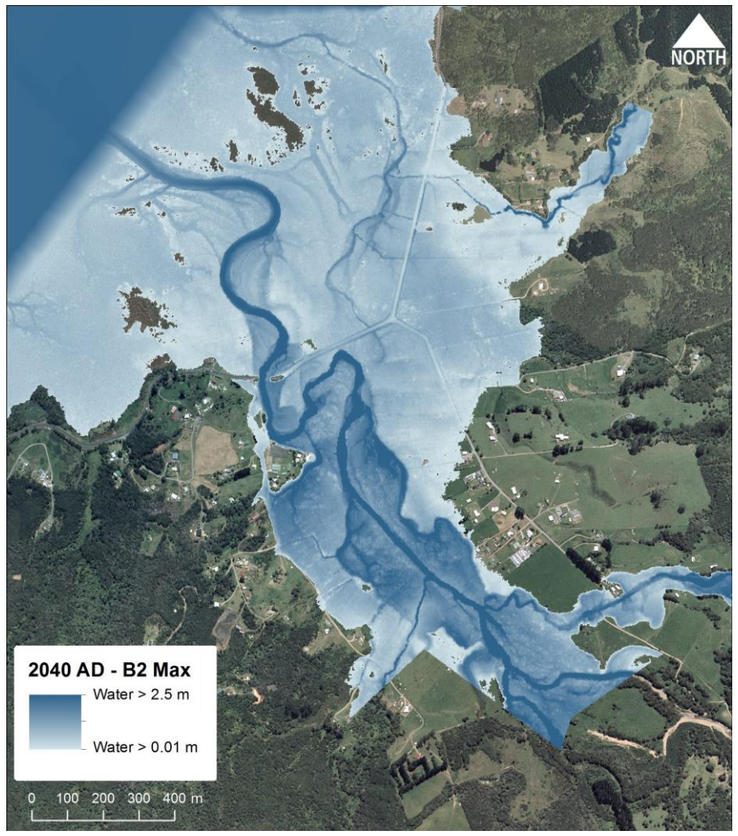
This appendix contains maps of the simulated June 2002 flood event as well as modelled 'minimum and maximum' climate change induced coastal-river reach flooding for 2040 and 2090 AD under the B2 climate change and the sea-level rise scenarios described in the text for Manaia – Waikato, New Zealand.

