Climate Change Assessment for Aoraki Mount Cook National Park

Climate change risk assessment and adaptation plan for Tasman Glacier huts

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Cover: Kelman Hut, Aoraki Mount Cook National Park. *Photo: Department of Conservation*

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Executive Summary

This report assesses the vulnerability of Kelman Hut and the nearby Tasman Saddle Hut, located on the upper Tasman Glacier in Aoraki Mount Cook National Park, to projected climate change impacts. Both huts are nearing the end of their physical and financial life and will need replacement soon. The aim of this report is to identify and describe adaptation options to ensure the resilience of the visitor infrastructure and experience on the upper Tasman Glacier to future climate change.

Decreasing snow and ice coverage in New Zealand and increasing frequency and intensity of extreme rainfall events because of projected climate change, will likely have a major effect on the alpine experiences and supporting infrastructure on the upper Tasman Glacier. The rising elevation of annual snowlines coupled with the continued loss of ice mass for the Tasman Glacier this century, will likely 'squeeze' glacier-based activities such as ski touring towards higher elevations. Compromised access is also an issue. Foot access to the upper Tasman Glacier is already compromised through loss of glacier ice mass and increasing moraine wall height. This, along with the increased frequency and intensity of extreme rainfall events, will continue to reduce the viability and reliability of traditional access routes to the upper Tasman over the coming century (e.g., via Ball Shelter Track).

A climate change assessment of the huts and associated experiences in their current setting, characterised vulnerability as increasing to '*highly*' or '*extremely*' vulnerable by 2090 under climate change emissions representative concentration pathways RCP4.5 (mid-range) and RCP8.5 (high-range) respectively. Where RCP8.5 represents the current scenario (i.e. high emission profile) and illustrates the 'greatest plausible change' that climate change may cause and allows a 'no-regrets' approach towards adaptation. Outputs from this vulnerability assessment were used in a collaborative process to identify adaptation options for the upper Tasman that would support resilience to climate change. A variety of options were discussed at a workshop which included internal and external stakeholders, to support the development of a dynamic adaptive pathway plan.

To ensure the resilience of the upper Tasman Glacier infrastructure and experiences to climate change, a dynamic adaptive pathway plan (DAPP) has been developed which lays out the possible immediate options for adaptation, and other future pathways. A number of adaption options were evaluated and sequenced over time. The three immediate adaptation options identified in the DAPP for Kelman Hut were to maintain the current structure, replace with a similar structure, or replace with a different type of structure. Of these, replace with a different type of structure was identified as the most resilient to the long-term effects and uncertainties of climate change. Other future pathways for changes in management and visitor experience for the upper Tasman were also flagged for further development. The complexity of these results highlights the need for decision makers to closely consider trade-offs and synergies in any adaptation. These identified adaptive pathways are an aid for planning and decision makers to support the ongoing resilience of visitor experience and structures to future climate change for Aoraki Mount Cook National Park.

1 Context

1.1 Purpose of this assessment

The purpose of this report is to assess the vulnerability to climate related hazards and identify possible adaptation planning pathways for alpine huts located on the upper Tasman Glacier, Aoraki Mount Cook National Park.

This assessment stemmed from a request, from the Eastern South Island Region Operations Group, to consider climate change adaptation options for replacing aging alpine infrastructure. Specifically, this regards Kelman Hut and the nearby Tasman Saddle Hut which are both nearing the end of their physical and financial life.

Outputs from this work will support current and future planning regarding the upgrade, replacement, and management of visitor recreation infrastructure and experience on the upper Tasman Glacier.

1.2 Requirement for adaptation

Kelman Hut and Tasman Saddle Hut are located on the upper reach of the Tasman Glacier in Aoraki Mount Cook National Park. Kelman is situated at an altitude of approx. 2,460 m.a.s.l. and Tasman Saddle at approx. 2,320 m.a.s.l. (Fig. 1).

