Alpine Resort Futures Vulnerability Assessment (Social and Economic)

Final Report

DELWP

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SGS Economics & Planning

Independent insight.

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EXECUTIVE SUMMARY

Victoria's alpine region is a much loved part of the state. Climate change will likely mean that the alpine resorts' current economic, social and cultural values will change. Whatever the change, the mountains will endure as an important part of Victoria's shared natural wealth.

This report assesses the vulnerability of the economic, social and cultural values of Victoria's six alpine resorts – Mt Hotham, Falls Creek, Mt Buller, Mt Stirling, Mt Baw Baw and Lake Mountain – to climate change.

Summary of supporting documents

The vulnerability assessment is the culmination of a program of work that included technical analysis and consultation. Not all of this work reproduced in this report but is available in a series of supporting documents for further interrogation. By way of context, a brief description of each report is provided below.

Conceptual model

The Conceptual Model report details the key concepts, the approach used to understand the alpine resorts system and its vulnerabilities and how the vulnerability dashboard that describes this was developed.

The framework describes how climate change impacts on the ecosystem goods and services of the alpine region (through exposure, sensitivity, thresholds and tipping points) and how this then affects the community and stakeholders economically, socially and culturally.

The conceptual model informed the design of the project steps that followed, including the process of data review; consultation planning; stakeholder consultation; systems analysis; and identifying and assessing vulnerabilities and capacities.

Literature review

The literature review includes:

- An overview of the climate change research, focusing on changes anticipated to affect alpine regions
- Approaches to climate change adaptation, focusing on approaches for alpine regions.

The literature review provided the climate change knowledge base required to undertake the project.

The literature review found:

- The climate is changing, and in alpine regions the signs are already starting to show. In the Victorian Alps snow cover has diminished by about fifty percent since the 1960s. The impacts of climate change are expected to accelerate towards 2100.
- Over the next 10 to 80 years the changing climate will:
  - impact the length and quality of snow seasons
  - increase operating costs for resorts due to additional snowmaking
  - possibly impact snow sport participation
  - lead to social and cultural impacts as a result of reduced snow cover and snow sport activity
  - limit green season tourism activities due to bushfires
- However, humans are adaptive and experience elsewhere shows that the resort sector can:

- undertake adaptation planning and capacity building
- implement efficient snowmaking
- diversify to other tourism offerings and to other industries
- prepare for bushfire events

These and other adaptive responses are already occurring in Victoria's alpine resorts.

Consultation report

A Consultation Report is available which provides a detailed break down of the current values in the alpine resorts and their perceived vulnerability to climate change. It also details the participants' perceptions of the sectors' strengths and weaknesses in relation to adaptation.

Engagement with key stakeholders in the alpine resorts sector was designed to inform the understanding of how the resorts currently operate, what their current values are, how vulnerable these values are when considered in the face of climate change, and what the strengths and weaknesses are in the sector for responding to the changing environment.

The consultation established that the economic value of the alpine resorts sector is dominant in the minds of stakeholders. There is a shared recognition that the resorts' contribution to the state economy, visitation, infrastructure and the white season are vital economic values, and that these values are vulnerable to climate change.

Consultation also identified the key social and cultural values of the alpine resorts sector. Social values included: the strength of the alpine community, social value of activity and the wellbeing that comes from being in the alpine environment. Cultural values are a way of being in or experiencing a place that a group of people share. In the alpine resorts, the consultation showed nature based culture as the standout cultural value, with activities based culture, snow culture and community culture also rating highly.

Social and cultural values are also vulnerable to climate change, although not as vulnerable as economic values. Social and cultural values are values that can be maintained – and are worth maintaining – in their own right, regardless of the scale of commercial activity or the degree of climate change.

Those consulted stated that the adaptive capacity of the resorts to climate change will require some fundamental weaknesses to be addressed. However, the consultation also identified a broad range of opportunities for further adaptation, and the significant strengths that can support the uptake of those opportunities.

System map

The systems analysis and mapping was undertaken using the systems mapping software Kumu. The system map of the alpine resorts sector developed for this project is available.

A systems map identifies the key segments of the system and reveals interrelationships and interdependencies between these segments.

The systems frame provides the organised and coordinated basis upon which values, vulnerabilities and adaptive response pathways can be identified, tracked and analysed. Using outputs from data analysis and stakeholder engagement, informed judgments can be made as to the direct and indirect impacts of vulnerabilities within and between segments, and across the system generally. Uncertainties can be directly taken into account, through the testing of possible responses to determine interactions and side effects, reveal unintended consequences, and provide insights that reveal better alternatives. This provides the basis for a more objective approach to the design, testing, implementation and acceptance of adaptive response alternatives.

Executive summary of the Vulnerability Assessment

The vulnerability assessment draws on the above analysis as well as available social, economic, institutional and environmental data.

A dashboard summarises the impacts on the assets and values that are affected directly or indirectly by climate change at each alpine resort. The vulnerability of these assets and values is based on assessments of exposure, sensitivity and adaptive capacity. These concepts are described below but further information on the concepts used for this assessment are available in the Conceptual Model report.

Exposure refers to the expected changes to climatic stimuli in a given location. For example, lower altitude resorts are subject to loss of natural snow to a greater extent than higher altitude resorts, at least initially.

The measures used for exposure (likelihood or probability) are:

Dark green	<1 percent
Light green	1 to 10 percent
Yellow	10 to 50 percent
Orange	50 to 90 percent
Red	>90 percent

Sensitivity is the degree to which a system or species is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (for example lack of snow due to warmer temperatures,) or indirect (for example, visitation numbers in response to snowfall).

The measures used for sensitivity (severity of impact) are:

Dark green	negligible, easily managed, no real impact
Light green	minor impact on value/returns
Yellow	impact on values/returns but not sufficient to change character or direction
Orange	major impact on values/returns forcing change of approach and much diminished outcomes
Red	all value lost and likely unrecoverable

Adaptive capacity indicates the extent to which the vulnerability could be reduced by action on the part of those affected. Adaptive capacity is the parameter that is most subjective, open to choice and change, and would be the focus of adaptation planning. Adaptive capacities may act on either exposure or sensitivity, or both.

The measures used for adaptive capacity are:

Dark green	complete, many options and resources, all of either exposure or sensitivity can be removed, can deal easily with change
Light green	effective, several options and good resources, most exposure or sensitivity can be removed by flexible approaches
Yellow	significant, some options so exposure or sensitivity can be significantly reduced at some cost; change accepted reluctantly
Orange	limited reductions in exposure or sensitivity, few options, can be achieved at high cost but resources required exceed those available, strong resistance to change
Red	none, no options available to change exposure or sensitivity, no or resources available and inflexible

Vulnerability is the degree to which a system, sector or social group is susceptible to the adverse effects of climate change; vulnerability depends on the nature of the climate changes to which the system is exposed, its sensitivity to those changes and its adaptive capacity.

Suggested interpretation of vulnerability, allowing for degree of exposure, sensitivity after adaptive capacity is considered:

Dark green	low, no significant concerns
Light green	moderate, manageable impacts
Yellow	significant impacts potentially requiring assistance to adjust
Orange	major impacts expected, external assistance needed to adjust, status quo unsustainable and new focus/values/priorities required
Red	non-recoverable losses, adaptation of current activities/values not feasible requiring retreat

Dashboards showing the vulnerability of the six resorts to climate change have been produced for this report. The dashboards focus on vulnerability in the white season. Each dashboard shows vulnerability over three timeframes: the next ten years (2020s), 20 to 30 years (2030s to 2050s) and 40 years plus (beyond 2050). A summary dashboard has also been created showing vulnerability for all resorts for the next ten years (2020s) and 40 years plus (beyond 2050).

Figure 1 summarises vulnerability for each of the resorts (Mt Buller and Mt Stirling are treated jointly) for the next ten years and for the period after 2050. Figure 1 assumes adaptation is fully effective. In the first timeframe, the vulnerability of the lower altitude resorts of Baw Baw and Lake Mountain is greater than for the higher altitude resorts of Mt Hotham, Falls Creek and Mt Buller and Mt Stirling: the changing climate affects the lower resorts' ability to maintain affordable snow (natural snow and cost effective snow making) earlier than the higher altitude resorts. Many of the economic and social values which rely on affordable snow – visitation, economic activity, jobs – are therefore also more vulnerable. By the second timeframe the vulnerability has increased for the higher altitude resorts.

Figure 2 shows vulnerability of each resort to climate change assuming adaptation is totally ineffective. This shows that without adaptation the economic values that flow from affordable snow are more vulnerable sooner. It would still be the case that the lower altitude resorts are more vulnerable sooner than the higher altitude resorts.

FIGURE 1. SUMMARY OF VULNERABILITY RESULTS BY RESORT – MAXIMUM ADAPTATION EFFECTIVENESS

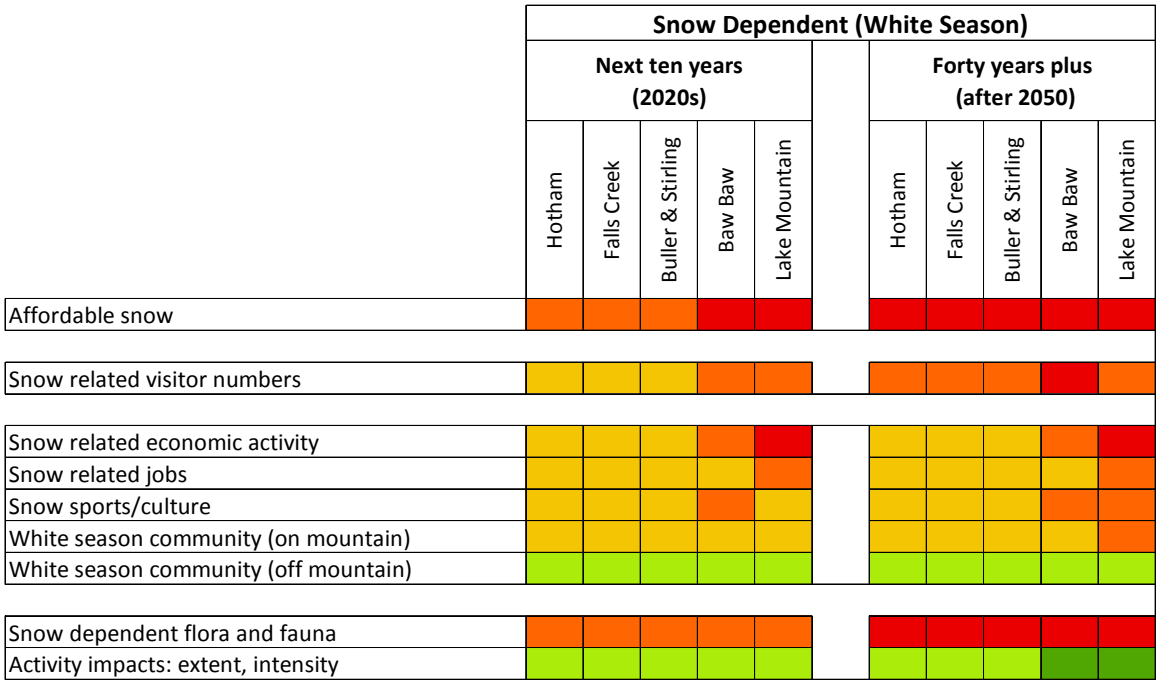
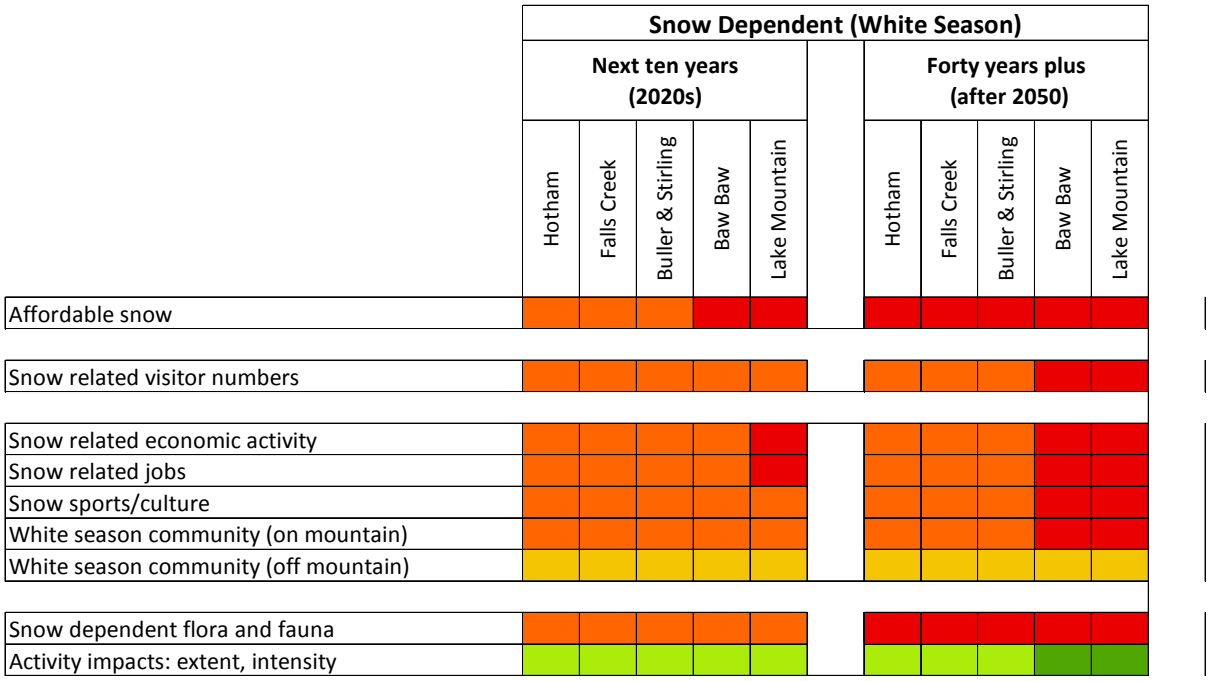


FIGURE 2. SUMMARY OF VULNERABILITY RESULTS BY RESORT – NO ADAPTATION EFFECTIVENESS



In practice neither 'perfect adaptation' nor 'total failure to adapt' are likely to occur. For the alpine resorts, the transition from the current situation to the future condition will depend in large part on the effectiveness of adaptation action. This will arise from a combination of the imagination and motivation of the range of stakeholders, their access to resources and the effectiveness of governance arrangements to coordinate and implement the actions required.

1 PROJECT OVERVIEW

This chapter provides the relevant background to the vulnerability assessment. This includes situating the assessment within the broader program of works being undertaken by the Department of Environment, Land, Water and Planning (DELWP) for the Victorian alpine resorts sector, and providing an overview of the methodology and findings used to inform this assessment.

1.1 Study background

The Alpine Resort Futures Climate Change Vulnerability Assessment (Social and Economic) is the first stage of the Alpine Resort Futures Climate Adaptation Project, one of three projects being undertaken by DELWP collectively titled the Alpine Resort Futures Project.

The purpose of the Alpine Resort Futures Project is to ensure the governance and operating model for the alpine resorts sector meets Government and community needs, and is responsive and adaptable to current and future challenges and pressures, particularly the impacts of climate change.

As described in the project brief, the Alpine Resort Futures Project includes the following three sub-projects:

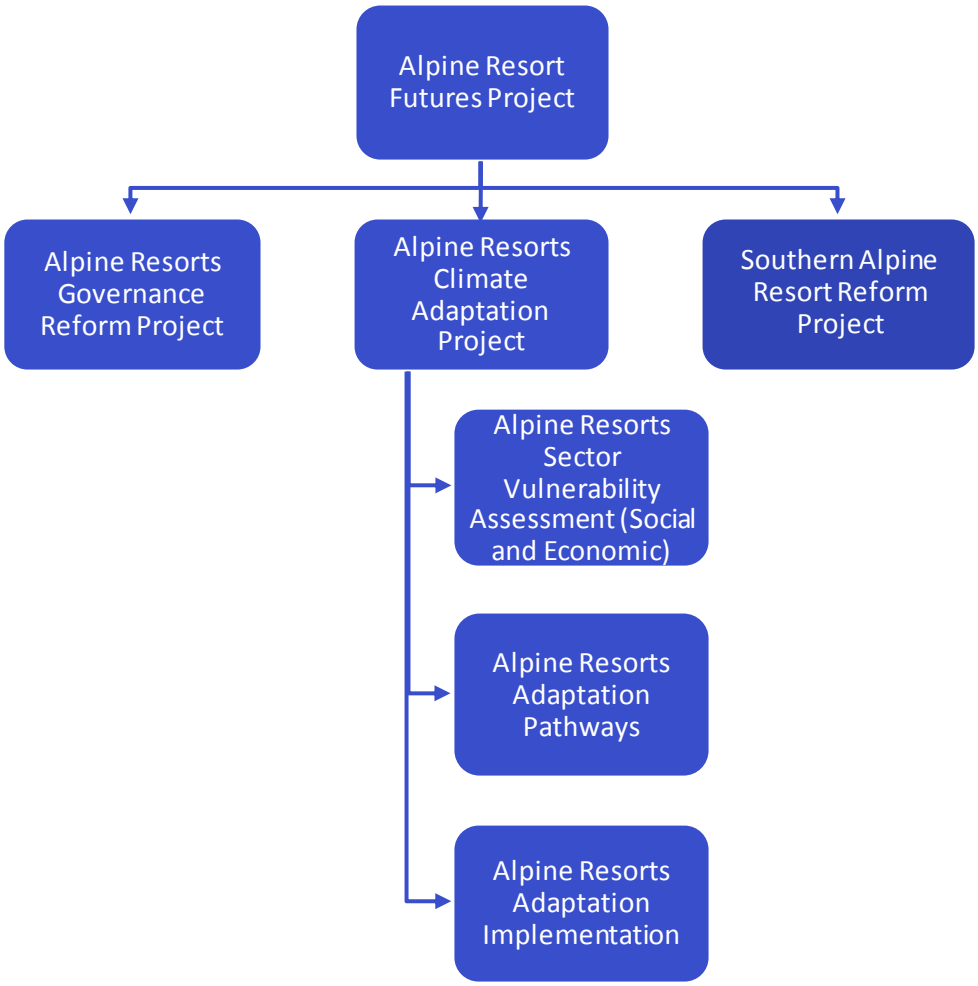
- The **Alpine Resorts Governance Reform Project** - the investigation of structural governance reform to enable effective response to current and future issues and challenges.
  - The Alpine Resorts Governance Reform Project includes a process to consult and determine the governance of the Victorian alpine resorts sector. The consultation period closed on 1 March 2017.

- The **Alpine Resort Futures Climate Adaptation Project** - the consideration of the specific risks, impacts and adaptation planning to address the effects of climate change.
  - **Stage One:** Alpine Resort Futures Climate Change Vulnerability Assessment (Social and Economic) – this project
  - **Stage Two:** Adaptation Pathways Planning
    - A sector wide adaptation pathways planning framework to guide development, implementation, learning, monitoring and review of climate adaptation in the Victorian alpine sector
    - Resort specific adaptation pathway plans that fit within the overall framework for the six alpine resort areas
  - **Stage Three:** Adaptation Implementation
    - Implementation of the recommendations arising from the adaptation pathways planning process
    - Monitoring and reviewing climate adaptation in the Victorian alpine sector.

- The **Southern Alpine Resorts Reform Project** – the examination and development of options for the future governance of, and climate adaptation at, Lake Mountain and Mt Baw Baw Alpine Resorts.

Figure 3 shows the relationship between the three projects and subprojects.

FIGURE 3. ALPINE RESORT FUTURES PROJECT DIAGRAM



The Vulnerability Assessment (Social and Economic) project assesses the vulnerabilities of the six Victorian alpine resorts on Crown land; Falls Creek, Mt Hotham, Mt Buller, Mt Stirling, Mt Baw Baw and Lake Mountain. The focus is on the alpine resorts sector, rather than the alpine region as a whole, and is to explore:

- The social, economic, institutional and technical vulnerabilities for the Victorian alpine resorts sector
- The skills and capacities available within the Victorian alpine resorts sector, including its local industries and communities, to respond to climate change impacts.