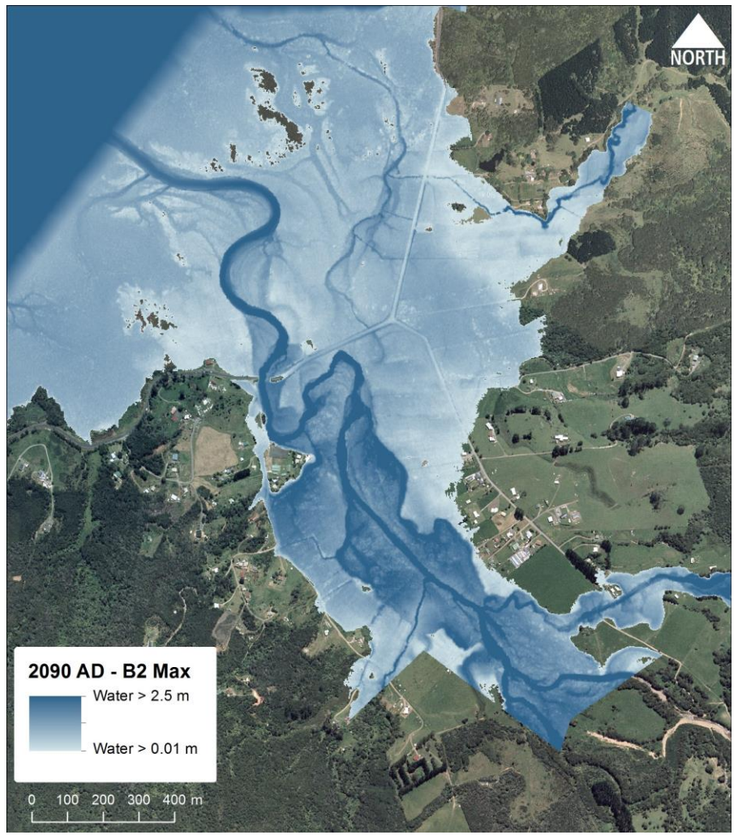






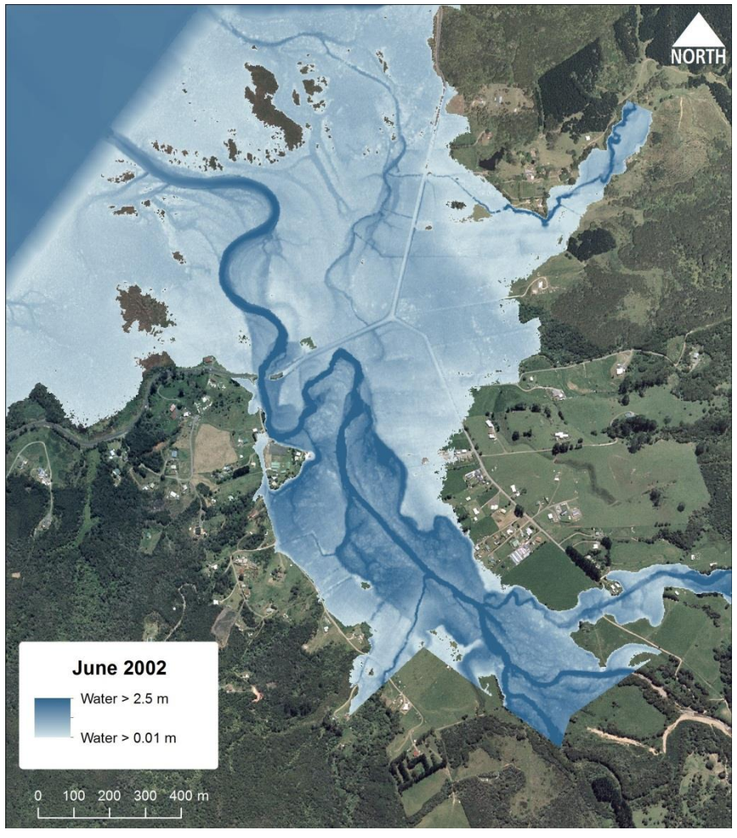

NORTH
June 2002
Water > 2.5 m
Water > 0.01 m
0 100 200 300 400 m

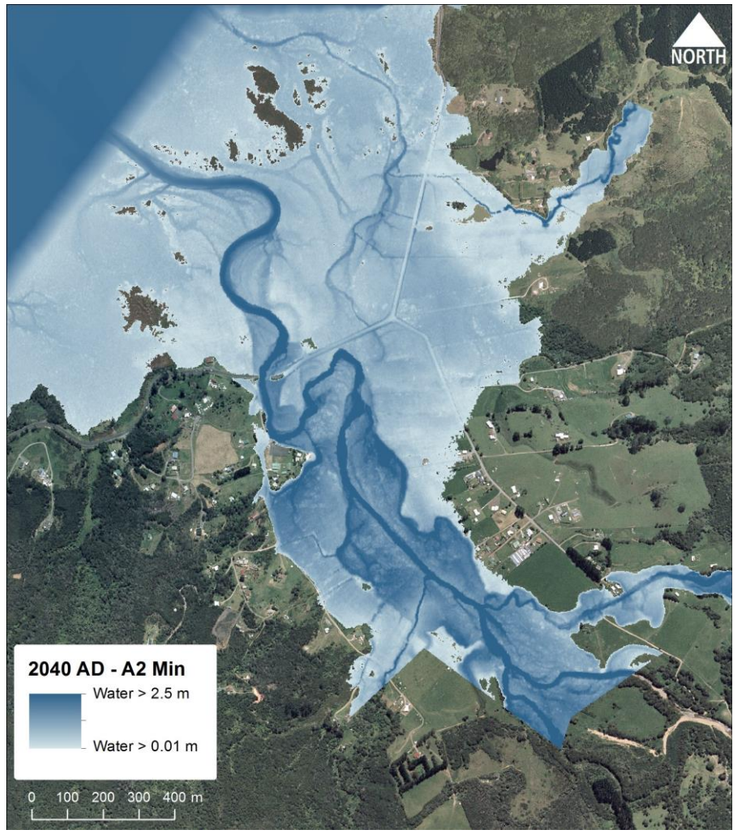

NORTH
2040 AD - B2 Max
Water > 2.5 m
Water > 0.01 m