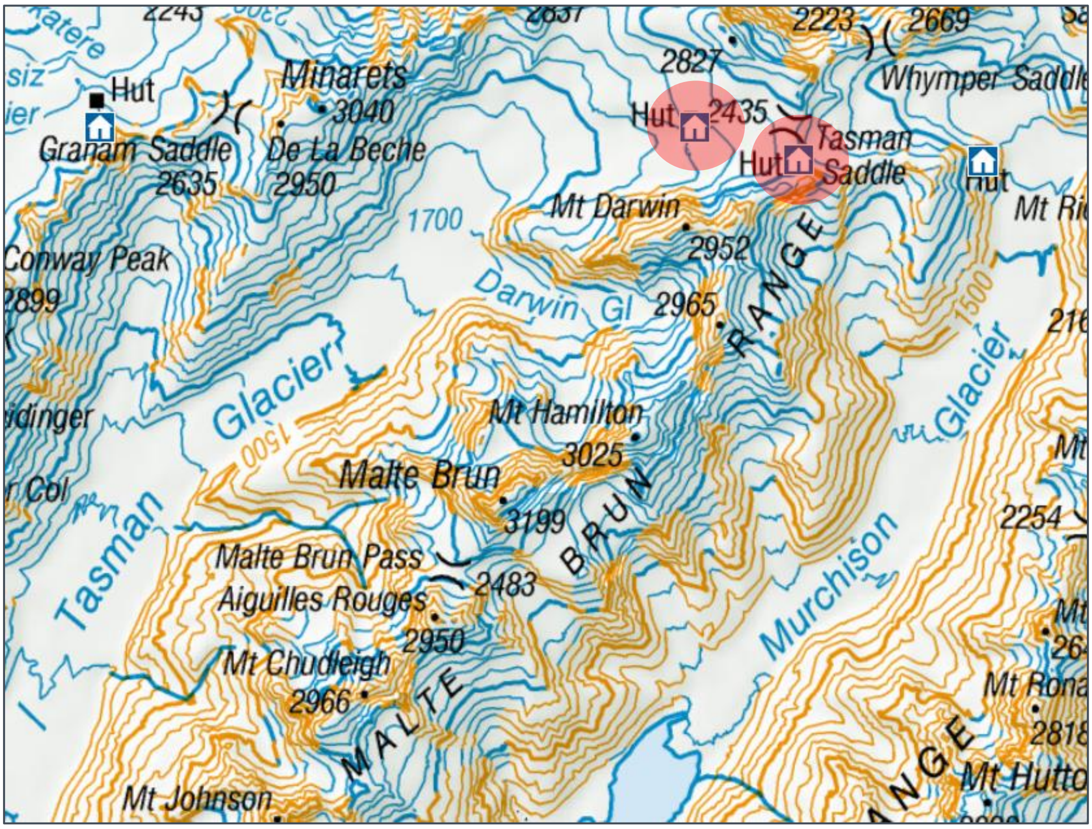

Figure 1: Location of Tasman Saddle Hut (left) and Kelman Hut (right) on the upper reach of the Tasman Glacier, Aoraki Mount Cook National Park.

Upgrade or replacement of hut assets on the upper Tasman Glacier is necessary in the immediate future due to ongoing structural and leakage issues with Kelman Hut. Furthermore, in the coming years both huts are nearing the end of their 'physical life'.

To enhance the long-term resilience of these assets and corresponding visitor experiences to the impacts of climate change, the key aspects that needs to be considered is:

- Will the assets be able to provide a suitable level of service for the intended visitor experience over the course of its lifetime.
- Will access to the experiences remain viable long-term.
- Is the desired alternative option enabled in the Aoraki Mount Cook National Park Management Plan.

The future Tasman Glacier snowline elevation will strongly influence whether the intended visitor experience will remain viable in its current location or retreat to a higher elevation. Over the past 20 years, the snowline elevation on Tasman Glacier has averaged 1,884 m.a.s.l., ranging between 1,710 m.a.s.l. and 2,215 m.a.s.l. (Willsman & Macara, 2020). The highest elevation of 2,215 m.a.s.l. was measured in 2019 and is within approx. 100 m.a.s.l. elevation of Tasman Saddle Hut and 240 m.a.s.l. of Kelman Hut. Under current climate change projections, the average snowline elevation in New Zealand could increase by 250 m.a.s.l. (RCP4.5) to 550 m.a.s.l. (RCP8.5) by 2100 (Huss & Hock, 2015).

Decreasing snow and ice coverage, together with increasing frequency and intensity in extreme rainfall events, will also likely further compromise the existing foot access routes to the upper Tasman Valley. The existing foot access to the upper Tasman Valley via the Ball Shelter Track has already been compromised following sustained heavy rainfall in December 2019, where over 1,000 mm of rain fell over eight days resulting in the collapse of the glacier moraine at Husky Flat, cutting off access to Ball Pass Route (Fig. 2). With a 35% increase in rainfall depth expected for a 1-hour extreme rainfall event and a 15% increase in a 1-day event (for a one-in-50-year event under RCP8.5), foot access via traditional routes is likely to become increasingly difficult.