1.2 Study objectives

As described in the project brief, the objectives of the Alpine Resort Futures Climate Adaptation Project are to:

- Inform, consult and involve stakeholders in identifying and understanding the current scientific research on the anticipated impacts of climate change for alpine environments, including Victorian alpine resorts
- Inform, consult and involve stakeholders in identifying and understanding the risks, vulnerabilities and capacities of the alpine resorts sector within the context of a changing climate
- Provide stakeholders with formal opportunities to share their views, expertise and vision on alpine resorts climate adaptation
- Engage and collaborate with key stakeholders to build resilience within the alpine resort sector to the impacts of climate change

– Engage and collaborate with key stakeholders to manage the transition and transformation required to maintain sector sustainability in a changing climate.

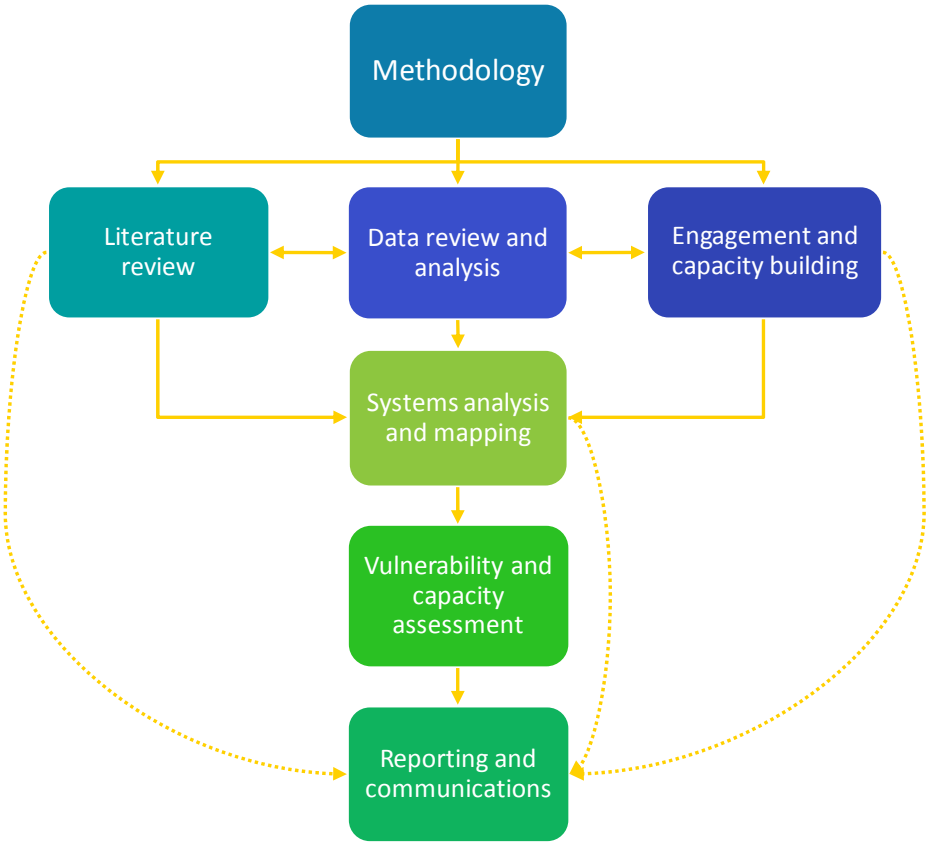
The objectives specific to this first stage of work: the Alpine Resort Futures Vulnerability Assessment (Social and Economic), are to:

– Learn from the experiences and knowledge of the alpine resorts sector
– Gather information to understand the alpine resorts sector's vulnerabilities
– Identify information gaps to improve alpine resorts sector's adaptive capacity.

1.3 Project approach

A methodology was developed to assess the social and economic vulnerability to climate change for the alpine resorts sector. Figure 4 shows the elements of the method and their relationships. Each of these elements is then described below.

FIGURE 4. PROJECT METHOD



Methodology

This first step was to design the conceptual framework. The framework describes how climate change impacts on the ecosystem goods and services of the alpine region (through exposure, sensitivity, thresholds and tipping points) and how this then affects the community and stakeholders economically, socially and culturally.

The design of the conceptual framework was informed both by academic literature and information gathered during early consultation. The conceptual model informed the design of the project steps that followed, including the process of data review; consultation planning; stakeholder consultation; systems analysis; and identifying and assessing vulnerabilities and capacities.

The Conceptual Model report is available. It details the key concepts; the approach that was used to understand the alpine resorts system and its vulnerabilities; and the development of the vulnerability dashboard that is used to describe vulnerability for each of the resorts.

Literature review

The literature review provided the knowledge base required to successfully undertake the project, particularly the way the climate in the alpine region is anticipated to change.

The literature review includes:

- An overview of the climate change research, with a focus on how changes are anticipated to affect alpine regions
- Approaches to climate change adaptation, again with a focus on approaches for alpine regions.

In summary, the literature review found:

- The climate is changing, and in alpine regions the signs are already starting to show. In the Victorian Alps snow cover has diminished by about fifty percent since the 1960s. The impacts of climate change are expected to accelerate towards 2100.
- Over the next 10 to 80 years the changing climate will:
  - impact the length and quality of snow seasons
  - increase operating costs for resorts due to additional snowmaking
  - possibly impact snow sport participation
  - lead to social and cultural impacts as a result of reduced snow cover and snow sport activity
  - limit green season tourism activities due to bushfires
- However, humans are adaptive and experience elsewhere shows that the resort sector can:
  - undertake adaptation planning and capacity building
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  - diversify to other tourism offerings and to other industries
  - prepare for bushfire events

  These and other adaptive responses are already occurring in Victoria's alpine resorts.

For additional detail, a copy of the literature review is available.

Data review and analysis

The data review and analysis included the collection of social, economic, institutional and environmental data and was used to inform the vulnerability assessment. Data provided an understanding of how each of the alpine resorts in Victoria currently operates, their current and historical visitation, economic activity and contribution to the state's economy, existing assets (such as lifting infrastructure, snow making equipment), accessibility and their access to resources including water and electricity.

For a detailed list of the types of data that informed the vulnerability assessment see the Conceptual Model report.

Engagement

Engagement with key stakeholders in the alpine resorts sector was designed to inform the understanding of how the resorts currently operate, what their current values are, how vulnerable these values are when considered in the face of climate change, and what the strengths and weaknesses are in the sector for responding to the changing environment.

The specific requirements of the stakeholder engagement were to:

- Identify strengths, gather sector knowledge, practical experience and community input
- Listen to and note issues, concerns, and ideas
- Raise awareness and develop adaptive capacity
- Understand what stakeholders value about the alpine resorts and their vision for the future.

The consultation established that the economic value of the alpine resorts sector is dominant in the minds of stakeholders. There is a shared recognition that the resorts' contribution to the state economy, visitation, infrastructure and the white season are vital economic values, and that these values are vulnerable to climate change.

Consultation also identified the key social and cultural values of the alpine resorts sector. The strength of the alpine community was the most frequently expressed social value. The social value of activity and the wellbeing that comes from being in the alpine environment were also considered key social values of the resorts. Cultural values are a way of being in or experiencing a place that a group of people share. In the alpine resorts, the consultation showed nature based culture as the standout cultural value, with activities based culture, snow culture and community culture also rating highly.

Social and cultural values are also vulnerable to climate change, although not as vulnerable as economic values. Social and cultural values are values that can be maintained – and are worth maintaining – in their own right, regardless of the scale of commercial activity or the degree of climate change.

Those consulted stated that the adaptive capacity of the resorts to climate change will require some fundamental weaknesses to be addressed. However, the consultation also identified a broad range of opportunities for further adaptation, and the significant strengths that can support the uptake of those opportunities.

A Consultation Report is available which provides a detailed break down of the current values in the alpine resorts and their perceived vulnerability to climate change. It also details the participants' perceptions of the sectors' strengths and weaknesses in relation to adaptation.

Systems analysis and mapping

A systems map identifies the key segments of the system and reveals interrelationships and interdependencies between these segments.

The systems frame provides the organised and coordinated basis upon which values, vulnerabilities and adaptive response pathways can be identified, tracked and analysed. Using outputs from data analysis and stakeholder engagement, informed judgments can be made as to the direct and indirect impacts of vulnerabilities within and between segments, and across the system generally. Uncertainties can be directly taken into account, through the testing of possible responses to determine interactions and side effects, reveal unintended consequences, and provide insights that reveal better alternatives. This provides the basis for a more objective approach to the design, testing, implementation and acceptance of adaptive response alternatives.

Chapter 2 of this report begins with a description of the alpine resorts sector. This description was developed through a systems analysis and mapping process undertaken using the systems mapping software Kumu. The system map of the alpine resorts sector developed for this project is available.

Vulnerabilities and capacities identification and assessment

Drawing on the preceding tasks, an assessment of vulnerability to climate change for each resort has been undertaken (this report). The assessment considers the vulnerability of the assets and values affected directly or indirectly by climate change at each resort. Vulnerability is determined through an assessment of exposure, sensitivity and adaptive capacity summarise the impacts on. This is based on assessments of exposure, sensitivity and adaptive capacity Vulnerability is described and shown graphically in a dashboard.

Reporting and communications

The results of the vulnerability assessment, and the background work that informed the assessment, are presented in a written report (this document). In addition, and as described above, there are several

supporting documents which provide more detail on elements of the project which informed this vulnerability assessment. These are: the Conceptual Model Report, the Literature Review and the Consultation Report. Two interactive tools also accompany the written documentation: a systems map (developed using Kumu, an online systems mapping tool) and the vulnerability dashboard (an Excel based tool).

1.4 Report structure

The remainder of this report is structured as follows:

- **Chapter 2** is the vulnerability assessment for each of the alpine resorts in Victoria
- **Chapter 3** has concluding remarks and observations

2 VULNERABILITY ASSESSMENT

2.1 The Victorian alpine resorts sector

A system map of the alpine resorts sector has been developed, using a systems analysis method. The system map reveals:

- The forces that are currently at work in the system
- The relationships and interdependencies between these forces
- The current set of values being produced by the system.

The systems approach highlights the forces and relationships most vulnerable to climate change. It can also support adaptation planning by revealing parts of the system that could be leveraged to maintain system health as climate change impacts upon parts of the system.

The 'deep structure' of the alpine resorts sector

The deep structure of a system is made up of the 'super forces' at work in the system. A super force is one that is critical to current system health. In the alpine resorts sector, the super forces identified are:

- The alpine environment
- Climate / climate change
- Snow cover
- Resort visitation
- Market forces
- Private investment
- Public investment
- Regulation and governance

Interrelationships and values

These super forces influence each other and are in turn influenced by other lesser forces operating in the system, through a web of interrelationships that either enable or inhibit system health. Changes in system health can affect the types and levels of value produced by the system. These dynamics can be revealed through a narrative about the system, and what follows is the story of the alpine resorts sector system.

The story of the alpine resorts sector system

The system develops from the interplay between the super forces of the **alpine environment** and **climate.** The seasonality of this interplay produces different conditions in winter and summer.

The **winter** conditions produce the super force **snow cover**. Snow cover generates the original visitation for snow driven recreation. People enjoy various forms of snow experience and recreation, across a range of sports and activities. The use and enjoyment of the alpine environment – and later resorts – by people leads to the formation and development of **social values** (like active living, wellbeing and community) and **cultural values** (like nature-based and snow culture).

Summer conditions also attract visitors who come to enjoy the alpine environment for activities like general leisure, trail walking, cycling, events, festivals, sight-seeing and the general enjoyment of

retreating into the mountains. This use and enjoyment also supports the formation and development of social and cultural values.

Historically, activity also occurred in the region in response to other economic or cultural uses: forestry, hydroelectricity, grazing and mining being most notable. This was the original basis of many of the surrounding non-resort communities as well as for some of what would later become the alpine resort communities.

Market forces responded to these values and activities with increased recreation spending, leisure tourism and marketing driving visitation as well. As the number of people visiting the resorts grows, **resort visitation** in the white season becomes a super force because of the demand for infrastructure, goods and services needed to support visitation and the snow activities that visitors wish to enjoy.

Public investment is attracted into the system, at first to enable and support accessibility (roads, land) for some of the early economic activities, and then to provide other public infrastructure and services that enable and support the public use and enjoyment of snow. As the scale of visitation and activity increases, public investment becomes a super force and takes on new dimensions – regulation and governance of the public good associated with the alpine environment becomes important, for example.

With the high levels of visitors' willingness to pay to access and enjoy the snow, **private investment** is attracted into the system. This includes investment in lodges by groups for their own benefit and the development of a range of commercial infrastructure and services that further enable and enhance the visitor experience. Lift infrastructure, accommodation and other private facilities and services that visitors can use and enjoy emerge, and these increase the attractiveness of being in the resorts. This, in turn, drives more visitation. To the extent that snow cover remains healthy, this loop remains strong and private investment becomes a super force.

As visitation increases, so does the scale of the resorts, and the level of public and private investment in them. The resorts become complex environments that require an increasing amount of management to balance public and private interests. **Regulation and governance** now becomes a super force that influences the relationships between public and private interests through land, environment, natural resources laws, policies and practices.

Snow related activity (white season)

The system map shows that the success of the white season recreation market depends critically on having enough (depth, extent and duration) reliable, accessible and affordable snow. This is the essential force affecting white season visitation and virtually all other elements of snow related activity depend upon this. Originally natural snow provided the depth, extent and duration to attract activity and that snow was a **free ecosystem service**.

With investment in roads, some lifting and accommodation, access to this natural snow improved. But seasons are (and always have been) variable. Investment in **snow making** improved reliability and made an economic return, building long term average visitation. At this point, while snow was no longer free, it was still affordable. Indeed, in the absence of significant climate change impacts, it gave a higher return than when there was no investment in snow making and natural snow alone was relied on.

In the past, investments in access and snow making provided positive returns. More recently investments in most resorts have continued but well below earlier levels. There has been limited expansion in capacity, partly due to uncertainty about market factors and partly due to concerns that development may have reached, or is close to, desirable environmental limits. This latter factor is a matter of contention for many. Of the recent investment, the focus has been on snowmaking.

This is important to know because it explains why another set of relationships related to snow cover and the effect of climate on this is becoming the **main vulnerability** for future system health. More recently the behaviour of the super force **climate** has **changed**. The recent data for temperatures and natural snowfall shows decadal trends consistent with a warming climate and declining natural snow fall. It is

also consistent with the trends foreshadowed by climate change analysis from the 1990s and confirmed by recent, more detailed assessments. However, the inter-year variability is so great that this is only apparent in decadal averages, and in any shorter period there will be seasons that are not dissimilar to even the 'best' historic seasons.

We can now see the system start to shift. Over these recent years snow making requirements went up, on average. Part of this was investment made to improve reliability as described above. But a portion of it would have been required to maintain overall snow levels compared to earlier periods, on average, over the decade.

Climate change also increases the number of **extreme weather events**. While this can mean large **dumps** of snowfall to improve snow cover, it can also mean large rainfall (precipitation that doesn't fall as snow) that increase or accelerate the **washing out** of natural snow cover. Increased temperatures and dry periods also have the effect of increasing or accelerating snowmelt and the loss of top up snow (which is important for protecting the snow cover base). Lower quality and variable snow cover is less enjoyable, and the ways in which snow can be experienced and enjoyed become less diverse (advanced skiing becomes harder to do, for example). This has the effect of changing visitation patterns, and in poor seasons visitation decreases substantially. At the same time, changing visitor demographics have recently favoured groups that focus on snow play and tobogganing which have less demanding requirements for snow depth and quality, and can be met in less favourable conditions.

For lower altitude resorts it is arguable that without artificial snow, the amount of snow available is too little for too short a period for the resorts to be viable even now, on average. The warmer conditions in some years already limit the number of days and hours when snow can be made by snow guns, particularly at the lower resorts such as Lake Mountain.

Changing technology is another lesser force acting on the system. With snow factories, there is little technical limit on the capacity to make snow, even in a warming climate. The limits are likely to be imposed in the form of limits on acceptable water extraction, energy availability and cost (other lesser driving forces).

Simply, as temperatures rise, both the amount of snow that must be made for marketable conditions increases, and the cost of making snow per cubic meter rises with any form of snow making. To achieve snow making reliably under warmer average conditions, there needs to be a shift from conventional snow making using evaporative cooling to freeze the water, to a much more energy intensive manufactured snow using refrigerant technology for freezing (snow factories). Greater use of snow farming and other management techniques may also be required to make the best use of snow making equipment and to provide the snow coverage where it is required.

Even with snow factories, it is more challenging to provide snow coverage on steeper slopes and create the atmosphere or setting arising from a broad extent of snow cover on surrounding areas for much of the season. Techniques such as favouring existing infrastructure for runs on south facing slopes may help contain snow making costs but may have an offsetting 'cost' of reducing attractiveness and willingness to pay on the part of visitors. Any new investment to develop new runs on south facing slopes, however, may increase costs.

With snow making costs rising, the price to users is likely to rise, arguably reducing the number of people attracted or at least changing the pattern of visitation. Costs will rise fastest for lower resorts and when these operations close, the remaining users of Victorian resorts will concentrate at the remaining resorts, maintaining the viability of higher resorts for longer. Some users, however, may longer go to the Victorian resorts choosing instead to go interstate or overseas. While higher resorts will generally remain viable longer, between them there will be competition, with those providing the best offer with the lowest cost of snowmaking having the strongest competitive position.

There may be more opportunities to diversify offerings in the white season to include activities less dependent on traditional snow cover distribution and facilities (snow play, snow shoeing, cross country

skiing, snowmobiles, etc.). These may contribute to keeping the resorts that can offer such options viable for longer periods, albeit with a significantly changed character. Albeit some snowmaking may still be required to support these activities.

Nonetheless, the long term effect will be to raise the cost to white season visitors while providing an offering that declines relative to past experiences. It may increasingly have value to some individuals as being considered 'rare' or 'nostalgic'. Either way, the higher cost means it is likely that visitors will increasingly be drawn from a narrower and wealthier segment of the community. This will change the character of the community of snow sports participants gradually over time.

Those that can no longer afford the cost will need to seek other forms of active recreation to achieve the sense of wellbeing previously associated with snow sports. Some visitors may go overseas to other ski areas with higher altitude resorts which will not face similar challenges until later. It is unlikely that all will go to other ski areas as other parts of the world will be facing similar dynamics, pushing up costs there too.

Increased costs from snow making are likely to be only one challenge faced by snow based recreation activities. Like any business dependent on discretionary spending, these resorts are potentially vulnerable to recessions and competition from other offerings. While visitation has grown over the past decade, this has not kept pace with the growth in the Victorian population, suggesting gradual erosion of snow sports' share of the leisure spending market, or an overall decline in leisure spending.

Another factor may increasingly come into play over time. If the resorts and winter sports are perceived to be intensive generators of greenhouse gases (GHG) it may affect the social acceptability of winter sports as an activity, affecting marketability. All of these market factors can add to the risk of (re)investment in facilities that are expected to face rising cost challenges over time.

Private investment and visitor spending has not been the only contributor to the alpine resorts sector's white season income. Government has provided support both in the form of public infrastructure investments and, in recent years, payments to assist resorts to meet shortfalls in operating revenue. Four of the six resorts have now received such payments. If snowmaking, or other costs, rise faster than visitor revenues, the need for such support is likely to grow.

Economic value is lost, not simply because an activity changes or no longer occurs. If one economic activity is replaced by another of equal value and participation over time, and the assets of the original activity are largely depreciated and 'used up' as the activity ceases, there may be only modest economic losses in the transition. However new economic activity may arise in other locations and local jobs will still be lost.

For those that valued the original activity, there may still be a loss: something of value to them that depends on snow and is no longer available, say snow sports, may be lost and not replaced by other activities. This may be unrecoverable, at least within the Victorian alpine region.

Those with a broader range of active recreation choices may simply substitute other activities for snow sports: surfing, sailboarding, water skiing, mountain biking, etc. with little sense of loss. They may even find they prefer one or more of these activities, or that changes in the climate even increase their opportunities to enjoy some of these activities.