0 100 200 300 400 m

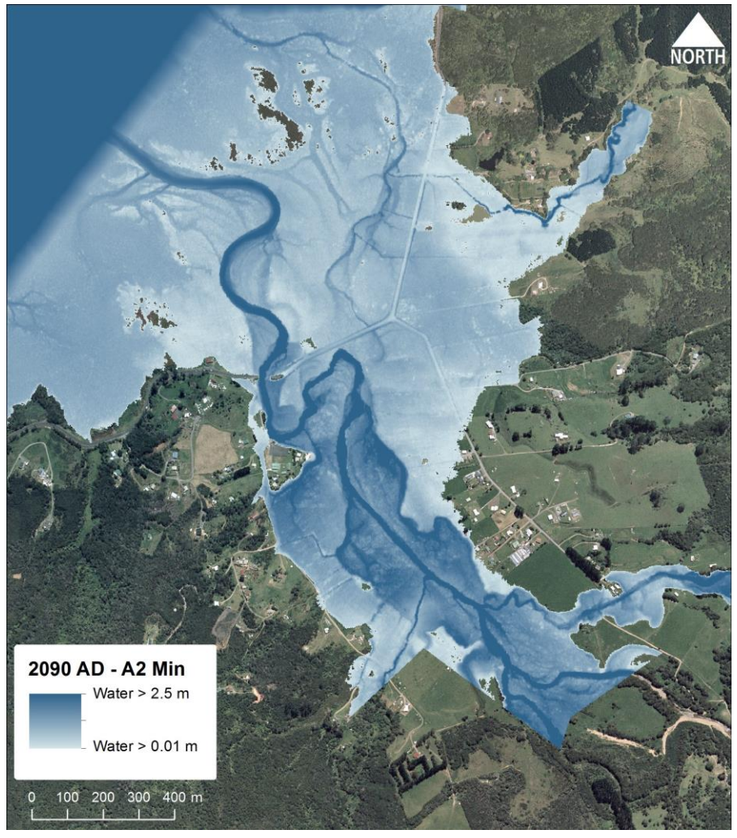

NORTH
2090 AD - B2 Max
Water > 2.5 m
Water > 0.01 m
0 100 200 300 400 m

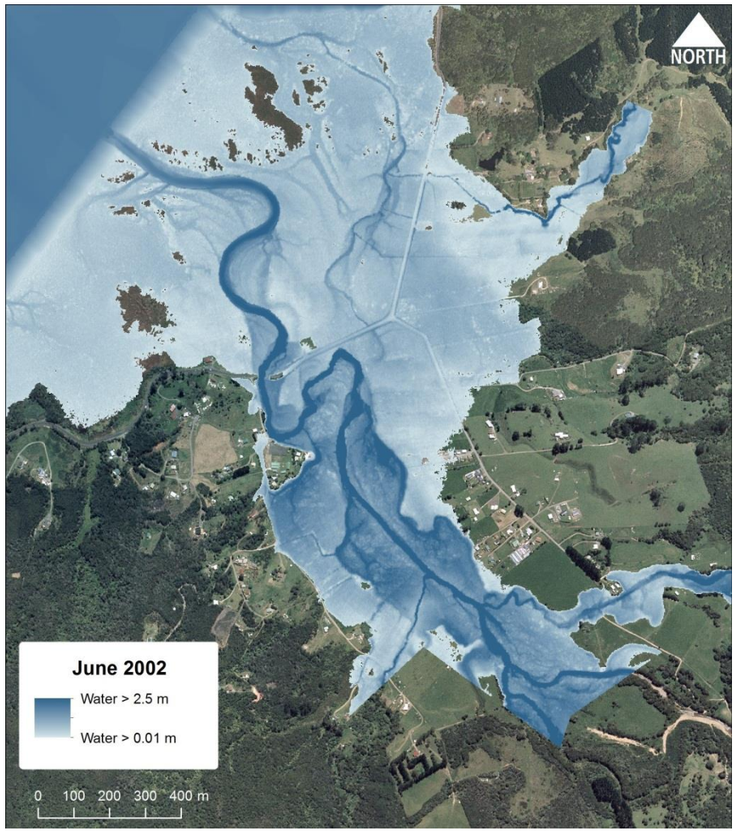
Appendix D Extreme flood scenarios at Manaia – A2 climate change scenarios