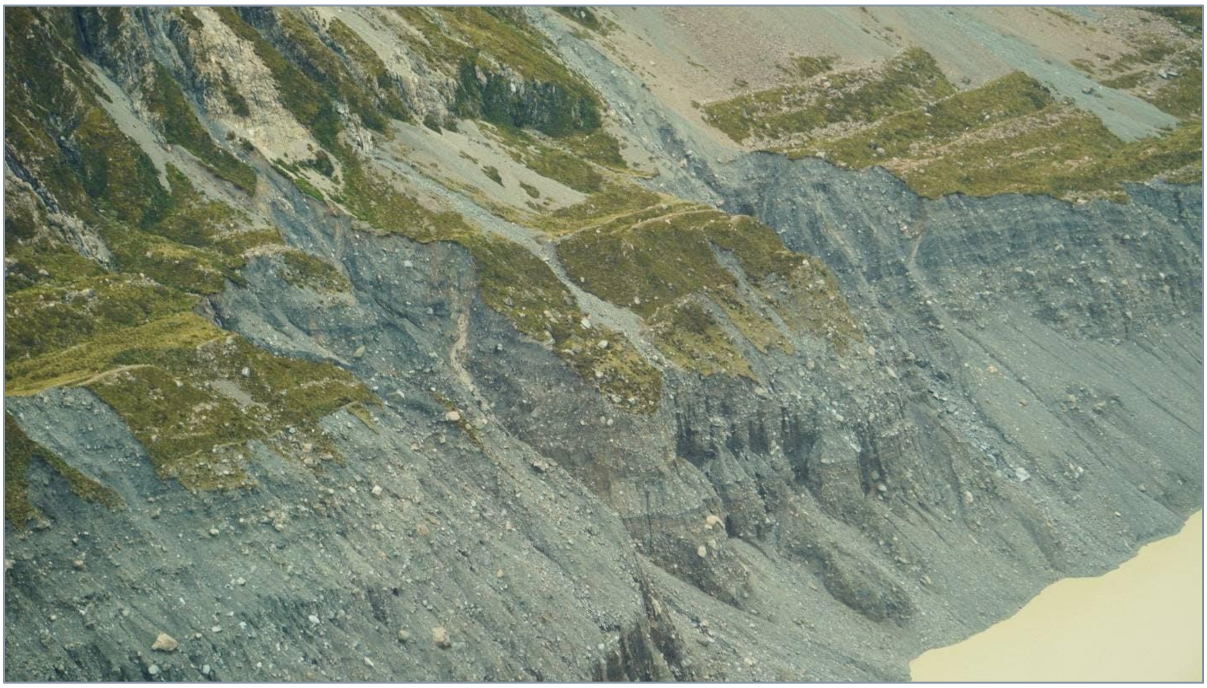

Figure 2: Numerous washouts on the eastern side of the Hooker Valley.

2 Assessment & Adaptation Methods

2.1 Climate change projections

Downscaled climate projections for Aoraki Mount Cook National Park were produced by the National Institute of Water and Atmospheric Research (NIWA) to understand plausible future climate changes for the area (for further details see MFE, 2018). A considerable effort has also been dedicated to validating simulated climate variables, and thus the projections provide a good basis for risk assessments and adaptation plans.

The average of six models (ensemble average) were used, and these were chosen because they represent historic climate conditions in New Zealand well, and span a range of future outcomes. The climate signal (i.e., projected change in climate) is better represented by ensemble averages since the uncertainty due to climate models and internal variability is much reduced. The climate change projections are provided for two time periods, 2040 and 2090. The projections for each period are 20-year ensemble average projections (i.e., projections for “2090” are the 20-year average of 2081-2100). Changes presented are relative to 1995 (i.e., the 1986-2005 average).

Climate change projections from two emission scenarios were evaluated. These scenarios are referred to as Representative Concentration Pathways (RCPs) and project different climate futures based on future greenhouse gas concentrations, determined by economic, political, and social developments during the 21st century:

- RCP4.5 - a mid-range scenario, where greenhouse gas concentrations are stabilised by 2100
- RCP8.5 -a high-range scenario, where greenhouse gas concentrations continue to grow following current emission trajectories.

The climate change projections summarised Table 2 are based on the RCP8.5 scenario. This illustrates the ‘greatest plausible change’ that climate change may create for the area and allows a ‘no-regrets’ approach towards adaptation. RCP4.5 projections are used in the further assessment of vulnerability in section 3.

2.2 Vulnerability assessment framework

Climate change impacts on assets or infrastructure will not be uniform - some assets will be exposed to greater levels of change than others, and some assets will possess physical or strategic characteristics that will make them more or less sensitive to change. Therefore, for an asset to be vulnerable to climate change impacts, it must be sensitive to the change, as well as exposed to the change.

This vulnerability assessment framework uses a weighted attributes system, where sensitivity attributes and exposure attributes are scored across four ratings (low, moderate, high, very high) and then combined to produce a vulnerability value and rank (Table 1). The assessment method generates transparent, easily understood outputs that provides insight into what assets are likely to be the most vulnerable to climate change impacts, identifies the key drivers behind this vulnerability, and illustrates any uncertainty or knowledge gaps.

For full methodology guidance, see DOC-6565642

Sensitivity:

Sensitivity refers to the characteristics that are likely to make an asset susceptible to harm or damage from a climate change hazard. This comprises of a variety of elements that cause it to be either adversely affected by a hazard or reduce its adaptive capacity.

Exposure:

Exposure is defined as the overlap between the built asset and the projected climate change measure. This can include changes in means or changes in extremes, depending on what is appropriate.

Table 1: Matrix for determining vulnerability rank based on component scores for sensitivity and exposure.

Sensitivity \ Exposure	Low [1]	Moderate [2]	High [3]	Extreme [4]
Extreme [4]	Moderate [4]	High [8]	Extreme [12]	Extreme [16]
High [3]	Low [3]	Moderate [6]	High [9]	Extreme [12]
Moderate [2]	Low [2]	Moderate [4]	Moderate [6]	High [8]
Low [1]	Low [1]	Low [2]	Low [3]	Moderate [4]

2.3 Pathways process

DAPP has emerged internationally and in New Zealand as a practical approach to support adaptive decision-making in a changing climate with widening future uncertainties. When considering the effects of climate change, the rate of change and the interaction between impacts is uncertain (Lawrence et al. 2020). DAPP introduces the concept of forward planning to anticipate and avoid adaptive thresholds. Instead of locking management practices into a single pathway that may prove unsuccessful in a changing climate, DAPP options are deliberately kept flexible and reviewed at predetermined intervals or events to better respond to change. By mapping adaptation options in a dynamic pathways format, decision-makers can ensure than an option implemented in the short-term can still maintain flexibility and preserve the viability of future options suitable for the changing climate (Cradock-Henry et al. 2020)

A group of DOC staff and external stakeholders with relevant expertise were assembled to input and undertake the DAPP process. This group was comprised of the DOC Climate Adaptation team, Aoraki Operations, ESI Operations Planning, Heritage and Visitor Technical Advisors, Management Planning, Te Rūnanga o Ngāi Tahu, New Zealand Mountain Guides Association, Backcountry Trust, New Zealand Alpine Club, and Mount Cook Ski Plans and Helicopters.