Government support is provided with a range of rationales:

- Provision of services and infrastructure on an equitable basis (roads, schools, police, health care, etc.)
- Investment in public goods such as recreation assets for the community (parks, tracks, etc.)
- Assistance to address short term stresses and provide continuity of publicly valued activities, even if of a largely private nature (as provided to resorts) or
- To assist with addressing stresses such as climate change.

For all of these the alpine resorts are competing with what are often found to be increasingly scarce resources. While funds directed to the resort areas may provide public benefits, redirecting them elsewhere may also provide benefits, in some cases perhaps larger benefits.

It is not appropriate to presume government policy regarding financial support for the alpine resorts. However, it is likely that over time, the need for government assistance will grow for the resorts to survive. In the longer term, it also seems likely that the perceived benefit of that assistance may diminish, relative to its deployment for other purposes.

Effective governance is essential to making the decisions on how best to attract and deploy resources for the benefit of both the resorts and the wider Victorian community. It is a key element in determining the effectiveness of a community's response to the need to adapt and deploying its adaptation capacity. While governance is not affected directly by climate change, it can be affected indirectly as the area loses resources from declining returns and visitor numbers. Making decisions and employing effective action before this decline occurs will be desirable.

All year round and non-snow related activities (green season)
Relative to the white season, green season visitation, investment and the community of activity associated with it is much less in the resorts. Some surrounding towns are much less seasonally dependent, having more all year round visitation and other economic activity.

There have been stronger efforts recently to develop green season activities, in part motivated for some by the recognition that diversification may support the viability of resorts' existing snow oriented infrastructure.

The role and strength of the resorts in green season visitation is distinctly different from white season visitation. In the white season the resorts are the destination and focus of visitors' attention. Surrounding communities play a supporting role in this higher altitude focussed activity. In the green season, surrounding communities also offer significantly competing and complementary products and services. While the alpine areas surrounding the resorts still have unique attributes, these are not so compellingly different as to dominate the green season leisure market offering as in the white season. The key to success is likely to lie in joint development and promotion of complementary offerings, both to attract more visitors to the region and to hold them longer.

For some green season visitors, the alpine resorts may even lack the attractions sought: white season infrastructure may be seen to mar the scenery, not enhance it; amenities and services may be relatively limited compared to what is available in the towns in the valleys; the choice and style of accommodation may also not be seen as competitive.

Some resorts have long had green season activity and there is certainly scope for development of additional attractions and activities associated strongly with the alpine resorts. Some have promoted green season activities, found them not to be commercially attractive and then curtailed them. For others further development and promotion is still growing. This includes events, education, mountain biking, trails, nature tourism, etc. Some of these activities will require additional investment to be attractive. Building green season visitation is likely to be a long term (15+ years) process and may provide formidable challenges for commercial investors unless committed, patient capital can be raised. There may be a case for government investment in public assets as transition occurs and to support the communities affected.

In the longer term (25+ years) there is likely to be potential for mountain retreats to provide an escape from the heat in the peak of summer. The alpine resorts are well situated for this, being located among the coolest parts of the region. This is likely to come into its own as a potential market in the same period that white season viability is most under threat. We may not see so much a transition to all year round resorts but a flip from white season to 'hot' season.

Green season visitation carries its own risks and potential limiting factors. A key risk identified is bushfire, with the risk characterised by the expected frequency and severity, the capacity to manage or control fires (topography, access, water supply) and the capacity for safe evacuation where fires cannot be controlled or contained. Each location has different exposure to the risks arising from this.

The change in summer rainfall patterns may also activity in the green season. Whilst the expected rainfall reductions are modest in the green season, more intense events are forecast to occur. These events will likely produce higher run off which could potentially damage infrastructure and the natural environment.

The other limiting factor may be water supply. as mentioned above, while the expected rainfall reductions are modest, the combination of fewer, more intense events will tend to produce higher runoff which may not be captured in soils or water retention dams, and less stream flow in the periods in between. Higher temperatures will increase evaporation, adding to demand from some uses while at the same time reducing supply. The issue will be the adequacy of water supply to meet the range of competing demands, rather than the requirements of green season visitors alone.

All year round

Whatever happens to the commercially oriented recreational activity, the alpine region will still be there. It will continue to offer opportunities for those that are interested in or care about the environment to experience high altitude conditions relative to the rest of Australia, and will continue to have distinctive fauna and flora. It may become a refuge area for species not adapted to the hotter conditions at lower altitudes. It will bear witness to a past that had a very different climate. It can provide an education to those who visit and observe. And it can provide a place to meet and share the environment in new communities of interest.

Thresholds and tipping points

A number of potential thresholds and associated tipping points have been considered:

- Rapid decline in natural snow feeding back to higher temperatures and less favourable snow making conditions
- Ceasing snowmaking
- Withdrawal or sustained reduction in public funding.

Rapid transition to no natural snow

The mountains are expected to warm faster as there is less snow. As a result, the transition from having significant natural snow to having almost no natural snow is expected to happen quite quickly across an area. While a threshold issue for viability, it is also likely to be a tipping point which once passed, is unlikely to be reversed.

The tipping point will not occur in a single year, and there may be a few years during the transition with significant, even heavy, snow fall. However once it becomes established, low/no snow conditions will be increasingly self-reinforcing, making such natural snow as does fall far more transient with both warmer air and ground temperatures.

While making snow can contribute some local cooling by reflection and cooling the ground, it will be insufficient to affect conditions at the scale required to prevent the transition. The transition will occur first at lower altitudes and rise up the mountains. Once this process starts, it may rise quite quickly from low to higher altitudes as extensive if transient lower altitude snow fields are lost causing regional scale changes in temperature.

Ceasing snowmaking

Ceasing to make snow would be a likely threshold condition leading to an economic tipping point. Ceasing to make snow would effectively kill the economics of ski lifts and substantial portions of accommodation provided. This may occur when the marginal cost of snow making exceeds the expected gain in revenue. This may be long after full cost recovery for snow making is past. Full cost recovery

would include capital depreciation of snow making equipment, water supply and power supply, plus fixed costs associated with maintenance for these systems.

As long as the marginal costs yield a benefit in visitor numbers and income, resorts/operators will be able to make some case for assistance for capital investment and operating cost, because snow making contributes to resorts' viability. Once even direct operating costs exceed the benefit, this case becomes very hard to maintain. This then becomes a tipping point that would be hard to reverse.

The transition to loss of snow making is likely to occur for different reasons at different resorts. Where water supply and energy costs are not prohibitive, it may occur when the more or less complete loss of natural snow leads to a steep deterioration in snow making conditions, suddenly raising costs. A potential response might be to raise admission fees or other forms of cost recovery, but if other resorts are not (yet) facing the same pressures, this would not be competitive. On the other hand, such a strategy may be viable for the last resort standing – although it may not be in the Victorian Alpine region.

Withdrawal or reduction in government funding
Withdrawal or reduction in government funding would be a threshold step and would make some resorts economically unviable even today. The lower altitude resorts of Baw Baw and Lake Mountain are unviable already and similar pressures will arise at higher altitude resorts over time. A very strong case would be required to reinstate funding once withdrawn, effectively making it a tipping point.

Lake Mountain received an average of $3 million per year from 2011 to 2015. This is roughly equal to the amount received from visitor spending in those years, in aggregate, or about $25-$30 per visitor. Taken at face value, about half the cost of resort operations is met by visitors and half by government support. The government contribution rises as a proportion on low visitation years and falls on strong visitation years.

Mt Baw Baw has a larger operating deficit (approx. $4 million) than Lake Mountain, and government contributions were much larger compared to both visitor derived revenue (double) and visitor numbers (nearly $200 per visitor) than Lake Mountain.

The Alpine Resorts Governance Reform Discussion Paper, released by DELWP in January 2017, identifies three main drivers of governance reform, one of which is: ***Be financially self-sustainable***.

> *The objective of the resorts should be to maintain the condition of the public infrastructure assets that they manage, while servicing their debt levels and maintaining their operating activities within a financially sustainable framework. Without grant revenue from the state and federal governments, the resorts are unlikely to be able to self-fund asset renewal and development projects.*
>
> *Page 28*

Even while government seeks to support Victorians to visit and enjoy parks and recreation areas, both in the Alpine Region and elsewhere in the state, expenditure will not be open ended where it is judged that greater good can be achieved by applying funds to other outdoor recreation uses.

2.2 Assessing vulnerability

Dashboard spreadsheet logic

The dashboard is used to summarise the impacts on the assets and values affected directly or indirectly by climate change. This is based on assessments of exposure, sensitivity and adaptive capacity.

These assessments are not precise and typically group many things together. Each row would need to be further unpicked, and the dependencies between the items at the next layer determined in more detail to improve precision. For example, we show a row for 'natural snow' but this is the result of

'temperature' and 'amount of precipitation' and 'white season precipitation falling as sleet/rain' and the effect of how each of these varies over time in order to assess both how much snow falls, how deep it accumulates and the resulting number of days of the white season.

Some of these more detailed relationships are shown in the systems map, and even these could be further broken down. While technically possible, this higher level of detail is beyond the scope of this project. Similar disaggregation would apply to the other lines in this dashboard.

The objective here is to help demonstrate the main dependencies and to highlight those that most demand attention or affect medium range decisions. For this a non-quantitative approach is adequate, and arguably preferable to arguing over numbers that are not expected to be precise. The stakeholders in each resort are encouraged to explore the assessments in more detail, revising where necessary, before taking any adaptation actions.

There may be many assets and values that are unaffected either directly or indirectly by climate change (e.g. external economic or market factors) or have very low sensitivities and are not significantly influenced by others either. Most of these are simply absent from the table but may be critical for investment decisions in either public or private assets.

Behind the colours, numerical values are used to help calculate the combined effects of exposure, sensitivity and adaptive capacity. The formulae for these calculations are documented in Appendix A.

Exposure

Measure of **exposure** (likelihood or probability):

Dark green	<1 percent
Light green	1 to 10 percent
Yellow	10 to 50 percent
Orange	50 to 90 percent
Red	>90 percent

In cases where there are dependencies, exposure may be calculated from the vulnerabilities of the asset or value on which something is dependent. For example, lifts are dependent on visitation which in the white season is substantially dependent on affordable snow. The calculated vulnerability measure for affordable snow then translates to the 'best estimate' of the exposure of lifts to 'no snow to access', hence loss of operating viability and eventual loss of this asset.

Sensitivity

Measure of **sensitivity** (severity of impact):

Dark green	negligible, easily managed, no real impact
Light green	minor impact on value/returns
Yellow	impact on values/returns but not sufficient to change character or direction
Orange	major impact on values/returns forcing change of approach and much diminished outcomes
Red	all value lost and likely unrecoverable

These measures of sensitivity are the response of the system under business as usual, with no attempt made at adaptation. It is not a prediction that this will be the case, merely an indication of the degree of impact if exposure occurs and therefore the importance of acting.

Sensitivity may vary over the three time frames, particularly where significant adaptive capacity has been effectively applied in earlier periods or if changes over time in other assets/values or technology are expected to influence sensitivity, regardless of actions by those affected. An example of this second condition is displacement of visitors from more vulnerable resorts closing partly offsetting visitors lost due to reduced snow conditions – until all the more vulnerable resorts have closed and this effect is lost. Sensitivity for many parameters may be relatively consistent between locations (resorts), unless local circumstances indicate variations.

Adaptive capacity
Adaptive capacity indicates the extent to which the vulnerability could be reduced by action on the part of those affected. Adaptive capacity is the parameter that is most subjective, open to choice and change, and would be the focus of adaptation planning.

When scoring adaptive capacity, it is proposed that the most effective approaches are assumed to be accessible, that resources are available and that they are implemented effectively.

Adaptive capacities may act on either exposure or sensitivity, or both. For some rows there are no adaptive actions that will have any direct effect (e.g. maintaining natural snowfall).

The levels used for adaptive capacity are:

Dark green	complete, many options and resources, all of either exposure or sensitivity can be removed, can deal easily with change
Light green	effective, several options and good resources, most exposure or sensitivity can be removed by flexible approaches
Yellow	significant, some options so exposure or sensitivity can be significantly reduced at some cost; change accepted reluctantly
Orange	limited reductions in exposure or sensitivity, few options, can be achieved at high cost but resources required exceed those available, strong resistance to change
Red	none, no options available to change exposure or sensitivity, no or resources available and inflexible

Note that some adaptive behaviours that protect particular assets/values may have a detrimental effect on others (e.g. more expenditure on snow making to maintain existing snow conditions reducing overall returns and capacity to invest in other white season assets). At present the dashboard does not directly take this into account.

Adaptive effectiveness
Adaptive capacity is a measure of what may be possible, but there are many steps that will determine what will be achieved by way of implementing that capacity. Central to this is the role of governance, supplemented by the access to resources. Many factors influence this, including: the degree of shared understanding of the need for action and agreement on the most appropriate actions; confidence that those actions will be effective and resourced; and flexibility when conditions change unexpectedly (including the host of non-climate related influences on success).

In the dashboard no judgement is made as to effectiveness. What is included is the option to change the assumed level of effectiveness from totally ineffective, in which the sensitivity adaptive capacity is presumed reduced to none up to presumed full effectiveness, in which adaptive capacity is fully achieved. This is controlled by a slider in the top left corner of the presentation. The formulae used is described in Appendix A.

The initial review of vulnerability assumes that available adaptive capacity is effectively deployed. In practice this may not occur. At the end of the review the effect of diminished adaptive effectiveness is shown, typically arising due to poor governance or inability to access the necessary resources.

Vulnerability
Vulnerability is a product of exposure and sensitivity measures which is then moderated down by the adaptive capacity and effectiveness to calculate the final level of vulnerability. It reflects the likelihood of 'value' being compromised or lost. At this point we have not quantified the scale of the loss which would be relative to the initial value of the asset or value, that is, different values may carry different weights. In practice, these different weights will vary for different stakeholders too.

As noted above, calculated vulnerability may be used as input to other rows and be enumerated as part of a group of values/assets that impact on a key 'super force' in the system.

The colour scale shows cells contributing to highest vulnerability in red, lowest in green and intermediate in yellow. Suggested interpretation of vulnerability, allowing for degree of exposure, sensitivity after adaptive capacity is considered:

Dark green	low, no significant concerns
Light green	moderate, manageable impacts
Yellow	significant impacts potentially requiring assistance to adjust
Orange	major impacts expected, external assistance needed to adjust, status quo unsustainable and new focus/values/priorities required
Red	non-recoverable losses, adaptation of current activities/values not feasible requiring retreat

The climate change vulnerability of all year round or non-snow related activities and visitation are harder to assess than for the white season. For the white season, so much established activity depends on affordable snow cover.

We have not assessed the vulnerability of the visitor based economy for the green season. There is much less established value from visitors outside the white season, with visitor days and spending per day lower at the resorts. For the green season, so much is about the potential for developing new activities and attractions as far as economic activity goes, as well as the development of an evolved appreciation of these areas by local residents and visitors through the social and cultural values that arise as the alpine environment changes. Some of the impact of climate change is to create an opportunity for a cool respite from heat elsewhere, an opportunity not a vulnerability.

It would be speculative to attempt to assess the vulnerability of activities still to be developed. Whether and how the green season product is developed will impact the financial success in the green season, more so than any climate change impacts. If expected climate changes and their impacts are taken into account, green season activity should plan for and be adapted to the conditions expected in the decades ahead. Climate change may affect the scope of feasible opportunities, through bushfire or impacts on water supply, but if these are being taken into account, only those opportunities that are viable in the expected future conditions should be developed.

Format of the dashboard

The dashboard is divided into sections. Vertically there are three sections covering the next ten years (2020s), twenty to thirty years (2030 to 2050) and forty years plus into the future (after 2050). Horizontally there are a series of subsections.

The first four subsections deal with the climate impacts on the white season:

- The first subsection addresses the issues affecting **affordable snow**, the underlying white season super force.
- The second subsection addresses economic infrastructure and access issues that affect the capacity of **visitors** to get to and enjoy the available snow, the second white season super force.
- These then flow into the third subsection that looks at the flow on effects to the **values** identified from the consultation and shown in the systems mapping.
- The fourth subsection for the white season shows the environmental effects and vulnerability of these values.

The green season has a single section dealing with changes arising more or less directly from climate change. The results are mixed and not summarised in a single driver or outcome.

The displayed results are generated from an interactive spreadsheet. Coloured cells without diagonal lines are filled against the ratings listed above by selecting from a drop down list. The rating of cells with a diagonal is determined by a formula that combines the inputs in that row or reflects the dependency

of that cell on a result from elsewhere, such as the super forces or other relevant rows above. These relationships are discussed for each section where the inputs are set.

2.3 Mt Hotham

Mt Hotham Alpine Resort is located about four and a half hours drive from Melbourne. There are two possible routes to the Hotham Alpine Resort. The Great Alpine Road runs from Wangaratta in the north of Victoria, to Bairnsdale in the south with Hotham midway. Visitors access the resort from the northwest pass through Wangaratta, Bright and Harrietville. Visitors approaching from the southeast pass through Sale, Bairnsdale and Omeo. There is also an airport (Mt Hotham Airport) located 25km from the resort.

In the white season there is a fee for access. Outside of the white season, there is no entry for access to the Resort and private vehicles are free to enter the Village and park as they tour the Great Alpine Road.

The population of the Resort Village all year round is 50-100. Many people who make a living on Mt Hotham all year round live in the surrounding district travelling to the mountain from Bright, Harrietville, Dinner Plain and Omeo. The nearest school operating all year round is the Bright P-12 College located in Bright. During the white season the college operate a campus at Dinner Plain for students living on the mountain or at Dinner Plain but limited spaces are available.

Aboriginal people have been present in the Mt Hotham region for many thousands of years before the arrival of the first Europeans. The principal language groups in the Mt Hotham region include the Gunaikurnai, Dhudhuroa, and the Jaitmathang. The first European activity associated with the region was from the mid-1830s, and largely occurred in the open plains of the foothills adjoining the alpine altitudes. Industries included grazing and gold mining. Bright and Omeo Shires upgraded the Alpine Road between Harrietville and Omeo from a 4ft wide pack track to an 8ft wide coach road in 1883 to attract business from the new gold mining boom. This road has influenced the region and resort development to the present day.

Development of snow related activities (white season)

The development of Mt Hotham as a ski resort began during the 1920s with the establishment of the Hotham Heights Chalet on the Alpine Road. In 1933, the Railways Department took over the management of the Hotham Heights Chalet and the first significant steps at clearing ski runs were made. The 1940s saw the establishment of the first ski clubs and lodges. The first ski tow was installed in 1951.

The Mt Hotham Alpine Resort covers 320 hectares of skiable area located between 1,450 and 1,845 metres above sea level. There are currently 13 lifts at Hotham capable of moving 25,000 people per hour. Lifts include eight quad chairs. The lifts service a total of 72 runs, with the longest being 2.5km in length. Of the skiable terrain 60 percent is considered beginner or intermediate:

- 20 percent are beginner runs
- 40 percent intermediate
- 40 percent advanced.

The Mt Hotham Village is unique in that it is located at the top of the mountain ridge at 1750 metres above sea level, the highest altitude of any of the Victorian resorts. Accommodation bed capacity is 7,000 and there are 11+ food and beverage outlets.

In terms of visitation in the white season, in 2016:

- 77 percent of visitors were from Victoria (compared to 82 percent for all Victorian resorts)
- 19 percent were interstate visitors (compared to 14 percent for all Victorian resorts)
- 4 percent were international (compared to 4 percent for all Victorian resorts).

The economic impact of visitation during the white season has been estimated for the ARCC by EY Sweeney (2017). The combined contribution of Mt Hotham on the gross regional product of the surrounding Alpine Shire totals $119 million, and supports 899 direct and 338 indirect jobs.

Visitors and visitor days since 2006 are outlined in the chart below. Total visitor numbers have decreased slightly in the last four years. However, the average stay has been relatively steady at between 2.5 and 2.75 nights per visitor.