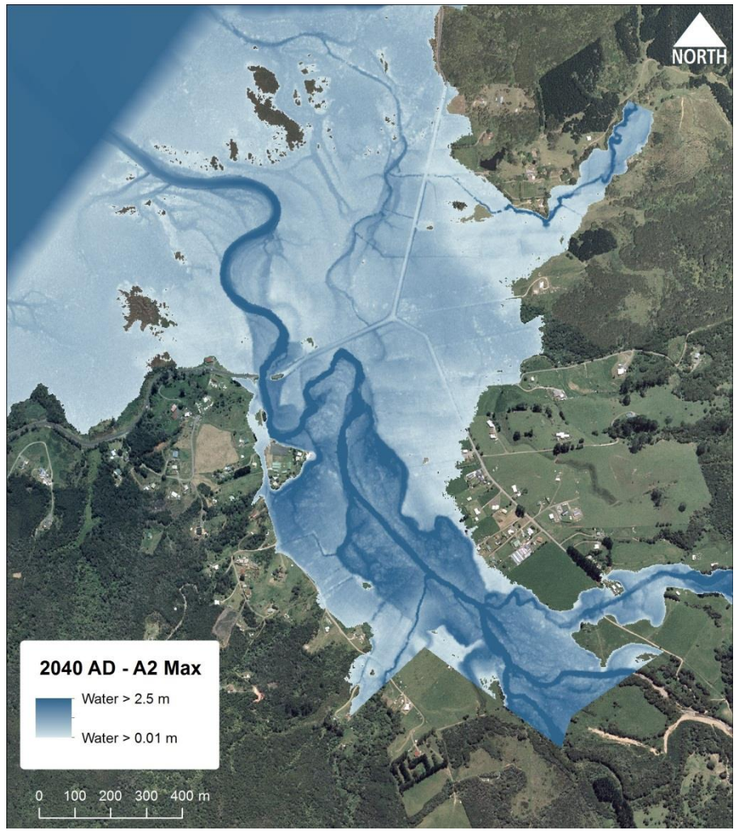
This appendix contains maps of the simulated June 2002 flood event as well as modelled ‘minimum and maximum’ climate change induced coastal-river reach flooding for 2040 and 2090 AD under the A2 climate change and the sea-level rise scenarios described in the text for Manaia – Waikato, New Zealand.

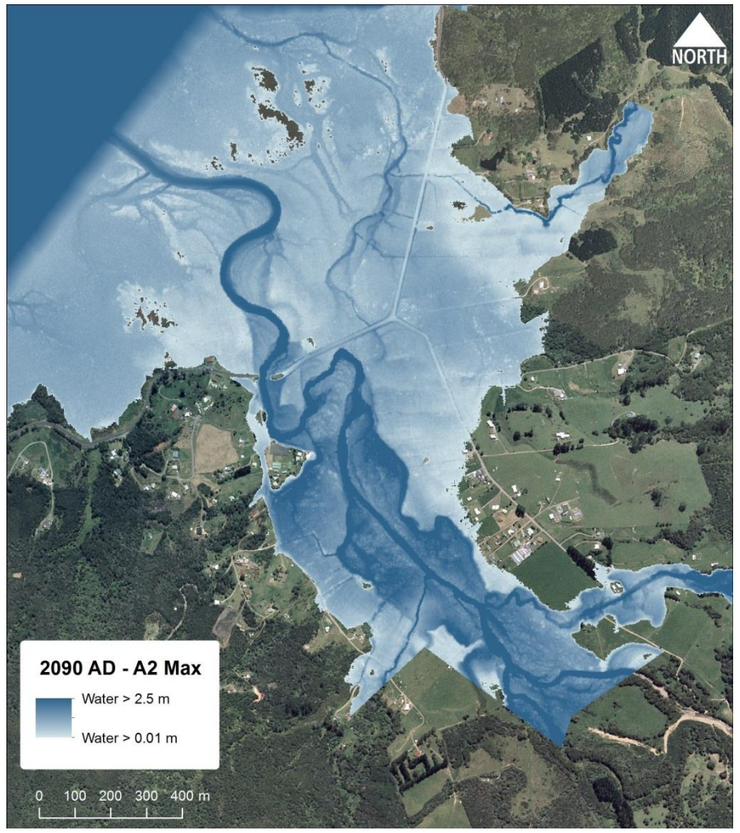







NORTH
June 2002
Water > 2.5 m
Water > 0.01 m
0 100 200 300 400 m


NORTH
2040 AD - A2 Max
Water > 2.5 m
Water > 0.01 m
0 100 200 300 400 m


NORTH
2090 AD - A2 Max
Water > 2.5 m
Water > 0.01 m
0 100 200 300 400 m

Appendix E Photo Gallery

This appendix contains a selection of photos conducted with Manaia community members - 16th October 2010.