2.3.1 Impacts and implications

The first step was to understand the current state and defining values. To do this a series of online Microsoft Teams meetings were held to develop a 'picture' of the current state of the environment, infrastructure, and activities in the area and how these may be affected by the projected climate changes. This included an assessment of what different values for the area that should be retained through adaptation.

2.3.2 Develop adaptation pathways

The second step was to develop possible adaptation options and pathways. This was done as an in-person (with MS Teams for those that could not attend in person) collaborative workshop. First an analysis of the plausible climate change scenarios for the area and discussions regarding the state of the huts, alpine experience, and wider social and economic trends was undertaken. Then adaptation options were identified based on what actions could be taken now (0-5 years), mid-term (5-50 years), and long-term (50-100 years). Options were also classified on whether they represented a change to the infrastructure, visitor experience or strategic management.

2.3.3 Identify signals and triggers

A system of pre-determined signals and triggers to avoid adaptive thresholds were identified. Where an adaptive threshold is the point at which a range of evolving conditions become unacceptable, and objectives are no longer achievable. These signals and triggers need to be embedded within DOC's monitoring and management systems in order to embody reviews, reporting, audits, and decision making. This is so that decision makers remain informed of changes over time and can act, if necessary, in a proactive, timely, and transparent manner.

3 Adaptation pathways

3.1 Summary of climate change projections

This summary provides downscaled climate change projections for the Aoraki Mount Cook National Park, obtained from NIWA’s contemporary climate modelling efforts (for further details see MFE, 2018). For the complete detailed assessment, see *‘Climate change in Aoraki/Mount Cook National Park’* (DOC-6412179).

The climate change projections summarised in Table 2 are provided for two time periods, 2040 and 2090, based on the high emissions RCP8.5 scenario. RCP4.5 projections are used in the further assessment of vulnerability in section 3, which can be found within the aforementioned detailed assessment.

Table 2: Summary of projected climate changes for Aoraki Mount Cook National Park based on RCP8.5 scenario.

Change	Direction	2040	2090
Mean annual temperature (°C)	⇧	1.1-1.5˚C	3.1-4.0˚C
Annual number of hot days (›25°C)	⇧	5-20 days at lower elevations	40-60 days at lower elevations
Annual number of frost nights (‹0 °C)	⇩	10-30	30-60
Mean annual rainfall (mm)	⇧	0-10%	15-25%
Extreme rainfall (1-in-50-yr-storm)	⇧	12% for 1-hr duration event 5% for 5-day duration event	35% for 1-hr duration event 15% for 5-day duration event
Glacier mass	⇩	-24 ± 16% (compared to 2015)	74 ± 16% (by 2100, compared to 2015)
Equilibrium snowline altitude	⇧	170 m.a.s.l. (RCP8.5) 130 m.a.s.l. (RCP4.5)	550 m.a.s.l. (RCP8.5) 250 m.a.s.l. (RCP4.5)

3.2 Vulnerability assessment

The vulnerability of huts on the upper Tasman Glacier to climate change related hazards is likely to increase significantly towards the end of the century. For full assessment workbook, see Appendix B.

Table 3: Vulnerability assessment outcomes for upper Tasman Glacier Huts. Note, information displayed in the 'Exposure' column references plausible changes by 2090 under RCP8.5 scenario.

Upper Tasman Glacier Huts Vulnerability Assessment Rank

Sensitivity	Exposure
• Both huts are rated as 'Deteriorating Condition' increasing sensitivity to extreme weather events. • Modification, repair, or replacement of the huts would require significant capital investment. • Due to construction design, existing huts cannot be simply relocated. Design and orientation of Kelman Hut make architectural modification difficult. • The close proximity of the huts allows choice for the users, however reduced capacity at Kelman Hut and limited capacity at Tasman Saddle could cause overcrowding should one be compromised. • Tasman Saddle Hut is in close proximity (~100 m.a.s.l.) to the highest summer snowline elevation measured in 2019 (2,215 m.a.s.l.) • Both huts are used regularly by multiple alpine guiding business and also form a base for outdoor education on the upper Tasman Glacier terrain.	• Considerable increases projected in mean annual temperature, particularly in Spring and Summer (›3 °C). • Significant decrease in annual number of frost nights (‹0 °C), 50 to 70 fewer nights. Combined with warmer daytime temperatures, will likely contribute to reductions in permanent ice. • Increase in mean precipitation for the area, particularly during winter (+10-25%). • Increase in extreme rainfall event frequency and intensity. For a one-in-50-year rainfall event, a 1-hour rainfall projected to increase +35% and a 24-hour event by +22%. • Significant glacier mass loss likely under 'high emission' scenario with equilibrium snowline elevation projected to increase by 550 m.a.s.l..

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Vulnerability		
2040 RCP8.5	*2090 RCP4.5*	*2090 RCP8.5*
Moderate [4]	High [8]	Extreme [16]

3.3 Impacts and implications

DOC staff and external stakeholders used the climate change projections for Aoraki Mount Cook National Park (DOC-6412179).to develop a 'picture' of the current state of the environment, infrastructure, and activities in the area and how these may be affected by climate changes Impacts and implications were classified as either natural and physical, or social and human (Table 4).