FIGURE 5. MT HOTHAM WHITE SEASON VISITATION (2006-2016)

Source: ARCC (2016). Victorian Alpine Resorts Entry Statistics

Non-snow related activities (green season)

Mt Hotham is marketed as the perfect cool retreat. Activities available include bushwalking, guided history tours, road cycling, mountain biking, and 4 wheel driving. The Great Alpine Road passing through the Hotham resort is the highest bitumen road in Australia, it offers an advantage in that the road is a popular touring and cycling route. Hotham has also developed Hotham365, two indoor ski slopes which operate all year round.

According to visitation data (EY Sweeney, 2017a) Mt Hotham had the third largest number of visitors in the 2016/17 green season of any of the alpine resorts, with 57,948 people visiting accounting for 98,512 visitor days. Hotham has the largest number of visitor days of all the resorts. At Mt Hotham during the green season:

- 83 percent of visitors were from Victoria (compared to 89 percent for all Victorian resorts)
- 17 percent were interstate visitors (compared to 10 percent for all Victorian resorts)
- 0 percent were international (compared to 1 percent for all Victorian resorts).

In terms of economic contribution of the green season, Victorian visitors are estimated to spend an average of $226 per day. This includes spending on food, shopping, travel, accommodation and other miscellaneous expenditures. This daily spending is lower than the white season where the average daily spend by Victorians is $520 per day. The average length of stay is also longer in the white season compared to the green, 2.7 days compared to 1.7. In total, EY Sweeney (2017a) found that the contribution of Mt Hotham to the gross regional product of the surrounding Alpine Shire totalled $15 million, and supports 112 direct and 41 indirect jobs, in the green season.

Green season visitor days are only 30 percent of white season days, and they are spread over a longer period with a lower expenditure per day. The economic impact is therefore much lower; only about one eighth of that of the white season.

Vulnerability assessment

The vulnerability of Mt Hotham resort is assessed in two parts:

- Snow related activities (white season)
- All year round and non-snow related activities (green season)

The initial review of vulnerability assumes that available adaptive capacity is effectively deployed. In practice this may not occur. At the end of the review the effect of diminished adaptive effectiveness is shown, typically arising due to poor governance or inability to access the necessary resources.

Snow dependent activity (white season) vulnerability
As with all alpine resorts in Victoria, the success of the white season recreation market is critically dependent on having enough reliable, accessible and affordable snow. The first five rows of the vulnerability dashboard (Figure 6) contribute to the vulnerability of the snow dependent (white season) super force – the **availability of affordable snow**.

Natural snow is expected to decline in amount and reliability with climate change. In the first decade of the 2000s, there was an average of 129 days per year of natural snow cover of one centimetre or more recorded on the higher slopes (1830m) and 98 at about 1650m elevation. In the 2020s, this is predicted to be about 100-120 days on the higher slopes and 59-92 days at 1650m, a modest but significant reduction. On the lower slopes the reduction will be from about 51 days in the 2000s to about 15-44 days. In the twenty years to 2050s, there is significant uncertainty about the number of days of natural snow cover with the estimate ranging from as few as 21 to as many as 114 for the higher slopes and 0-29 days for the lower slopes. The annual number of days of snow cover could stabilise at about this level if there is significant global mitigation of greenhouse gas emissions.

By the 2070s, under the business as usual emissions levels[1], the number of days of natural snow cover of one centimetre or more is likely to reduce to the point that there will be only transient natural cover each year. Whether and how quickly this occurs depends on the global success in reducing emissions. Maximum accumulated natural snow depth is also expected to decline to zero to 20 centimetres over this period.

Natural snow is highly sensitive to climate change. This sensitivity results directly in the loss of snow. Short of weather modification, there is no adaptive capacity to restore natural snow across the region. As the highest altitude resort, Mt Hotham will lose natural snow cover later than lower altitude resorts.

Snow making at Mt Hotham is currently used over an area of about 33 hectares. This represents approximately 30 percent of the skiable area. The capacity to make snow is broadly dependent on the availability of water, energy and suitable snow making conditions in order to be both technically feasible and cost effective.

At Mt Hotham there is currently sufficient **water** available for snow making, although there are plans for expanding storage. Current storage amounts to 29,000 cubic metres in a reservoir, plus a small storage of 1600 cubic metres beside a creek which is constantly being refilled and can be used to refill the large reservoir. Hotham has a license to divert 500,000 cubic metres of water from the stream. The upper Swindlers Creek watershed is a protected catchment comprising groundwater source, snow melt and precipitation within a 177 hectare area. The snow making water reticulation is largely independent of the potable drinking water supply system. Only the snow making operation on Big D Ski area draws water from the potable storage tanks. 2,000 cubic metres is available from the potable water supply.

[1] Business as usual emissions rates = Zero Mitigation (RCP8.5)' scenario. For more detail see the Literature Review.

Mt Hotham, over a five year average, has been using 124,000 cubic metres of water for snowmaking per year. The upper limit under the current licence would be about four times that, but with warmer conditions and a higher demand for snowmaking on existing areas, this may not translate into an equivalent increase in area covered.

Water availability may be affected over time with changing climate affecting the pattern of rainfall. More extreme events and less regular rainfall may diminish the available water. While some water is likely to be available in the reservoir, the calls on water downstream may affect permits to divert stream water into storage, and the use of potable water, for use in snowmaking if downstream and potable uses are deemed to be higher priority. This will occur at a time when the requirement of water for snowmaking is likely to be rising. Sensitivity to lack of water is relatively high – if water is not available you cannot make snow. However, it is not absolute in that you can make some snow with what water is available and the likelihood of no water at all is low. Thus, overtime, exposure to limits on water will rise, albeit judged not to be to high levels, while adaptive capacity may fall – bigger storage may not improve actual supply in dry years.

Energy is required to make snow. The amount of energy required will rise initially for snow guns as average operating temperatures rise and then further if there is a shift from conventional snow making to using snow factories, as may be expected to occur over the longer term.

Mt Hotham is connected to the State electricity grid. Prices have risen in recent years so future energy costs may be a concern. On the other hand, the cost of energy generation from renewables has continued to fall and is expected to fall further, albeit at a declining rate. Supporting this is a fall in battery costs for energy storage.

Mt Hotham resort currently receives none of their energy from renewable sources, though the Alpine Resort Management Board has been investigating alternative energy production and has completed a wind power feasibility study. The Masterplan reads that there are opportunities to pursue viable renewable energy sources, such as wind, hydro and solar to supplement energy requirements for resort operations. The evaluation of energy vulnerability has a high level of uncertainty beyond the first time horizon.

Snow making conditions affect the cost of snow making, potentially quite dramatically. For conventional snow making, conditions are likely to remain generally favourable during the 2020s but suitable conditions are likely to be increasingly restricted as the climate warms beyond 2030, offering fewer operating hours, on average as each decade passes. Initially more machines operating during the fewer hours available can address this. In the longer run it would require a transition to snow factories, capable of operating in almost any conditions but requiring a much higher input of energy as noted above.

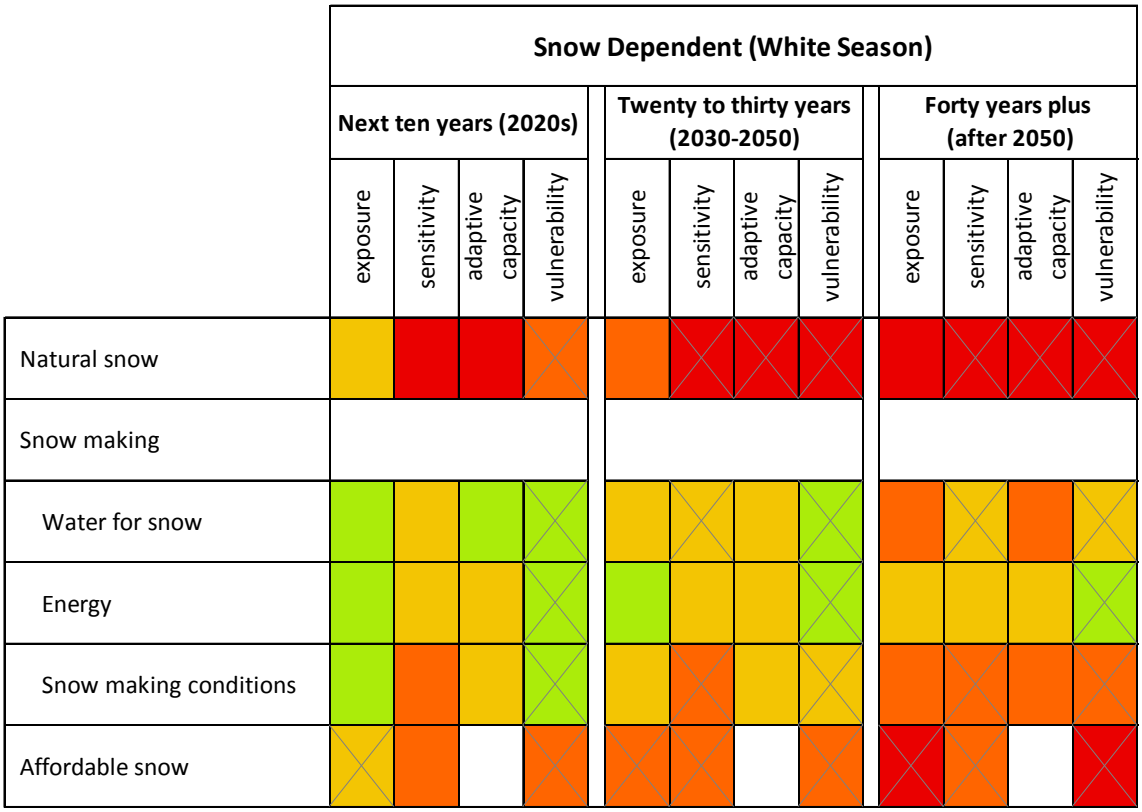
Thus, in the business as usual emissions scenario, the adaptive capacity becomes increasingly constrained over time, even allowing for technological advancement.

The calculated exposure to **loss of affordable snow** is a combination of the preceding conditions. It is represented as the combination of the calculated vulnerability of natural snow combined with the highest calculated vulnerability for the factors affecting snow making. At Mt Hotham, this is likely to be snow making conditions in the long term, pushing up the costs of snow making. In the longer time horizon water supply may also be a significant factor.

With significant global emissions reduction, a situation where significant snow making can continue to be viable indefinitely is plausible, but a much smaller area of the resort would likely be available with snow cover.

In the business as usual emissions scenario, after 2050 there would be a significant likelihood that conditions mean snow making would be cost prohibitive even if there is water and energy and it is technically possible. To put it in perspective, conditions under business as usual would be far worse at Mt Hotham after 2050 than they are at the lowest Victorian alpine region resorts today.

FIGURE 6. AFFORDABLE SNOW VULNERABILITY, MT HOTHAM



The next super force evaluated is snow related (white season) **visitor numbers** (dashboard shown in Figure 7). While clearly driven in part by the first super force, affordable snow, the economic infrastructure affecting access may also act to influence vulnerability of visitor numbers.

The exposure of lifts as infrastructure becoming unavailable is based on estimates of available affordable snow. If investors do not consider that snow will be available, and provide conditions that will be attractive to visitors needing lifts, then they will not invest. A failure to invest would have a strong impact on access to any snow that is available. With no/few operating lifts there will be fewer visitors.

There will be some adaptive capacity in the form of selecting different lift options, relocation of lifts to higher slopes and consolidating lifts to areas where snow is made most cost effectively. This adaptive capacity may decline over time once these options have been fully exploited.

Mt Hotham has a total of 13 lifts. There has been some discussion to add further lifts to the resort to relieve congestion and connect existing runs, with the Masterplan costing the expansion at $20 million. The expansion is an ARMB plan, not the ski lift companies. The expansion is currently on hold.

Roads are not expected to be affected as directly by climate change. At Mt Hotham the road serves through-traffic in both the green and white seasons and serves purposes other than white season visitation. Over time, road closures are more likely to arise from landslides and flooding/washouts than snow. While road closures may occur from time to time, the climate change impacts are not seen as lasting or deep in their impact. Adaptation may occur by building or repairing roads in ways making them less susceptible to landslides or flooding. Climate impacts on roads never act as a limiting factor for visitation at Mt Hotham.

Accommodation is affected by snow, again as a feedback like lifts. If there are not expected to be sufficient visitors there will not be (re)investment in accommodation and over time facilities will become

run down. Accommodation is different from lifts in that it has a useful green season role that may contribute increasingly to its white season viability. The provision of services (accommodation, food and beverage etc.) has been increasing over recent years to support green season activities, although most facilities still only operate during the white season months. Capacity expansion in accommodation is being considered, but is currently limited by the supply of potable water that can be achieved.

Mt Hotham does not support a permanent large population as it functions in a resort capacity role i.e. the provision of short term accommodation associated with transient holiday makers, with this current role predominantly focusing on the white season. Nearby towns, particularly Dinner Plain, also offer a range of accommodation, and support Mt Hotham all year round with schools and other services.

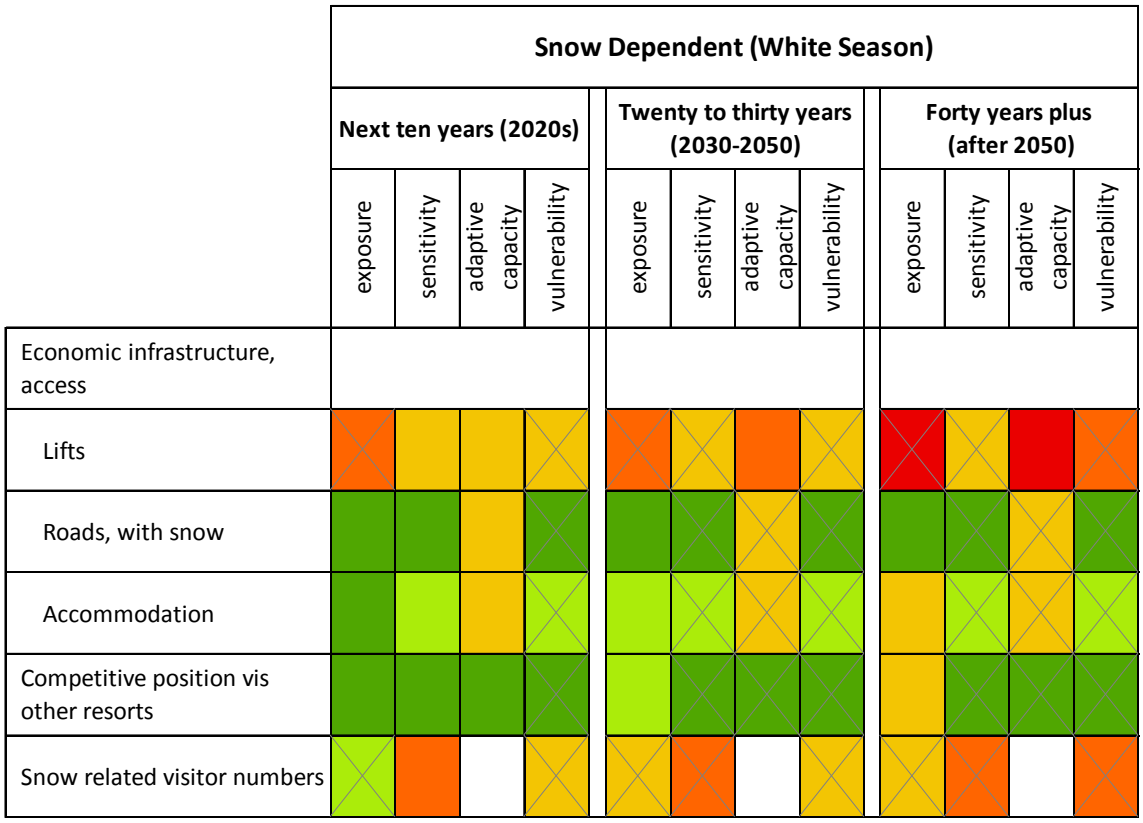
Should capacity closures occur due to decreased demand, capacity may still be sufficient and would not necessarily limit visitation, unlike closed lifts that restrict access. Adaptive capacity may be increased as well by appealing to more diverse markets even within the white season for those times when snow conditions are less adequate.

The **competitive position,** with respect to other resorts, recognises that as some lower altitude resorts close, some of their visitors will be displaced to the next best alternative. That position will be affected by many factors but relative altitude and capacity to continue serving snow sports by having lifts open and effective snow making will be the main determinants.

For snow related **(white season) visitor numbers** exposure is a calculated outcome from the super force affordable snow, combined with the 'limiting factor' among lifts, roads and accommodation and the influence of competitive position compared with other resorts. Lifts are likely to be the limiting factor among these. Sensitivity is deemed high. As with affordable snow, the adaptive capacity is taken to be captured in calculating the contributing factors.

The overall vulnerability of visitor numbers at Mt Hotham is deemed to be moderate with manageable impacts in the 2020s, but increasing in later years to significant impacts potentially requiring assistance to adjust. This is likely to be driven by increased dependence on manufactured snow which is unlikely to cover the current extent, with a corresponding reduction of lifts, limiting capacity of the resort.

FIGURE 7. SNOW RELATED VISITOR NUMBERS VULNERABILITY, MT HOTHAM



The two super forces of affordable snow and visitor numbers flow through to impact on values related to the white season. The vulnerability dashboard for these values is shown in Figure 8.

Exposure of snow related **economic activity** is directly derived from snow related visitation vulnerability. This is shown as moderately likely in the 2020s and managed by adaptation from snow making, increasing to highly likely in later periods as snow making becomes increasingly expensive and investment in lifts becomes less viable.

Sensitivity is taken to be high, consistent with stakeholder perceptions. This may be reduced by adaptation strategies such as diversification of economic activity away from snow sports. The scale of Hotham also provides some greater opportunities for diversification. In practice, future economic prospects may be more greatly affected by non-climate change factors (market competition with other activities, general economic conditions) so while sensitivity is high, it is not a directly predictive relationship. Overall snow related economic activity is expected to see significant impacts in the 2020s.

Snow related jobs exposure is equated to snow related economic activity vulnerability. As with economic activity, adaptation may include some diversification in employment activity that is not snow sport related but that takes advantage of snow related infrastructure and activity (winter relaxation/health spas) and some of this has already occurred. Employment may also be affected adversely by unrelated trends such as automation. Vulnerability of jobs is expected to result in significant impacts potentially requiring assistance to adjust by the next decade, even assuming 'effective' adaptation to non-snow related employment.

Snow sports culture exposure is taken as the vulnerability rating for snow related visitation. Here the definition of snow sports has a few facets: participation by large numbers or development of more advanced and competitive skills. Mt Hotham has developed historically as a resort for "serious" skiers due to the Resort's steep slopes. However more advanced and competitive skills may start to become limited in this region as snowmaking is generally less effective on the steeper slopes advanced skills in

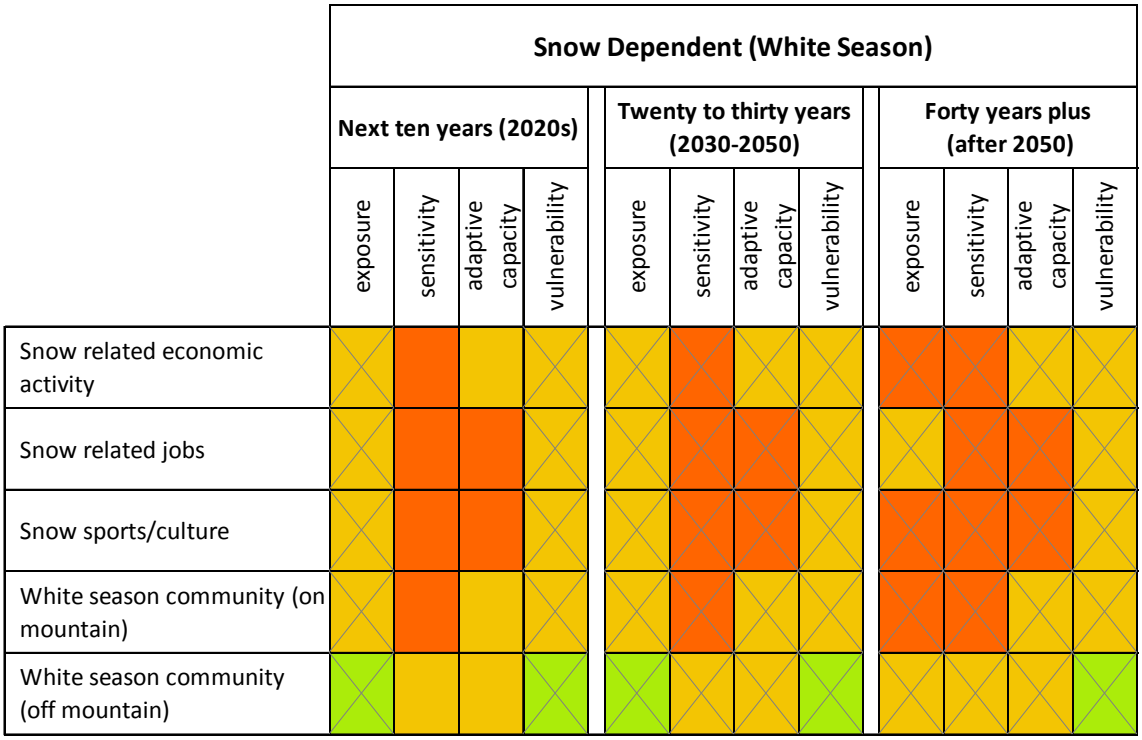
snow sports require. As these are less able to be maintained with snow making, the trend is likely to be towards less sophisticated beginners and intermediate participants, hence the link to visitor numbers. The exposure, sensitivity and vulnerability of advanced skills in snow sports would be higher as the terrain required tends to be steeper and therefore harder to use snowmaking to improve coverage. Overall the vulnerability is rated 'significant impacts are expected'.

The exposure of the **community and social base** is recognised as having distinct impacts on the communities on the mountain including nearby Dinner Plain. The on-mountain community is clearly strongly affected by visitor numbers in terms of exposure. Fewer people coming to the area reduces the base on which any community is built. Adjacent Dinner Plain may be more severely affected as they rely primarily on natural snow which is more vulnerable.

Lodges often form the basis for communities with a significant connections beyond the white season activity and with longer traditions of visitation and identification with the area will persist somewhat even if the quality of snow activities declines, thereby reducing sensitivity. Hotham has a significant proportion of lodge accommodation which may support shared values, and new activities, events etc. beyond those based on snow activity.

Off-mountain impacts on the towns of Omeo and Bright will be affected by changes in activity at Mt Hotham. Of the two, Bright has the strongest links, being the direction from which most visitor traffic flows. Bright has a more diverse economic base so the population underlying the community and social base has broader support. Associated with this route are smaller towns such as Harrietville which have a greater dependence on white season visitors and so are likely to be more affected. Overall the vulnerability of off-mountain towns is assessed as manageable, particularly while snow making provides affordable snow.

FIGURE 8. WHITE SEASON COMMUNITY VULNERABILITY, MT HOTHAM



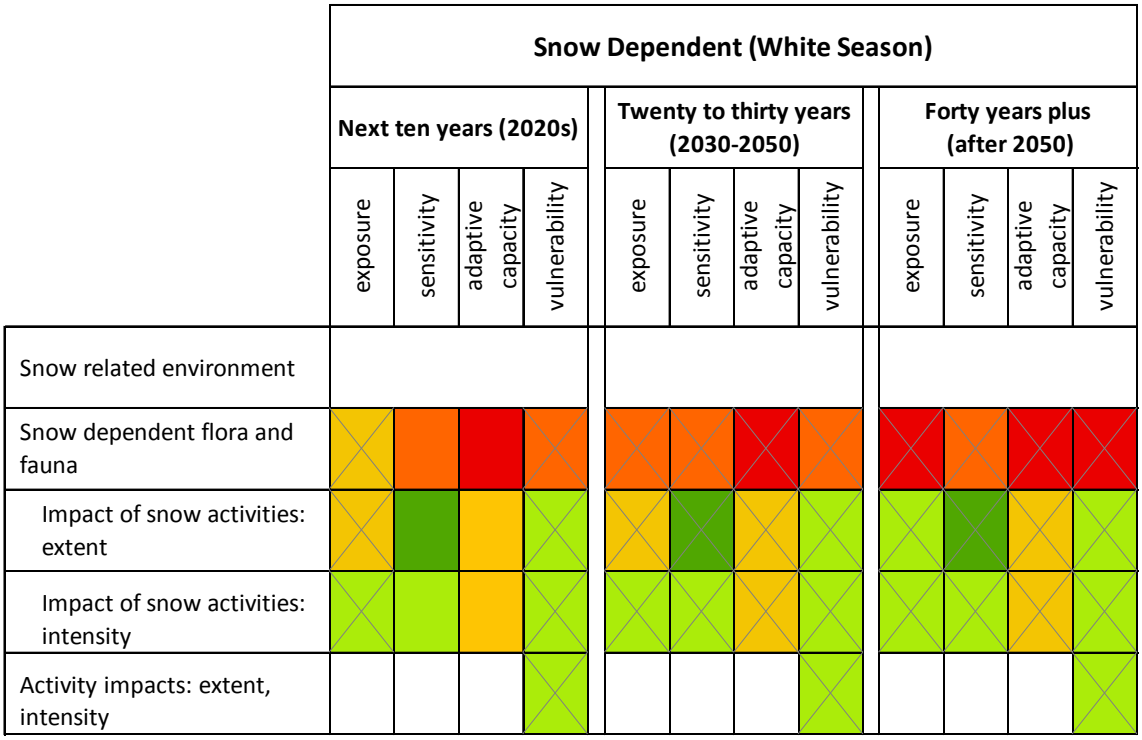
The **environment** encompasses a wide range of elements and values. This dashboard treatment (see Figure 9) selects only two snow related aspects that reflect workshop input as 'indicators' of the kinds of values articulated by participants for the white season.

Snow dependent flora and fauna will likely be unable to respond to loss of natural snow should it go. It is unlikely that, at this location, options exist for many of these species to adapt. Snow making is unlikely to contribute to their survival both because the area covered is too small and because the area that is covered is subject to unusual conditions of management and use (relative to what they are adapted to). If the snow is lost, many of these species will be lost. The exposure of the species is taken as the same as the vulnerability of natural snow. The sensitivity is taken to be total. The adaptive capacity is none. In practice a few species may adapt in some way to the changed conditions, but this is likely to be a minor part of the ecosystem community, and it will then be operating differently in a new context. Things will not be the same without snow and these species will be lost in the long term.

Snow activities have caused impact on the environment by physical changes to slopes and vegetation, and the addition of various built form and equipment including dams, roads, trails, pipelines, etc. The use of the area changes the pattern, frequency and character of snow cover, in some areas leading to compaction or other impacts on such vegetation that remains on ski runs and pathways. As climate change reduces the areas covered by natural snow, activity may become more concentrated on areas where snow is made. This may reduce the area impacted by snow related activities. Depending on trends in visitation, this may lead to intensification of impacts on areas that are still used, until ultimately use declines should white season activity no longer be viable. If climate change proceeds to the point that there is no longer white season snow activities, there are issues about remediation of sites, but otherwise the impacts from activities will be reduced.

Overall, the small environmental gains of reduced impacts on the environment in the areas where snow activities occur will be a small compensation for the loss of snow dependent species.

FIGURE 9. ENVIRONMENT VULNERABILITY, MT HOTHAM



All year round and non-snow related activity (green season) vulnerability/opportunities
Increasing temperatures coupled with a general drying of soil and ground fuels will increase the likelihood of bushfire into the future in Victoria. No specific modelling or research into the current risk of bushfire on the alpine resort locations has been conducted, but it can be assumed there will be some increased exposure to risk of loss of property and life at Mt Hotham.

The Mt Hotham Community Bushfire Emergency Management Plan recognises that bushfire risk management is complex within the Resort due to its isolated location, steep topography, climate, environmental significance, management arrangements and the vegetation in the surrounding Alpine National Park. Development approvals must meet the requirements of provisions within the Wildfire Management Overlay (WMO) of the Alpine Resorts Planning Scheme.

The WMO is intended to ensure development of land prioritises the protection of human life and strengthens community resilience to bushfire, and ensure development is only permitted where the risk to life and property from bushfire can be reduced to an acceptable level. Due to the topography and vegetation, meeting the requirements of the WMO was challenging within the resort. Managing defendable space in the steep terrain also has the potential for significant environmental impacts including loss of habitat, land slip and visual/amenity impacts.

Good management means that while fires may occur more often and be more intense, direct impacts on property and people can be managed – at a cost – but not eliminated. Under Code Red conditions the resort will, in effect, close to new visitors if significantly threatened by fire. This avoids risk by minimising people in harm's way but with climate change, this could increasingly affect green season visitation.

In Mt Hotham's favour, access from two opposite directions also provides greater flexibility and security of escape. Given the ski runs and the grassy alpine areas around the Resort, Mt Hotham village is arguably the safest location from bushfire for a considerable distance.

Besides the cost and building amenity impacts of protecting the resort, secondary impacts of more frequent and intense bushfires can be considerable. A burnt and degraded landscape combined with soil erosion and runoff contributing to landslides and degraded water quality may well be much larger than the direct impacts of fire. Loss of amenity could deter visitors for a period of time.

As the atmosphere warms, it can hold more moisture, resulting in longer dry periods, and more intense precipitation events. This will have impacts on the vegetation, water supply and prevalence of landslides at Mt Hotham. Although fire is a natural process in nearly all Australian ecosystems, many ecosystems and species around the resort including Alpine, subalpine, rainforest and riparian communities are not reliant on fire for regeneration. Maintaining or improve the resilience of natural ecosystems is therefore important.

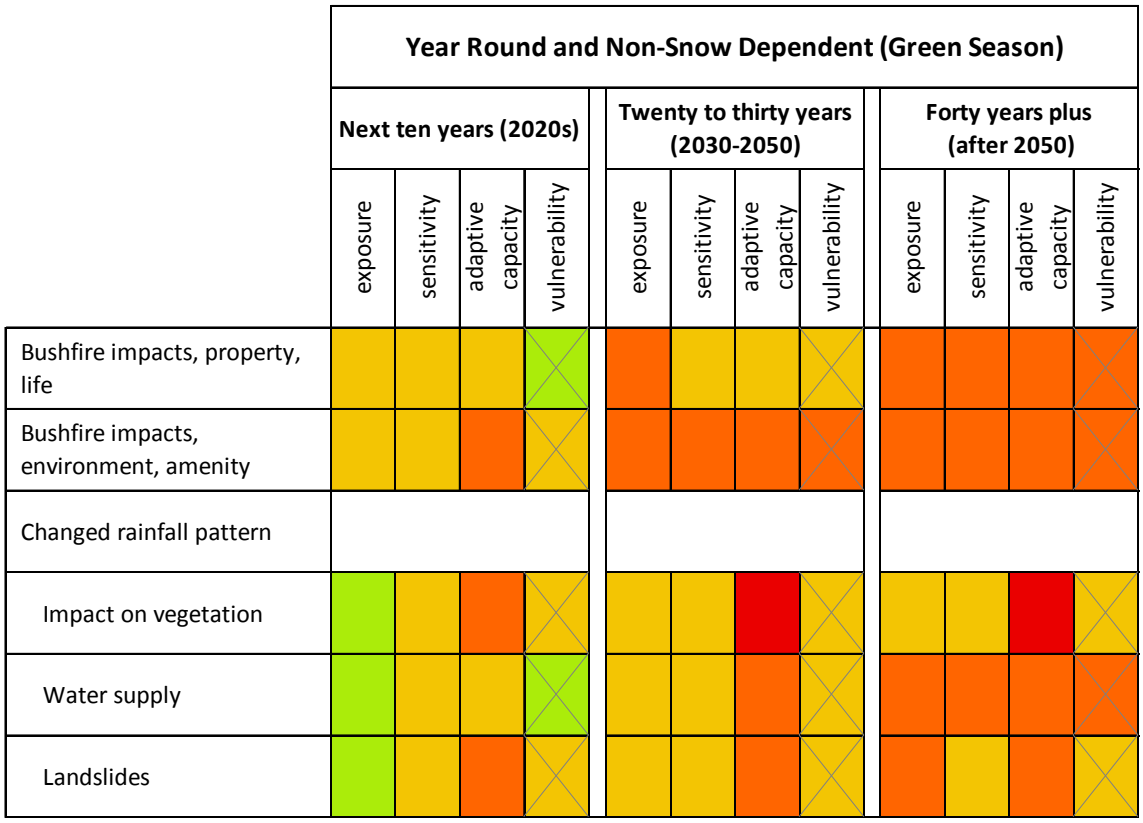
Water supply will be more highly exposed, potentially less able to provide the needs of communities with less reliable stream flow, and muddy flood waters during downpours. Against this, there will be adaptive capacity by building dams, filter beds and other potentially costly engineering solutions. Given the generally good starting water supply, this is not likely to be a major issue in the short term but will be increasingly vulnerable in the long term, as both natural water courses become more unreliable and adaptation options are used up.

Changed rainfall patterns, combined with fire and loss of some vegetation, are likely to lead to increased landslides. The direct effects on built assets and roads will likely be manageable, particularly for Mt Hotham as there are two options for exit should one of the roads be closed. There is some limited capacity to adapt by ensuring construction avoids the highest hazard slopes, though some sections of road will likely remain exposed.

These factors all act to reduce the attractiveness of the resort and surrounding area during the green season. This will eventually be all year round, and the fire season will extend to potentially become an all year round hazard.

This assessment of green season vulnerability is summarised in Figure 10.

FIGURE 10. GREEN SEASON VULNERABILITY, MT HOTHAM



Climate change in the long run could benefit the resort as people are increasingly drawn to the mountains to escape the heat in summer. The Great Alpine Road passing through the Mt Hotham resort is the highest bitumen road in Australia, it offers an advantage in that the road is a popular touring and cycling route.

Competition with other summer attractions and the other resorts will be a barrier, as will the current poor level of amenity at Hotham caused by the significant infrastructure focused on the white season, a perception that the resort is closed and uninhabited during the green season, and the large distance from Melbourne being a deterrent to day-trippers or weekend getaways.

2.4 Falls Creek

Falls Creek is predominantly accessed by road and is located approximately four and a half hours from Melbourne by road, making it the furthest of the six alpine resorts from Melbourne (based on driving time). Vehicular access is via the sealed Bogong High Plains Road. The road runs from the Kiewa Valley Highway at Mt Beauty across the high plains to the Omeo Highway at Shannonvale in the Mitta Mitta Valley.

Falls Creek's northerly location means it is relatively close to Albury in New South Wales. There are direct flights to Albury from Melbourne, Canberra, Sydney and Brisbane. The drive time from Albury to Falls Creek is approximately two hours. It is also possible to access Falls Creek via helicopter from Albury, Melbourne and Mt Beauty; a journey time of approximately 30-90 minutes.

Falls Creek is the second highest of the resorts, after Mt Hotham. It has the highest number of total visitor days of any Victorian resort and is both the single largest economic contributor to the state and region, as well as the single largest direct and indirect employment source for all the Alps. Falls Creek is Falls Creek is second highest in visitor numbers, after Mt Buller. Along with Mt Hotham, it shares a relatively high proportion of overnight visitors, reflecting its distance from major population centres.

Development of snow related activities (white season)

The Falls Creek Alpine Resort covers 1,530 hectares located between 1,210 and 1,850 metres above sea level. Of that area, 450 hectares is currently skiable terrain, all of which is located above 1,500 metres.

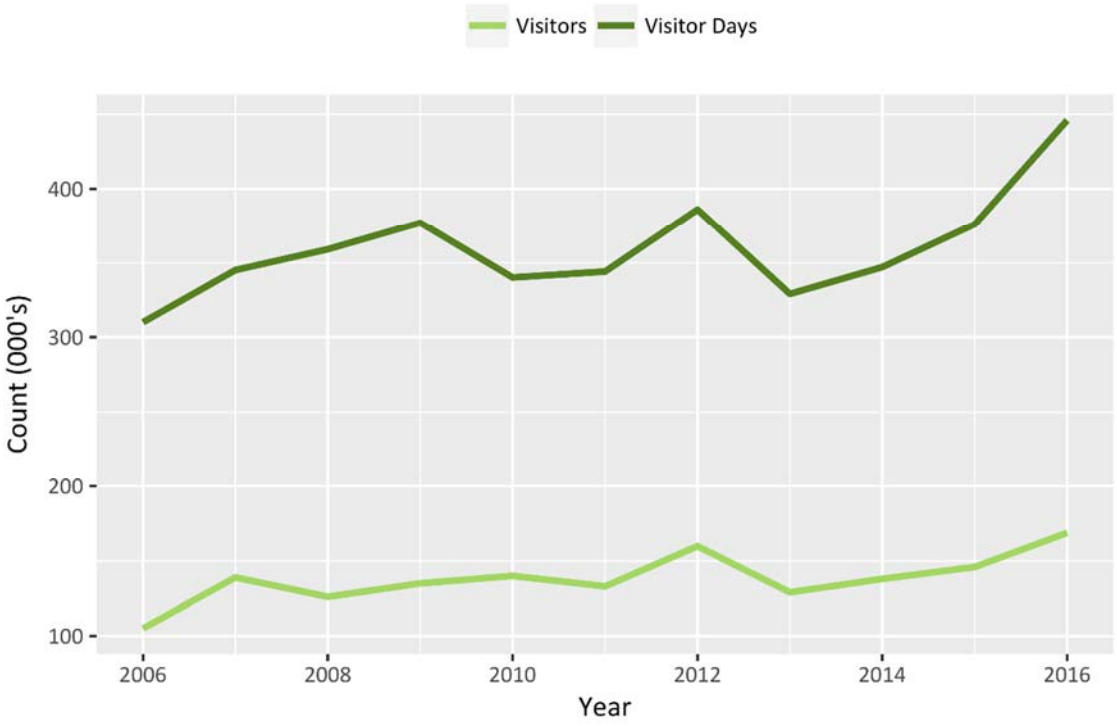
Falls Creek Village is the focus of white season activity. It is located approximately 1,600 metres above sea level. During the white season the village has a permanent population of approximately 1,000 people and a bed capacity of 5,000 with accommodation provided by a mix of commercial and club lodges. There are approximately 35 food and beverage outlets that operate during the white season and approximately 14 retail outlets.

The economic impact of visitation during the white season has been estimated for the ARCC by EY Sweeney (2017). The contribution of Falls Creek on the gross regional product of the surrounding Alpine Shire totalled $171 million, and supports 1,366 direct and 476 indirect jobs.

Falls Creek has a higher percentage of interstate visitors during the white season than the average for all Victorian alpine resorts. During the white season, 71 percent of visitors are from Victoria (compared to an average of 82 percent for all Victorian alpine resorts), 25 percent are interstate visitors (compared to 14 percent for all Victorian alpine resorts) and three percent are international visitors (compared to four percent for all Victorian alpine resorts).

Visitors and visitor days since 2006 are outlined in Figure 11. Visitor numbers have remained fairly constant over much of this period, although visitors and visitor days have increased steadily since 2013. Visitors to Falls Creek are increasingly spending longer at the resort.

FIGURE 11. FALLS CREEK WHITE SEASON VISITATION (2006-2016)



Source: ARCC (2016). Victorian Alpine Resorts Entry Statistics

Non-snow related activities (green season)

Visitor counts for the green season are available for 2017 when there were 94,269 visitors and 169,684 visitor days (EY Sweeney, 2017a).

Whilst visitor numbers in the 2016 green season are about 55 percent of those in the white season, and visitor nights even lower, at 38 percent, there has been significant investment in green season activities in recent years. Green season activities are currently dominated by hiking and biking (mountain and road). The Falls Creek Mountain Bike Park now has 19 trails which total over 40 kilometres. As of the 2016/17 green season, a shuttle for riders operates every weekend of the season as does the Village Bike Cafe.

The chair lifts operate in the green season, however are limited to sightseeing over Christmas and Easter, and by negotiation with FCARMB, however, under the operating model and business determination by the leaseholder it is not currently profitable to operate. The revenue generated over the green season weekends when the lifts do operate is minimal. In addition to commercial viability, maintenance works occur during the green season and any expansion of their operation would impact the maintenance schedule.