Table 4: Climate change implications and impacts for upper Tasman Glacier Huts.

Climate Changes	Natural & Physical Implications	Social & Human Implications
⇧ Mean Rainfall ⇧ Extreme Rainfall ⇧ Heavy Rain ⇧ Mean Temperature ⇩ Frost Nights ⇩ Snow & Ice ⇔ Visitor Behaviours ⇩ Emission Budgets ⇧ GHG Pricing	• Increased moraine slumping and landslides from valley side • At higher elevations, increased heavy snow events may increase avalanche risk. • Rising permafrost levels, increasing risk of large rockfalls. • Increased wasting of Tasman Glacier, with possible break in the upper glacier and increased size of Tasman Glacier Lake. • Crevasses opening up earlier in summer season and taking longer to fill in at start of winter. • Retreat of alpine biodiversity uphill.	• Increasingly compromised foot access to upper Tasman via traditional routes. • Compromised foot access routes from huts to visitor experiences. • Increased demand for heli access • Higher demand for alpine recreation activities and facilities in Aoraki due to poor snow in other alpine areas + last chance tourism • Lack of hut use near end of season (Mar-Apr) due to harder access, causing truncated booking season during peak season. • Helicopters unable to land on specified sites during poor snow/ice periods. • Stigmatisation of high emission activities or industries. • Increasing costs for carbon intensive services

3.4 Dynamic adaptive pathway plan

Adaptation of the huts on the upper Tasman Glacier is required to reduce the exposure and sensitivity, where possible and practical, to the impacts of climate change. A range of adaptation options were identified in the workshop (Section 2.3.2). These options were collated into change in hut infrastructure (Table 5), change in management (Table 6), and change in visitor experience (Table 7).

These options were then used to develop a dynamic adaptive pathway plan to support future planning and management. The adaptive pathways show the variety of options discussed that would support increasing resilience to the climate change impacts, and likely lifespans where they remain suitable (Fig. 3).

3.4.1 Interpreting the DAPP

The DAPP displayed in Figure 3 seeks to visually display the range of adaptation options and pathways over time. The foundation of the DAPP structure (adapted after Sienbentritt & Stafford Smith, 2016) is:

- **X Axis**: the time scale starting from the present day and projecting into the future over the course of this century. The time units chosen for this version are varied rather than incremental to highlight actions required in the short-term (2-5 years).

- **Y Axis:** the adaptation options, starting with the current state in the centre. Actions that are immediately possible are located closest to the current state, whereas actions that require some lead-in time or are dependent on the completion of other actions (e.g. revision of park management plan controls) are located further away.

As detailed in Figure 2 key, an adaptation options 'life-span' is displayed by a line. The likely length on the line is determined by the common use-by-date of the option such as financial life span of the asset, time period covered by a National Park Management Plan, etc.

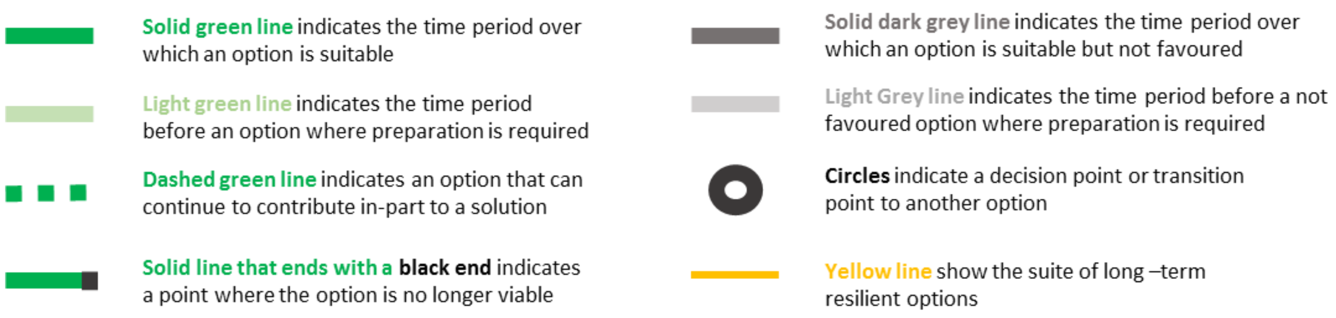

Figure 2: Key to interpret the DAPP map

3.4.2 Upper Tasman Glacier Huts DAPP

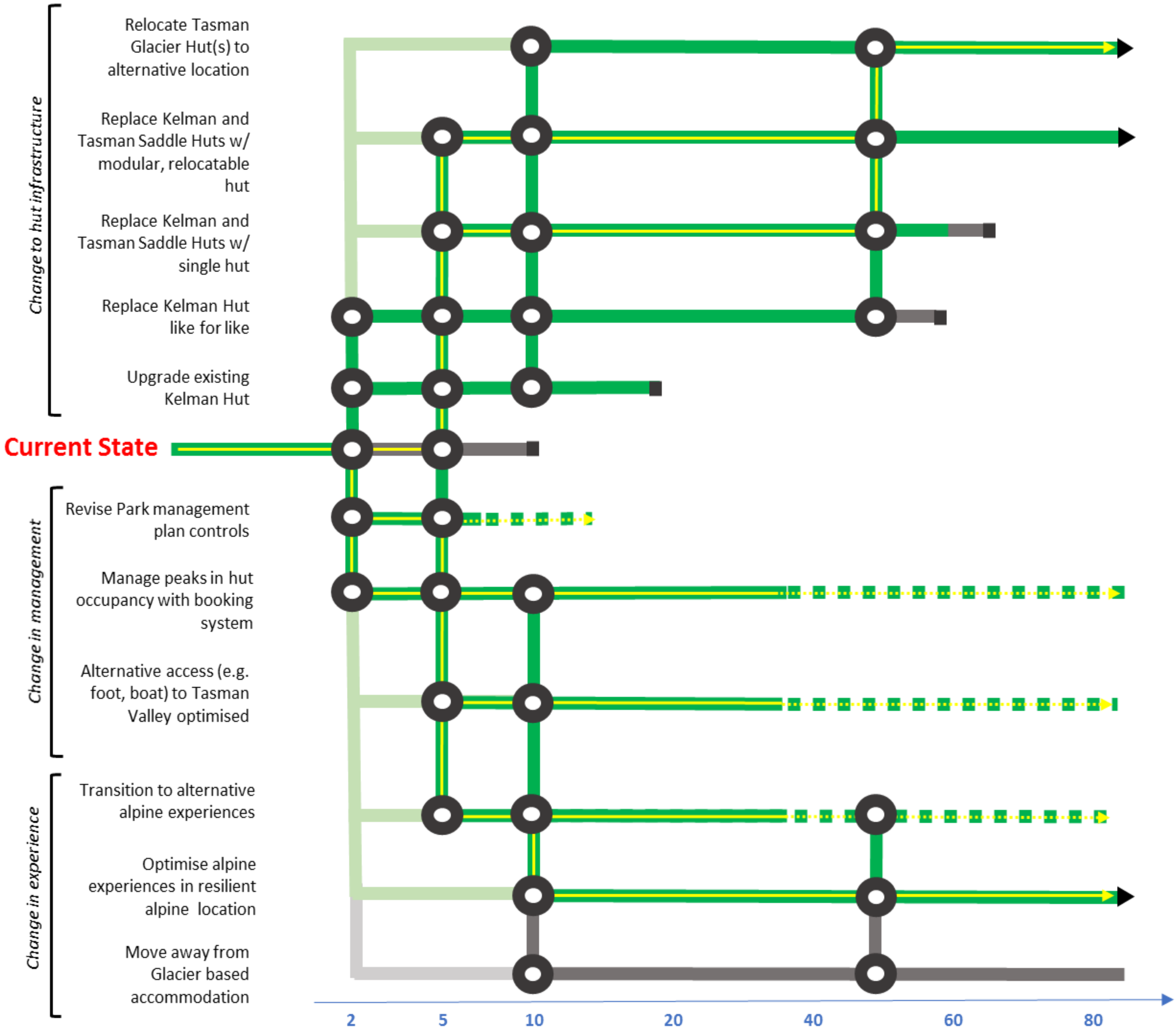

Figure 3: Dynamic adaptive pathway plan for upper Tasman Glacier huts and interpretation key (colour scheme adapted from Siebentritt and Stafford Smith, 2016).

The options identified in the above DAPP are listed in Table 5, 6, and 7 as per their grouping of 'Change in hut infrastructure', 'Change in management', and 'Change in experience'. Where known, possible actions include listed considerations and dependencies that should be taken where possible as part of an adaptation pathway. Should the decision-maker chose to follow these pathways at a point in time, these considerations and dependencies can support the formation of an Adaptation Action Plan as displayed in an example in Appendix A.

Table 5: Summary of 'Change in hut infrastructure' adaptation options.

Option	Benefits	Disbenefits	Considerations	Dependencies
Current state: remove Kelman Hut at end of life	• Minimal cost required	• Health risk from mould. • Lack of accommodation in area unable to support visitor demand. • Overcrowding and high dependency on Tasman Saddle Hut.	• Detailed review of monthly visitor trends historically in relation to climate conditions to consider likely future visitor demand.	• N/A
Replace Kelman Hut like for like	• Continuity in current visitor experience offering	• Hut asset locked into permanent location for physical life (50+ years). • Access to existing location may become difficult as snowline retreats.	• Detailed review of monthly visitor trends historically in relation to climate conditions to consider likely future visitor demand. • Consider investigation of likely impacts of glacial recession/declining ice on geological stability.	• N/A
Replace Kelman and Tasman Saddle Huts with single hut	• Cost benefit is management of services (e.g. toilets)	• Removes secondary accommodation for experience should the hut be damaged. • Option not immediately feasible.	• To mitigate dependence on single hut for the upper glacier, consider the provision of 2-4 bunk, low-maintenance huts near key climbing and skiing areas. • Consider also the optimal location for a single hut for future snowline altitudes.	• Dependant on Tasman Saddle Hut reaching end of physical and financial life. • If the hut was to be relocated to an alternate location National Park Management Plan controls will need to enable this.
Replace Kelman and Tasman Saddle Huts with modular, relocatable hut	• Management of the asset in relation to visitor demand will be more resilient as can be adapted if/when future conditions require.	• Option not immediately feasible	• Consider smaller Colin Todd Hut design (10-bunk). • Consider investigation/ feasibility of relocatable modular alpine huts.	• If the hut was to be relocated to an alternate location, National Park Management Plan controls will need to enable this.
Relocate Tasman Glacier hut(s) to alternative location	• Management of the asset in relation to visitor demand will be more resilient as can be adapted if/when future conditions require	• Option not immediately feasible	• Consider feasibility of NZMGA proposal of Mt. Wakefield location. • Consider feasibility of NZMGA proposal of Murchison-Aida confluence location	• If the hut was to be relocated to an alternate location, National Park Management Plan controls will need to enable this

Table 6: Summary of 'Change in management' adaptation options.