Road cycling, hiking and water activities based at Rocky Valley Lake are also available during the green season. The roads around Falls Creek are popular with road cyclists with a number of road cycling events passing through. There are over 100 kilometres of hiking trails accessible from Falls Creek. There is access to multi day walks and day walks with the village used as a base. At Rocky Valley Lake activities include fishing, boating, swimming, kayaking and dragon boating.

Over the last five years the number of events either held or culminating at Falls Creek in the green season has doubled. Events include:

- Three Peaks Challenge (road cycling)
- Herald Sun Tour (road cycling)
- Gravity Enduro National Series (mountain biking)

- Alpine Challenge (trail running)
- Falls Creek Mile High Regatta (dragon boating).

In addition to recreational activities, Falls Creek is also used as a base for professional athletes and sports teams for altitude training. Prior to the Rio Olympic Games, 13 Australian track and field athletes trained at Falls Creek. AFL, NRL and regional teams have also utilised the location for altitude training.

In terms of economic contribution the green season is significantly smaller than the white. Victorian visitors on average spend $176 per day in the green season. This includes spending on food, shopping, travel, accommodation and other miscellaneous expenditures. This daily spending is lower than the white season where the average daily spend by Victorians is $574 per day. The average length of stay is also longer in the white season compared to the green, at 2.6 days compared to 1.8.

In total, EY Sweeney (2017a) found that the contribution of Falls Creek on the gross regional product of the surrounding Alpine Shire totalled $21 million in the green season, and supports 168 direct and 59 indirect jobs. This about one eighth of the impact the white season generates

Vulnerability assessment

The vulnerability of the Falls Creek resort is assessed in two parts:
- Snow related activities (white season)
- All year round and non-snow related activities (green season)

The initial review of vulnerability assumes that available adaptive capacity is effectively deployed. In practice this may not occur. At the end of the review the effect of diminished adaptive effectiveness is shown, typically arising due to poor governance or inability to access the necessary resources.

Snow dependent activity (white season) vulnerability
As with all alpine resorts in Victoria, the success of the white season recreation market is critically dependent on having enough reliable, accessible, affordable snow. The first five rows of the vulnerability dashboard (Figure 12) contribute to the vulnerability of the snow dependent (white season) super force – the **availability of affordable snow**.

Natural snow is expected to decline in amount and reliability with climate change. In the first decade of the 2000s, there was an average of 125 days per year of natural snow cover of one centimetre or more recorded on the higher slopes (1800m) and 105 at about 1625m. In the 2020s, this is predicted to be about 92-120 days on the higher slopes and 68-99 days at 1625m, a modest but significant reduction. On the lower slopes the reduction will be from about 77 days in the 2000s to about 41-71 days.

Up to the 2050s, there is significant uncertainty about the number of days of natural snow cover with the estimate ranging from as few as 18 to as many as 108 for the higher slopes, and 2-59 days for the lower slopes. This annual number of days of snow cover could stabilise at about this level if there is significant global mitigation of greenhouse gas emissions. Eighty five percent of the resort has slope aspects that have south or south westerly facing topography. The altitude and south facing aspect are favourable for natural snow fall and retention, with Falls Creek showing slightly higher expected snow days in the future than Mt Hotham, reflecting this difference.

By the 2070s, under the business as usual emissions levels, the number of days of natural snow cover of one centimetre of more is likely to reduce to the point that there will be only transient natural cover each year. Whether and how quickly this occurs depends on the level of global emissions that occur. Maximum accumulated snow depth is also expected to decline to zero to 10 centimetres over this period.

Natural snow is highly sensitive to climate change. This sensitivity results directly in the loss of snow. Short of weather modification, there is no adaptive capacity to restore natural snow across the region.

As one of the higher altitude resorts with favourable topography, Falls Creek is expected to be the last resort to lose natural snow cover, and much later than the lower altitude resorts.

Snow making is used to ensure reliable snow cover at Falls Creek. Snow making is used over approximately 110 hectares, or 25 percent of the resorts primarily beginner and intermediate runs. Manmade snow is most effective on beginner and intermediate slopes as advanced terrain is generally steeper and the snow does not stay in place as easily. The terrain at Falls Creek is well suited to snow making with almost 80 percent of the ski runs classified as either beginner or intermediate. The capacity to make snow is broadly dependent on the availability of water, energy and suitable snow making conditions in order to be both technically feasible and cost effective.

One of the critical inputs to snow making is water. Whilst other Victorian alpine resorts have constraints on their water supply, Falls Creek currently has ready access to an abundant water supply. Water is sourced from the Rocky Valley Lake which holds 28,000 megalitres (28 million litres). Currently, approximately 0.5 percent is used for snow making each year.

While ample water is likely to be available in the dam, the calls on water downstream in the very long term may affect availability for use in snowmaking if these downstream uses are deemed to be higher priority in a future with reduced rainfall. This will occur at a time when the requirement of water for snowmaking is likely to be rising.

Energy is required to make snow. The amount of energy required will rise initially for snow guns as average operating temperatures rise and then further if there is a shift from conventional snow making to using snow factories, as may be expected to occur over the longer term.

Falls Creek is connected to the State electricity grid. Prices have risen in recent years so future energy costs may be a concern. On the other hand, the cost of energy generation from renewables has continued to fall and is expected to fall further, albeit at a declining rate. Supporting this is a fall in battery costs for energy storage. With short winter days, solar is not well matched to winter peak demands but may make some contribution on an all year round basis. Other forms of renewable energy including wind or small hydro may be cost effective.

However, even with the required resource inputs, the cost of snow making relative to revenues received will be critical to determining whether it is feasible to make snow. **Snow making conditions** affect the cost of snow making, potentially quite dramatically. For conventional snow making, conditions are likely to remain generally favourable during the 2020s but suitable conditions are likely to be increasingly restricted as the climate warms beyond 2030, offering fewer operating hours on average as each decade passes. Initially more machines operating during the fewer hours available can address this. In the longer run it would require a transition to snow factories, capable of operating in almost any conditions and with greater water efficiency but requiring a much higher input of energy as noted above.

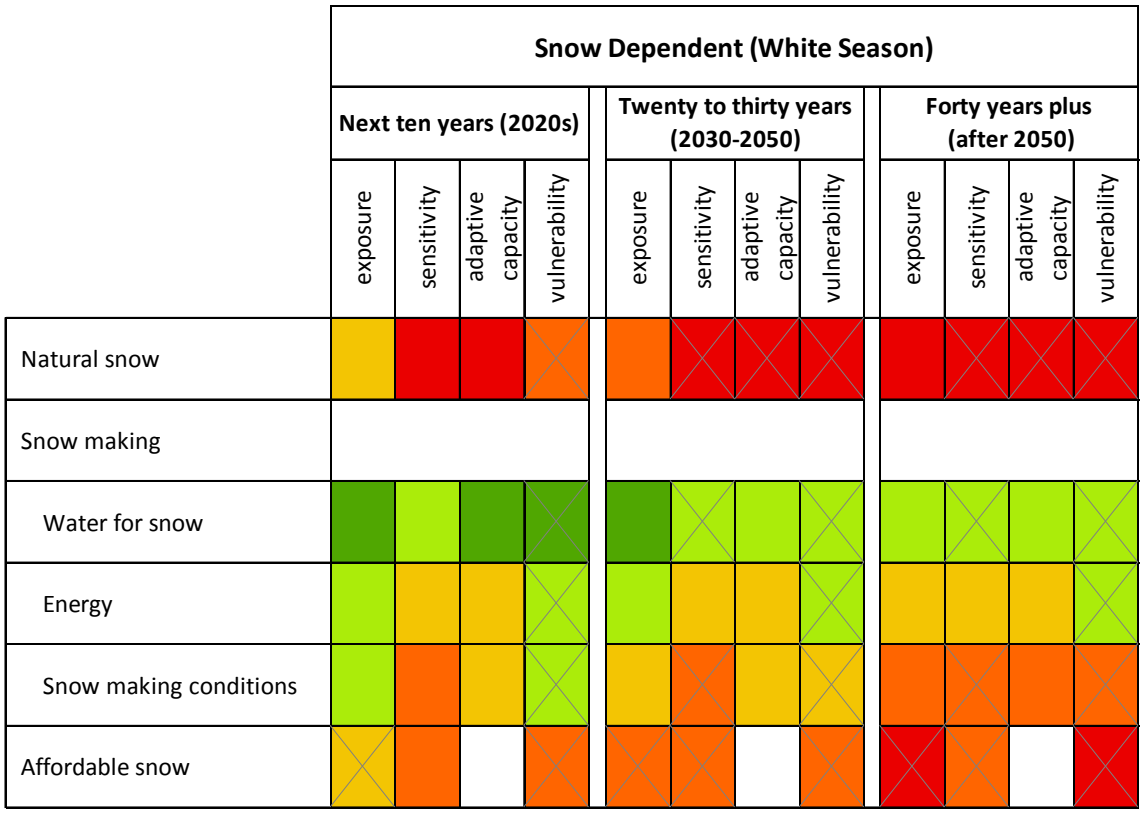
Thus the adaptive capacity becomes increasingly constrained over time in the case of business as usual global emissions, even allowing for technological advancement in snow making.

The calculated exposure to **loss of affordable snow** is a combination of the preceding conditions. It is represented as the combination of the calculated vulnerability of natural snow combined with the highest calculated vulnerability for the factors affecting snow making.

For Falls Creek, in each time horizon snow making conditions have the highest (or equal highest) vulnerability and thus contribute to the ultimate vulnerability of the exposure to loss of affordable snow. This vulnerability will be realised either as current or past investments in snow making are no longer sustainable on costs (on average over a number of seasons) or, for new investment, returns are insufficient over a reasonable investment horizon leading to a failure to invest in snow making and a loss

of actual snow making capacity. The vulnerability is assessed as having major impacts with external assistance likely to be required to adjust and the need for a change in values or priorities[2].

FIGURE 12. AFFORDABLE SNOW VULNERABILITY, FALLS CREEK



The next super force evaluated is snow related (white season**) visitor numbers** (dashboard shown in Figure 13). While clearly driven in part by the first super force, affordable snow, the economic infrastructure affecting access may also act to influence vulnerability of visitor numbers.

The exposure of lifts as infrastructure becoming unavailable is based on estimates of available affordable snow. If investors do not consider that snow will be available, and provide conditions that will be attractive to visitors needing lifts, then they will not invest. A failure to invest would have a strong impact on access to any snow that is available. With no/few operating lifts there will be fewer visitors.

There will be some adaptive capacity in the form of selecting different lift options, relocation of lifts to higher slopes and consolidating lifts to areas where snow is made most cost effectively. This adaptive capacity may decline over time once these options have been fully exploited.

There are currently 14 lifts operating at Falls Creek: three platter lifts, three conveyor lifts, two triple chair lifts and four quad chair lifts (one of which is a detachable quad chair). Lifts range in age from seven to 48 years. The typical life span of a lift is 30 years, meaning investment to replace the existing lift infrastructure will be required in the near term. In particular, of the eight triple and quad chair lifts, five of them are 25 years or over meaning significant investment decisions will be required in the short term.

These existing lifts service 92 downhill ski runs with the highest lifted point currently 1,780 metres above sea level. There is potential, therefore, to expand the skiable area to higher altitudes if lift infrastructure were developed to support this. Mt McKay is currently used for back country skiing and if it were developed would put the highest peak for lift assisted skiing at 1,846 metres.

[2] We note that the calculated values (not shown) are just out of yellow and into orange for the 2020s and at the top edge of the orange range, just short of the red in 2050+.

There are some planned lift infrastructure expansions proposed at Falls Creek, including the development of an enclosed Gondola servicing the Gully (this project is likely to be a public/private partnership development) and the proposed reconfiguration and upgrade of the Eagle Chair to principally support the movement of beginner skiers/snowboarders. The last investment in lift infrastructure (excluding on ground lifts) came in 2004 with the introduction of a 4 person chairlift Drover's Dream.

Falls Creek also has a cross country ski area with 65 kilometres of groomed trail network across 21 trails. Cross country skiing does not require lift access and can therefore act as a visitor attractor even if the full scope of existing lift capacity is not maintained, as long as it has adequate natural snow or can attract funds for some snowmaking.

The summary vulnerability to closure of lifts is shown as significant impacts expected, potentially requiring assistance to adjust in the 2020s, increasing to major impacts expected with external assistance needed to adjust and a new focus/values/priorities required in the longer term.

At Falls Creek, the **road** serves through-traffic in the green season and serves other purposes than white season visitation, therefore continued maintenance is relatively assured. During the white season, however, the road is closed from Falls Creek to Omeo meaning there is only one road in and out. If there is a landslip, crash or other incident that closes the road, Falls Creek is unable to be accessed by road until the road is reopened. However, with reduced winter snowfall expected, in the long term the road may be upgraded to be open in the white season. While road closures may occur from time to time due to fire, landslides or flooding from extreme rain events, the climate change impacts are not seen as lasting or deep in their impact. Adaptation may occur by building or repairing roads in ways that make them less susceptible to landslides or flooding. Roads are not a significant limiting factor for visitation at Falls Creek.

Accommodation is affected by available snow feeding through to visitor attractiveness. If there are not expected to be sufficient visitors there will not be (re)investment in accommodation and over time facilities will become run down. Accommodation is different from lifts in that some will have a useful green season role that may contribute increasingly to its white season viability.

Should capacity closures occur due to decreased demand, capacity may not limit visitation if it still meets demand, unlike closed lifts that restrict access. Adaptive capacity may be increased as well by appealing to more diverse markets even within the white season for those times when snow conditions are less adequate.

The **competitive position,** with respect to other resorts, recognises that as some lower altitude resorts close, their visitors will be displaced to the next best alternative. That position will be affected by many factors but relative altitude and capacity to continue serving snow sports by having open lifts and effective snow making will be the main determinants.

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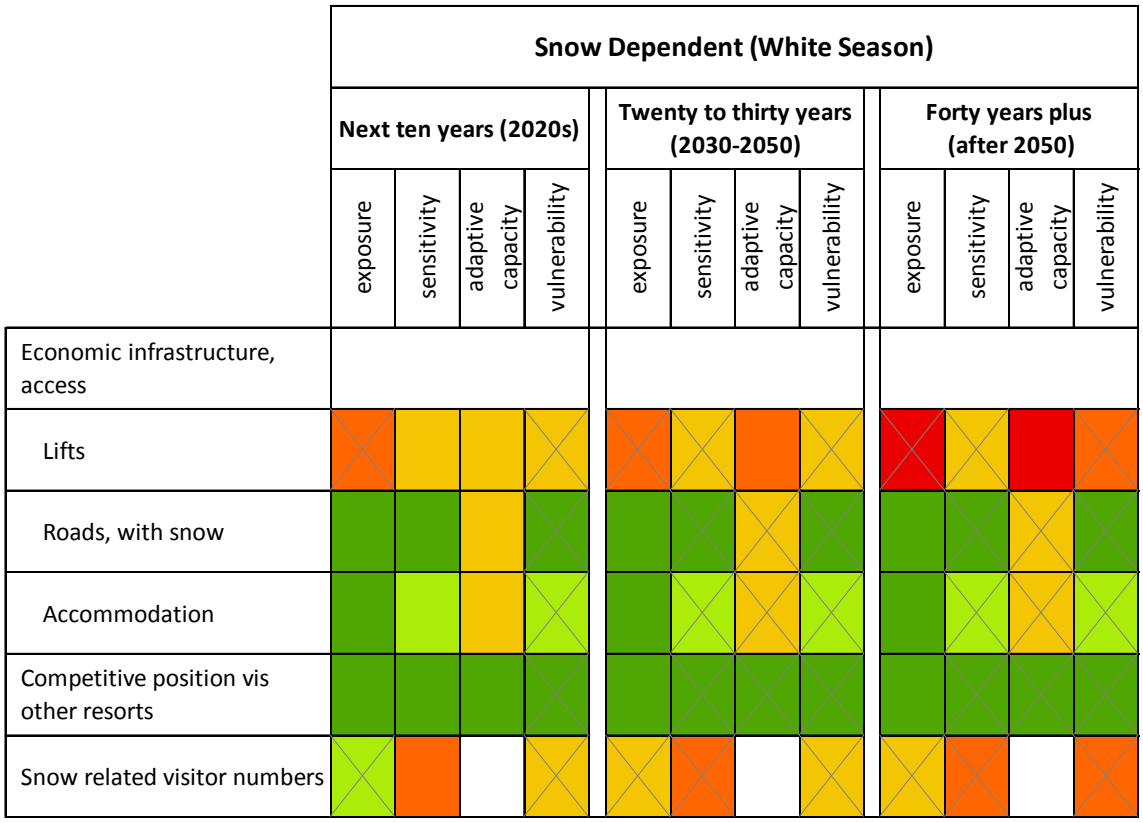
The overall vulnerability of visitor numbers at Falls Creek is deemed to be moderate with manageable impacts in the 2020s, but increasing in later years to significant impacts, potentially requiring assistance to adjust. This is likely to be driven by increased dependence on manufactured snow which is unlikely to cover the current extent, with a corresponding reduction of lifts, limiting capacity of the resort.

FIGURE 13. SNOW RELATED VISITOR NUMBERS VULNERABILITY, FALLS CREEK



The two super forces of affordable snow and visitor numbers flow through to impact on values related to the white season. This is shown in the vulnerability dashboard for these values is shown in Figure 14.

Exposure of snow related **economic activity,** is directly derived from snow related visitation vulnerability. This is shown as moderately likely in the 2020s, aided by adaptation from snow making, and increasing to highly likely in later periods as snow making becomes increasingly expensive and investment in lifts becomes less viable. Stakeholder feedback suggested even higher levels of exposure are expected in all periods.

Sensitivity, should visitation drop significantly, is taken to have a major impact on values/returns forcing change of approach and much diminished outcomes. This may be reduced by adaptation strategies such as diversification of economic activity away from snow sports. There are already a range of other activities available during the white season in addition to skiing and snowboarding. This includes day spas, fat biking trails, snow mobile guided tours, cooking classes and a museum. Further expanding these is an additional option for attracting visitors.

In practice, adaptation potential may be more affected by non-climate change factors (market competition with other activities and general economic conditions) so while sensitivity is high, it may be a weak predictor of outcomes.

Snow related jobs exposure is equated to snow related economic activity vulnerability. As with economic activity, adaptation may include some diversification in employment activity that is not snow sport related but takes advantage of snow related infrastructure and activity (winter relaxation/health spas) and some of this has already occurred. Employment may also be affected adversely by unrelated trends such as automation. Vulnerability of jobs is expected to result in significant impacts potentially requiring assistance to adjust by the next decade, even assuming 'effective' adaptation to non-snow related employment.

Snow sports culture exposure is taken as the vulnerability rating for snow related visitation. Snow sports have a few facets: participation by large numbers or development of more advanced and competitive skills. More advanced and competitive skills may start to become limited in this region if snowmaking proves to be more difficult to deploy on the steeper slopes advanced skills in snow sports require.

Falls Creek has a large proportion of beginner and intermediate slopes, the most easily maintained with snow making subject to availability of snow. This level of snow sports culture would be well sustained as long as visitor numbers are maintained. The exposure, sensitivity and vulnerability of advance skills in snow sports would be higher.