Option	Benefits	Disbenefits	Considerations	Dependencies
Revise Park Management Plan Controls	• N/A	• N/A	• Spatial planning review/stocktake of visitor asset network including location of existing huts and corresponding experiences and demand. • How to enable greater flexibility in location of future hut sites.	• N/A
Manage hut capacity with occupancy management system	• Avoid overcrowding of huts during peak periods. • Enable better planning for visitors	• Require system management	• Consider simple hut booking or concessionaire 'taxi medallion 'system • Consider alternative occupancy monitoring system.	• N/A
Alternative access (e.g. foot, boat) to Tasman Valley optimised	• Enabled suitable 'low carbon' access to upper Tasman Valley. • Ensure resilient access from upper Tasman Valley should heli access be disrupted.	• Require capital investment	• Consider feasibility of alternate access route to Tasman Valley and new Beetham Hut proposed by NZMGA.	• National Park Management Plan controls will need to enable this.

Table 7: Summary of 'Change in experience' adaptation options.

Option	Benefits	Disbenefits	Considerations	Dependencies
Transition to alternative alpine experiences	• Decreased reliance of alpine visitor experiences on snow/ice availability • Increased experience offering	• Options not immediately feasible	• Explore and analysis of users, their vision for the alpine zone and desired diversity of experiences.	• National Park Management Plan controls will need to enable this. • Dependant on provision of suitable infrastructure for access and accommodation
Optimise alpine experiences in resilient locations	• Long-term resilience of snow/ice based experiences in Aoraki Mt. Cook.	• Option not immediately feasible	• GIS analysis of future snowline elevations and glacier change under climate scenarios	• National Park Management Plan controls will need to enable this. • Dependant on provision of suitable infrastructure for access and accommodation

Move away from Glacier based accommodation	• Minimal cost required	• Visitor demand currently necessitates	• N/A	• N/A

3.5 Adaptation measures, signals and triggers

As DAPP seeks to enable forward planning and decision making in a changing climate with widening future uncertainties, a system of pre-determined signals and triggers can be employed to avoid an adaptive threshold – the point at which a range of evolving conditions would become unacceptable and objectives no longer achievable.

For signals and triggers to be effective and relevant over time as the climate changes, long-term consistency is required. This means that the identified signals and triggers will need to be embedded within an organisations' monitoring system that embodies review, reporting, audits, and decision making, so that decision makers remain informed of changes over time and can act, if necessary, in a timely and transparent manner.

Possible measurements, signals and triggers to inform adaptation action on the upper Tasman Glacier are listed in Table 8.

Table 8: Possible measures to be used to inform upper Tasman Glacier adaptation action.

Measurement	Signal	Trigger	Source
Asset structural inspection	Huts are nearing end of physical life (‹20%)	Huts are no longer structural safe for occupancy	ESI Operations Planning inspection regime
Capital expenditure	Increased reactive capital expenditure of associated assets following extreme weather events.	Reactive capital expenditure in a single financial year surpasses a predetermined threshold value	ESI Operations Planning CAPEX
Visitor use	Huts are significantly overcrowded or have low occupancy for extended periods of former peak season.	Huts no longer able to accommodate the required visitor demand for alpine recreation.	Aoraki Operations Team hut bed nights
Snowline altitude	Average snowline elevation consistently surpasses Tasman Saddle Hut elevation	Former alpine recreation experiences are no longer viable in current location	NIWA annual summer snowline survey
Emissions Profile	Annual emissions from use and service of upper Tasman Glacier huts increases year-on-year	Emissions from use and service of upper Tasman Glacier huts exceed budgeted profile.	DOC Emissions Monitoring (not yet operational)

4 Recommendations

The climate change vulnerability assessment and adaptation plan for the upper Tasman Glacier huts identifies how their vulnerability to climate change is likely to change over time, and the suitable adaptive actions that can be implemented to increase resilience to these hazards.

The DAPP presents recommended pathways to increase resilience to support decision makers. It helps to lay out what the immediate options for adaptation may be, and what future pathways may need to be prepared for to retain resilience. Over time, resources, information, technology, social and economic demand, and management restrictions will evolve and change – DAPP enables decision makers to consider and plan for current and future climate change pressures alongside all other competing needs and priorities.

To enable more informed adaptation, the following considerations are recommended:

- Climate change in Aoraki/Mount Cook National Park projection **information should be actively made available** to DOC statutory planners, operational staff, visitor planning and advice staff, and external groups (e.g. NZAC, BCT) with interests in Aoraki Mount Cook National Park.
- **Consider the adaptation pathways and approach** presented in this report when deciding future management actions for the upper Tasman Glacier huts or other similar alpine huts.
- A detailed **review of monthly visitor trends historically in relation to climate conditions** be undertaken to understand how user behaviour may change over time in response to climate scenarios.
- A **spatial plan review/stocktake of visitor asset and experience network** within Aoraki Mount Cook National Park and neighbouring alpine areas in relation to climate change scenarios and long-term viability.
- Considerations made in the review of the Aoraki Mount Cook National Park Management Plan to enable **greater flexibility in the relocation of huts** within the park.
- Explore **alternative funding and management options** for alpine huts through a greater use of the partnership model.
- Investigate **alternative access means** (e.g. foot, boat) to the upper Tasman Valley huts to ensure user access and egress is possible in varying weather conditions.

5 References

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6 Appendix A: Example Adaptation Plan

Table 1 outlines an example climate change adaptation action plan structure to enable long-term resilience should the pathways in Figure 1 be followed:

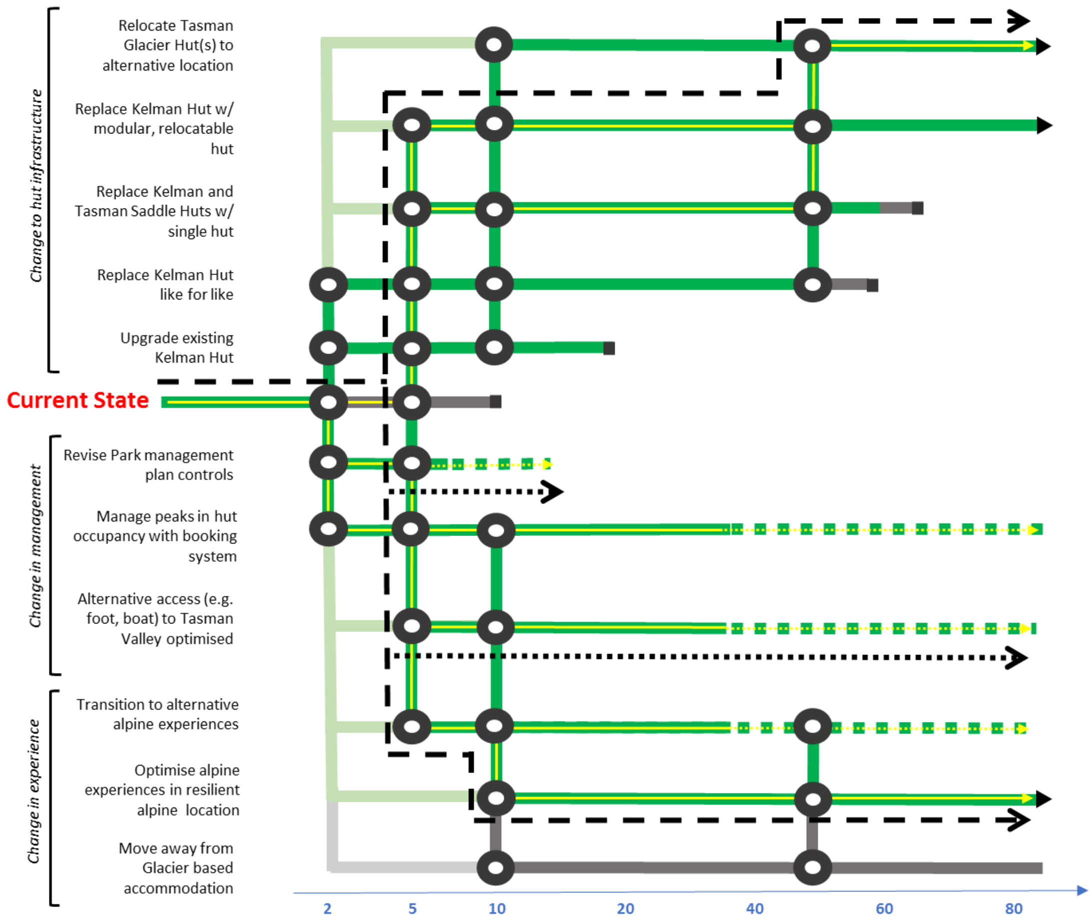

Figure 1: Example adaptation pathway scenario to infrom action plan in Table 1.

Table 1: Example climate change adaptation action plan based on pathways following the black dashed lines in Figure 4.

Actions	Accountability	Delivery Timeframe			
		2020	2025	2030	2060+
Make existing Kelman Hut safe and habitable to retain for short-term	Operations	✓			
Undertake a detailed review of monthly visitor trends historically in relation to climate conditions	Visitor Advice	✓			
Investigate design feasibility of modular relocatable hut to cater to required visitor capacity	Operations Planning	✓			
Enable greater flexibility in the relocation of huts within the Aoraki Mount Cook National Park Management Plan	Management Planning	✓			
Undertake feasibility/costing of alternate access route to Tasman Valley and new Beetham Hut	Operations	✓			
Replace Kelman Hut with modular, relocatable hut	Operations Planning		✓		
Implement alternative access (e.g. foot, boat) to Tasman Valley	Operations Planning		✓		
Undertake spatial plan review/stocktake of visitor asset and experience network	Visitor Advice		✓		
Investigate feasibility of alternative alpine hut locations	Operations			✓	
Optimise alpine experiences in resilient locations	Operations			✓	
Relocate modular hut to alternative location identified.	Operations				✓

7 Appendix B: Supporting Information

- Upper Tasman Glacier Huts climate change vulnerability assessment workbook: DOC-6613895
- NZMGA letter regarding Beetham Hut access: DOC-6613877
- NZMGA correspondence regarding possible Murchison-Aida Glacier hut sites: DOC-6613886
- NZMGA correspondence regarding possible adaptation options: DOC-6613888