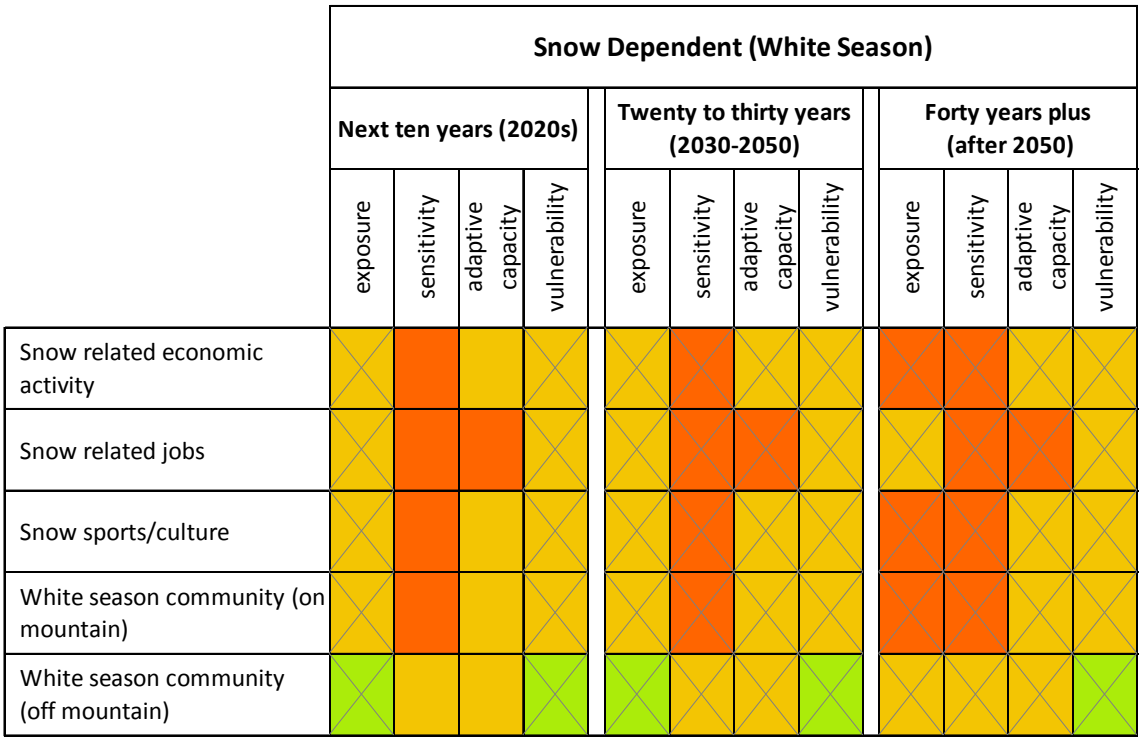
The exposure of the **community and social base** is recognised as having distinct impacts on the communities on and off the mountain. The on-mountain community is clearly strongly affected by visitor numbers in terms of exposure. Fewer people coming to the area reduces the base on which any community is built.

Off-mountain impacts on the larger towns of Omeo and Bright will be affected by changes in activity at Falls Creek. Of the two, Bright has the strongest links, being the direction from which most visitor traffic flows. Bright has a more diverse economic base so the population underlying the community and social base has broader support. However the significant dependence on snow season visitation means significant exposure to impacts should the ability to make affordable snow decline. Associated with this route are smaller towns such as Bogong which arguably has a greater dependence on white season visitors and may close if white season activity is greatly reduced.

Lodges can form the basis for communities with a significant connections beyond the white season activity. Longer traditions of visitation and identification with the area will persist somewhat even if the quality of snow activities declines, thereby reducing sensitivity. Falls Creek has a proportion of lodge accommodation which may support shared values, new activities, and events, etc. beyond those based on snow activity.

For all of the values assessed, except off-mountain community, the vulnerability rating is yellow meaning significant impacts potentially requiring assistance to adjust. That it is not higher is largely due to the expected capacity to make snow, even in the longer term, and to adapt by diversifying activity in both white and green seasons. Much depends on this adaptation effectiveness.

FIGURE 14. WHITE SEASON COMMUNITY VULNERABILITY, FALLS CREEK



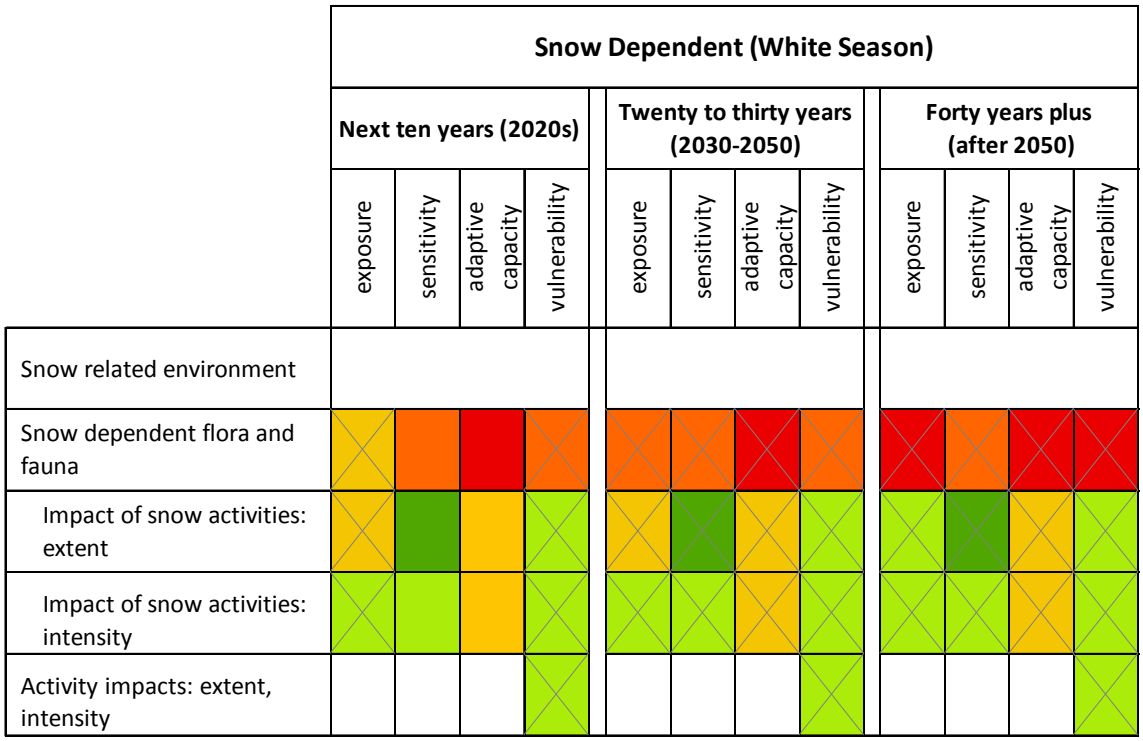
The **environment** was a key value raised by stakeholders. It encompasses a wide range of elements and values. This dashboard treatment (see Figure 15) selects only two snow related aspects that reflect workshop input as 'indicators' of the kinds of values articulated by participants for the white season.

Snow dependent flora and fauna will likely be unable to respond to loss of natural snow should it go. It is unlikely that, at this location, options exist for many of these species to adapt. Snow making is unlikely to contribute to their survival both because the area covered is too small and because the area that is covered is subject to unusual conditions of management and use (relative to what they are adapted to). If the snow is lost, many of these species will be lost. The exposure of the species is taken as the same as the vulnerability of natural snow. The sensitivity is taken to be total. The adaptive capacity is none. In practice a few species may adapt in some way to the changed conditions, but this is likely to be a minor part of the ecosystem community, and it will then be operating differently in a new context. Things will not be the same without snow and these species will be lost in the long term.

Snow activities have caused impact on the environment by physical changes to slopes and vegetation, and the addition of various built form and equipment including dams, roads, trails, pipelines, etc. The use of the area changes the pattern, frequency and character of snow cover, in some areas leading to compaction or other impacts on such vegetation that remains on ski runs and pathways. As climate change reduces the areas covered by natural snow, activity may become more concentrated on areas where snow is made. This may reduce the area impacted by snow related activities. Depending on trends in visitation, this may lead to intensification of impacts on areas that are still used, until ultimately use declines should white season activity no longer be viable. If climate change proceeds to the point that there is no longer white season snow activities, there are issues about remediation of sites, but otherwise the impacts from activities will be reduced.

Overall, the small environmental gains of reduced impacts on the environment in the areas where snow activities occur will be a small compensation for the loss of snow dependent species.

FIGURE 15. ENVIRONMENT VULNERABILITY, FALLS CREEK



All year round and non-snow related activity (green season) vulnerability/opportunities
Increasing temperatures coupled with a general drying of soil and ground fuels will increase the likelihood of bushfire into the future in Victoria. No specific modelling or research into the future risk of bushfire on the alpine resort locations has been conducted, but it can be assumed there will be some increased exposure to risk of loss of property and life at Falls Creek.

Being surrounded by forested National Park, Falls Creek's natural environment places the resort at potential risk during bushfire conditions. Falls Creek features its own CFA Fire Station and crew and actively operates a bushfire management plan. However, like most parts of country Victoria, certain conditions can place the High Country at high risk of bushfire threat.

Falls Creek has been assessed as having an extreme bushfire risk in accordance with the Victorian Fire Risk Register. This is due to a range of factors including bushfires moving quickly uphill and it is impossible for emergency services to protect every property in the area. Long distance spotting can occur and impact on the village, and it is highly likely road access to the village could be cut in the event of bushfire. The Upper Kiewa Valley (the location of Falls Creek Village) has experienced three major fires in the last 10 years

Good management means that while fires may occur more often and be more intense, direct impacts on property and people can be managed – at a cost – but not eliminated. Under Code Red conditions, the resort will be closed to new visitors if significantly threatened by fire. This avoids risk by minimising the number of people in harm's way but with climate change, this could increasingly affect green season visitation.

Secondary impacts of more frequent and intense bushfires on landscape and amenity, combined with soil erosion and runoff contributing to landslides and degraded water quality, may well be much larger than the direct impacts of fire. Loss of amenity could deter visitors for a period of time. To adapt to this will require successful early suppression of any fires that occur, an increasingly challenging task. Sensitivity is likely to rise over time as vegetation becomes more stressed and degraded.

As the atmosphere warms, it can hold more moisture, resulting in longer dry periods, and more intense precipitation events. This will have impacts upon the vegetation, water supply and prevalence of landslides.

Although fire is a natural process in nearly all Australian ecosystems, many ecosystems and species around the resort including alpine, subalpine, rainforest and riparian communities are not reliant on fire for regeneration. Maintaining or improving the resilience of natural ecosystems is therefore important. As the atmosphere warms, it can hold more moisture, resulting in longer dry periods, and more intense precipitation events. This will have impacts upon the vegetation, water supply and prevalence of landslides at Falls Creek.

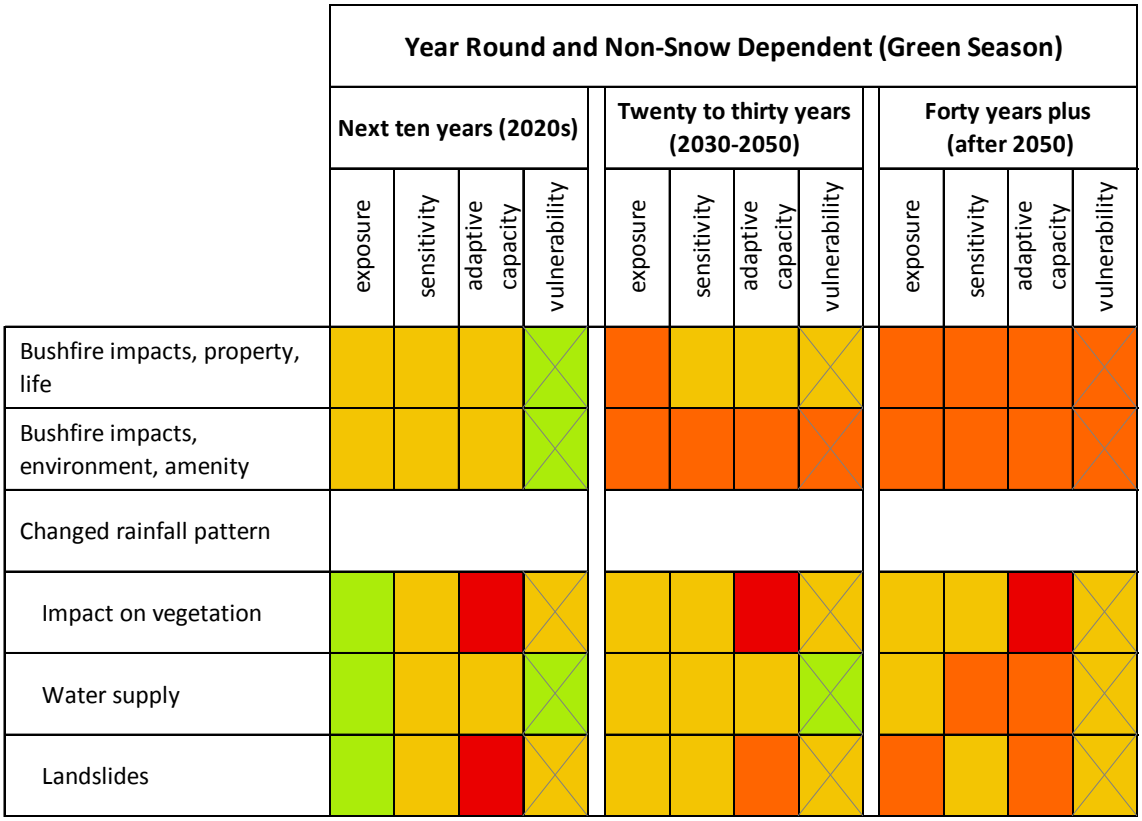
Given the ample existing water supply, this is not likely to be a major issue in the short to medium term. Surface water quality may decline, requiring more processing to reach acceptable levels, if used. This is expected to become more sensitive over time as vegetation cover becomes degraded from fire and other stresses. Water supply may be affected if downstream demands increase.

Changed rainfall patterns combined with fire and loss of some vegetation are likely to lead to increased landslides. The direct effects on built assets and roads will likely be manageable, particularly for Falls Creek as there are two options for exit should one of the roads be closed. There is some limited capacity to adapt by ensuring construction avoids the highest hazard slopes, though some sections of road will likely remain exposed.

These factors all act to reduce the attractiveness of the resort and surrounding area during the green season. This will eventually be all year round, and the fire season will extend to potentially become an all year round hazard.

This assessment of green season vulnerability is summarised in Figure 16.

FIGURE 16. GREEN SEASON VULNERABILITY, FALLS CREEK



Climate change in the long run could benefit the resort as people are increasingly drawn to the mountains to escape the heat in summer. Competition with other summer attractions and the other resorts will be a barrier. The relatively attractive setting and layout of the village combined with the early advantage of having established a growing calendar of green season activities may provide a significant advantage for Falls Creek in the region.

2.5 Mt Buller and Mt Stirling

The Mt Buller and Mt Stirling Alpine Resorts are approximately three to three and a half hours drive from Melbourne. Mt Buller is the closest to Melbourne of the three major ski resorts. The resort is only accessible by one road, the Mt Buller Tourist Road – a winding 16km road rising from Mirimbah to Mt Buller Village. Accessing the resort from Melbourne, visitors pass through the town of Mansfield.

Legislation does not permit lifting infrastructure at Mt Stirling. It is therefore the only Victorian alpine resort with a largely undeveloped and unspoilt alpine summit, offering a readily accessible 'semi-wilderness' experience for visitors. The resort is popular with backcountry skiers, and beginner snowboarders and skiers in the white season, and with nature lovers, hikers and 4WD enthusiasts in the green season. Mt Stirling is the only Victorian alpine resort to have more visitation in the green season than the white.

In the white season there is a fee for access to the resorts. Outside of the white season, there is no entry for access to the resorts and private vehicles are free to enter the village at Mt Buller and the 4WD trails surrounding Mt Stirling.

The population of the resort village at Mt Buller all year round is 50-100. Many people who make a living on Mt Buller all year round live in the surrounding district travelling to the mountain from Sawmill Settlement, Merrijig and Mansfield. Community facilities include a primary school. There is no resort village on Mt Stirling. Excluding ski patrol accommodation, there is no accommodation on Mt Stirling but there are camping areas. Visitors (including school groups) regularly camp in the resort both in the green and white seasons.

All year round attractions at Buller include the National Alpine Museum and Breathtaker on High Alpine Spa Retreat. The centre of the village was a highland grazing campsite prior to the mid 1960's and aboriginal artefacts have been documented in this area. The significance of environmental and cultural values has recently been recognised by its resort's inclusion on the National Heritage Register.

Development of snow related activities (white season)

Mt Buller

The development of Mt Buller as a ski resort was initiated by people's desire to ski and access the snow. In 1946 a road was built to the village area, and the first tow was installed in 1949. From a handful of lodges built by members in the 1950's, it has grown to be a major resort in the Victorian and Australian context. Today, in terms of visitor numbers, number of beds and ski lift capacity, Mt Buller is the largest Victorian alpine resort, attracting on average 35 percent of all visitor nights to the Victorian Alps per white season, over the past 10 years. Mt Buller's key strength is its proximity to Melbourne, enabling snow enthusiasts to head for the mountain in response to a good snowfall.

The Mt Buller Alpine Resort covers 300 hectares of skiable area located between 1,375 and 1,780 metres above sea level. There are currently 22 lifts at Mt Buller capable of moving 40,000 people per hour, the highest capacity in Victoria. The lifts service a total of 25 runs, with the longest being 2.5km kilometres in length. There are also three terrain parks and two toboggan parks. Of the skiable terrain, 70 percent is considered beginner or intermediate:

- 25 percent are beginner runs
- 45 percent intermediate
- 30 percent advanced.

The Mt Buller Village is located at approximately 1,600 metres above sea level. The Mt Buller Village is situated at the heart of the mountain allowing for ski in, ski out accommodation and a huge range of bars and restaurants.

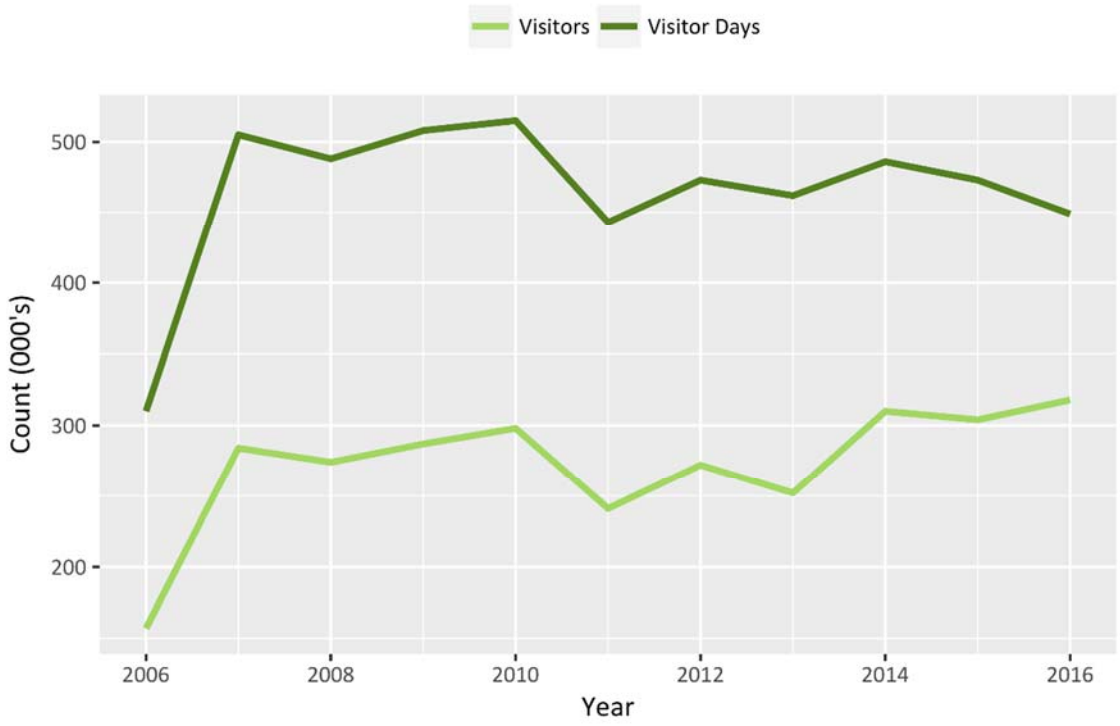
Permanent white season population is 1,700 people but during busy periods the number of people at the Resort can number 16,000 during the day, and 7,900 overnight. Accommodation bed capacity is 7,000 and over 30 food and beverage outlets service visitors and residents.

The mountain infrastructure is in place to cater for high demand, but only over two to three consecutive days. Core services such as water supply and sewerage treatment require several days to stabilise between major weekend peaks.

In terms of visitation in the white season Mt Buller is very popular with Victorians. In 2016:
- 88 percent of visitors were from Victoria (compared to 82 percent for all Victorian resorts)
- 7 percent were interstate visitors (compared to 14 percent for all Victorian resorts)
- 5 percent were international (compared to 4 percent for all Victorian resorts).

Visitors and visitor days since 2006 are outlined in the table below. The trend shows a decline in the average stay from about 1.8 up to 2013 down to 1.4 more recently, even while total visitor numbers rose.

FIGURE 17. MT BULLER WHITE SEASON VISITATION (2006-2016)



Source: ARCC (2016). Victorian Alpine Resorts Entry Statistics

Mt Stirling

The modern history of Mt Stirling prior to 1983 is dominated by forestry for timber production, and cattle grazing. Nordic skiing at the resort grew in popularity through the 1970's and 1980's. Many of the 68kms (approx.) of maintained trails winding through bushland have been developed on already existing access trails and old logging tracks. Mt Stirling has become established as a major cross-country venue, with timber production essentially phased out.

Resort accommodation is limited to an alpine camp. The Camp, operated by Stirling Experience, features a central tepee for dining and socialising around a pot belly stove, and seven accommodation tents on raised, insulated platforms.

The Mt Stirling Alpine Resort covers 3,000 hectares located between 1,400 and 1,750 metres above sea level. Of the cross-country skiable terrain 80 percent is considered beginner or intermediate:

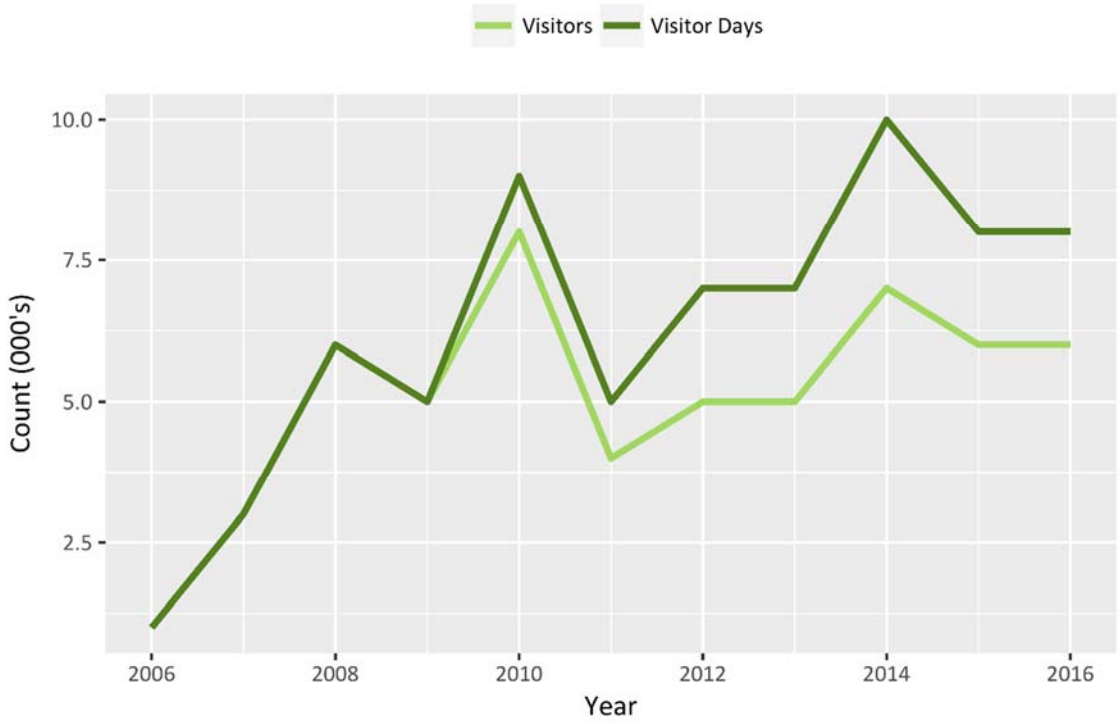
- 20 percent are beginner runs
- 60 percent intermediate
- 20 percent advanced.

At Mt Stirling, ski areas are generally considered feasible if there is at least 90 percent probability of 60 to 75 cm of snowpack for a period of three months during the white season. Experience at the resort has demonstrated that snowpack can be limited in poor snowfall seasons, however slope grooming of ski trails markedly improves ski ability performance. Mt Stirling is operated by the Mt Buller and Mt Stirling Alpine Resort Management Board. Legislation does not permit lifting infrastructure at Mt Stirling and therefore no private ski lift company operates on the mountain.

The resort has very limited infrastructure with the main buildings located at Telephone Box Junction (TBJ). TBJ is located approximately 2 km to the west of the summit, at the end of the gravel access road at 1,250 m elevation. Buildings at the TBJ site house the Mt Stirling Ski Patrol (operated by the Mt Buller and Mt Stirling Alpine Resort Management Board), a ski hire shop, a public shelter, a small bistro, a generator and a male/female toilet block. These facilities do not operate over night in the white season, and generally do not operate in green season. Also, within the resort area there are three public shelters, a machinery shed, cattleman's hut and a small house, located at the entrance to the resort for ski patroller staff to stay overnight. Apart from the house, the facilities within the resort do not have permanent power or potable water.

In terms of visitation in the white season, Mt Stirling received 6,041 visitors in the 2016 white season equating to 8,288 visitor nights. Visitors and visitor days since 2006 are outlined in the table below.

FIGURE 18. MT STIRLING WHITE SEASON VISITATION (2006-2016)



Source: ARCC (2016). Victorian Alpine Resorts Entry Statistics

The number of visitor days compared to total number of visitors has been increasing, due to people being increasingly attracted to snow camping.

The economic impact of visitation during the white season has been estimated for the ARCC by EY Sweeney (2017). The combined contribution of Mt Buller and Mt Stirling to the gross regional product of the surrounding Mansfield Shire totalled $157 million, and supports 1,346 direct and 441 indirect jobs.

Non-snow related activities (green season)

Mt Buller is a popular destination for visitors who enjoy four-wheel-driving, hiking, scenic chairlift rides, trail running, horse riding, fly fishing and various high-quality biking activities including cross-country and downhill mountain biking, and road cycling.

Mt Buller is Australia's first and only International Mountain Bicycling Association (IMBA) endorsed Ride Centre, in recognition of its large-scale mountain bike facilities that offer something for every rider. Four downhill mountain bike trails are serviced by a chairlift from Boxing Day until the end of January ($65 for an adult day pass), and shuttle services from February to the end of April.

Mt Stirling is a popular destination for visitors who participate in four-wheel-driving, hiking, education excursions, camping, fishing, horse riding and other activities with a focus on being in nature. Mt Stirling is the only Victorian alpine resort to receive more visitors in the green season than in the white season. The Circuit Road is open in the green season from Mt Stirling and provides a starting point for many 4WD tours across the high country. The road is used to access camping spots at Pineapple Flat and King Hut in the Alpine National Park. It is also used to get to Craig's Hut and Bindaree Falls.

According to visitation data (EY Sweeney, 2017a) Mt Buller and Mt Stirling had the most visitors in the 2016/17 green season of any of the alpine resorts, with 106,883 people visiting; accounting for 128,260 visitor days at the resorts during the green season.

- 92 percent of visitors were from Victoria (compared to 89 percent for all Victorian resorts)
- 7 percent were interstate visitors (compared to 10 percent for all Victorian resorts)
- 1 percent were international (equivalent to 1 percent for all Victorian resorts).

At Mt Buller, the total green season visitor numbers are around a third of the white season visitor numbers, and spread over a much longer period. However, at Mt Stirling there are more visitors in the green season than in the white season. None-the-less, in terms of economic contribution the green season is significantly smaller than the white. Victorian visitors on average spend $293 per day in the green season. This includes spending on food, shopping, travel, accommodation and other miscellaneous expenditures. This daily spending is lower than the white season where the average daily spend by Victorians is $510 per day. The average length of stay is also longer in the white season compared to the green, at 1.5 days compared to 1.2.

In total, EY Sweeney (2017a) found that the combined contribution of Mt Buller and Mt Stirling to the gross regional product of the surrounding Mansfield Shire totalled $24 million in the green season, and supports 212 direct and 70 indirect jobs. This about one sixth of the impact the white season generates.

Vulnerability assessment

The vulnerability of Mt Buller and Mt Stirling Alpine Resort is assessed in two parts:

- Snow related activities (white season)
- All year round and non-snow related activities (green season).

The initial review of vulnerability assumes that available adaptive capacity is effectively deployed. In practice this may not occur. At the end of the review the effect of diminished adaptive effectiveness is shown, typically arising due to poor governance or inability to access the necessary resources.

Snow dependent activity (white season) vulnerability

As with all alpine resorts in Victoria, the success of the white season recreation market is critically dependent on having enough reliable, accessible and affordable snow. The first five rows of the

vulnerability dashboard (Figure 19) contribute to the vulnerability of the snow dependent (white season) super force – the **availability of affordable snow**.

Natural snow is expected to decline in amount and reliability with climate change. At Mt Buller and Mt Stirling, at the highest altitude range of the resorts (around 1,700m elevation), in the first decade of the 2000s, there were about 108 days per year of natural snow cover of one centimetre or more. In the 2020s, this is predicted to be about 70-102 days per year of at least one centimetre of natural snow cover per year. In the 2050s cover is predicted to be between 7-89 days. By the 2070s natural snowfall is likely to reduce to the point that there will be only transient natural cover each year. How quickly this occurs depends on the global emission reductions achieved. Maximum depth is also expected to decline to zero over this period.

Natural snow is highly sensitive to climate change. This sensitivity results directly in the loss of snow. Short of weather modification, there is no adaptive capacity to restore natural snow across the region. As a higher altitude resort, Mt Buller and Mt Stirling will lose natural snow cover later than lower altitude resorts. It is also important to note that snow cover of 1cm is not conducive to snow sports, at least 30cm is required.

Snowmaking at Mt Buller provides adaptive capacity to both natural snow variability and unreliability, and to the expected overall reduction in natural snow. The current snowmaking coverage at the resort is 70 hectares. This represents 23 percent of the skiable area. Snowmaking consists of 213 fixed guns (164 of which are automated), 36 portable guns and one snow factory.

There is no snowmaking capacity at Mt Stirling, leaving the resort particularly vulnerable to loss of snow in the white season. For example, during the 2006 white season the average snow depth was 0cm, as a result visitor numbers only totalled 1,190, well below the following 10 year average of 5,647 visitors. Even if snowmaking was to be installed at Mt Stirling it would be much less effective due to the mountains focus on cross country skiing.

The capacity to make snow at Mt Buller is broadly dependent on the availability of water, energy and suitable snow making conditions in order to be both technically feasible and cost effective.

At Mt Buller **water supply** is currently limited for snowmaking, although there are plans for expansion in storage. Current storage amounts to 70ML for snowmaking. The resort typically consumes 210-250ML per season for snowmaking. There are plans for an additional 100ML of water storage, allowing the resort to use the full capacity of the snowmaking system. The expansion of snowmaking at Mt Buller is seen as critically important as the white season becomes increasingly reliant on man-made snow. The construction of additional water storage on the mountain is critical for the implementation of this expansion. The Water Storage Project is the resort's highest priority project.

In terms of water supply into storage, initial studies for the Water Storage Project suggest that there may be sufficient water for the new dam within the catchment. Water availability however may be affected over time with changing climate affecting the pattern of rainfall. More extreme events and less regular rainfall may diminish the available water. The calls on water downstream may affect availability to divert stream water into storage. This will occur at a time when the requirement of water for snowmaking is likely to be rising. Sensitivity to lack of water is relatively high – if water is not available you cannot make snow. However, it is not absolute in that you can make some snow with what water is available and the likelihood of no water at all is extremely low. Thus, overtime, exposure to limits on water will rise, albeit judged not to be to high levels, while adaptive capacity may fall – bigger storage may not improve actual supply in dry years.

Energy is required to make snow. The amount of energy required will rise initially for snow guns as average operating temperatures rise and then further if there is a shift from conventional snow making to using snow factories. Mt Buller has already installed their first snow factory. Mt Buller is connected to the national grid which has seen sharp price rises over recent times. The cost of electricity may also rise if there is some form of carbon pricing in the future, something more likely as time passes.

On the other hand, the cost of energy generation from renewables has continued to fall and is expect to fall further, albeit at a declining rate. Supporting this is a fall in battery costs for energy storage. Using renewables, particularly solar, in short winter days for peak winter loads is challenging but may help stabilise long term energy costs. The evaluation of energy costs for snow making has a high level of uncertainty beyond the first time horizon. It has been assumed that in the furthest time period renewable energy will be plentiful and affordable.

Snow making conditions affect the cost of snow making, potentially quite dramatically. Currently at Mt Buller, snowmaking equipment allows for production of good quality snow at low temperatures when humidity is low, plus an ability to produce snow in warmer conditions using the snow factory. This has allowed the natural snow fall levels to be supplemented. However, conditions are likely to become increasingly restricted for conventional snow making as the climate warms, offering fewer operating hours, on average, as each decade passes. Initially more machines operating in the fewer hours available may meet needs.

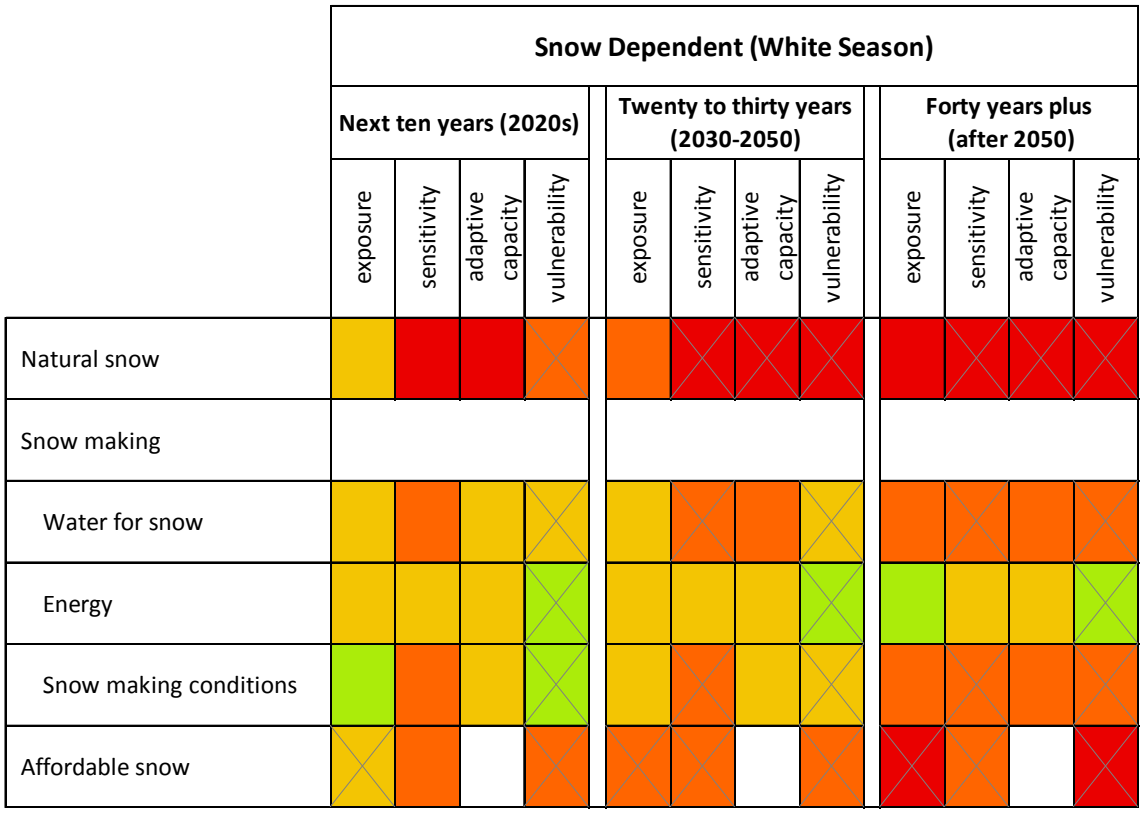
A transition to more snow factories will be necessary to continue making enough snow to cover runs. But these require a much higher energy input than snow guns. Thus the adaptive capacity becomes increasingly constrained over time, even with some expected technological advancement. A wide variety of factors affect the cost and viability of snow making in the future: new technology, cost of energy and the volume of snow required each year as natural snow fall declines. Fully assessing these individual elements for each resort is beyond the scope of the current project and we simply raise the likely exposure to deteriorating snow making conditions over time while adaptive capacity will be reduced in the long term. Over time this leads to increasing costs for snow making, even if water and energy are available and not otherwise cost prohibitive.

The calculated exposure to **loss of affordable snow** is a combination of the preceding conditions. It is represented as the combination of the calculated vulnerability of natural snow combined with the highest calculated vulnerability for the factors affecting snow making for Mt Buller.

This vulnerability will be realised either as current or past investments in snow making are no longer sustainable on costs (on average over a number of seasons) or, for new investment, returns are insufficient over a reasonable investment horizon leading to a failure to invest in snow making and a loss of actual snow making capacity. The vulnerability is assessed as having major impacts with external assistance likely to be required to adjust and the need for a change in values or priorities.

For Mt Stirling the loss of natural snow is all that counts due to the absence and low likelihood of adding snowmaking capacity. It will see a higher vulnerability from the second period (2030-2050) with a corresponding earlier decline in snow activities.

FIGURE 19. AFFORDABLE SNOW VULNERABILITY, MT BULLER AND MT STIRLING



The next super force evaluated is snow related (white season**) visitor numbers** (dashboard shown in Figure 20). While clearly driven in part by the first super force, affordable snow, the economic infrastructure affecting access may also act to influence vulnerability of visitor numbers.

The exposure of **lifts** as infrastructure becoming unavailable is based on estimates of available affordable snow. If investors do not consider that snow will be available, and provide conditions that will be attractive to visitors needing lifts, then they will not invest. A failure to invest would have a strong impact on access to any snow that is available. With no/few operating lifts there will be fewer visitors.

There are currently 22 lifts at Mt Buller capable of moving 40,000 people per hour, the highest capacity in Victoria. Lift infrastructure has an economic life of 20-30 years generally. The oldest lift at Mt Buller was built in 1963 (The Skyline T-bar), the oldest operating chairlift was built in 1979. Mt Buller installed a new four person chair in 2005, an express six person chair in 2008 and a four person chair in 2012. Two new chairs were proposed in 2010, but have not been constructed.

Therefore chair lifts range in age from 5 years to 38 years. The typical life span of a lift is 30 years, meaning investment to replace some of the existing infrastructure will be required. In particular, eight of the triple and quad chair lifts at Mt Buller are 25 years or over meaning significant investment decisions will be required in the short term.

There will be some adaptive capacity in the form of selecting different lift options, relocation of lifts to higher slopes and consolidating lifts to areas where snow is made most cost effectively. This adaptive capacity may decline over time once these options have been fully exploited. Even without reinvestment, groomed cross country trails are available from the village to Corn Hill, and further on to Mt Stirling (in a good season) which can still attract visitors to the mountains.

In terms of **road** access, currently the only access route to Mt Buller is via the Mt Buller Tourist Road – a winding 16km road rising from Mirimbah to Mt Buller Village. To reach Mt Stirling in the white season there is an 8km gravel access road from a junction in the Mt Buller Tourist Road. In the green season, visitors and tourists can continue further up the mountain via The Circuit Road. The Circuit Road is 47km long and winds throughout the various sub-alpine and alpine forests around Mt Stirling. It is a gravel road but still accessible by 2-wheel drive vehicles. Due to the significant infrastructure and all year round activity at Mt Buller, maintenance of the road can be expected, at least in the short to medium term.

While road closures may occur from time to time due to fire, landslides or flooding from extreme rain events, the climate change impacts are not seen as lasting or deep in their impact. Adaptation may occur by building or repairing roads in ways that make them less susceptible to landslides or flooding. Roads are not a significant limiting factor for visitation at Mt Buller and Mt Stirling.

Accommodation is affected by available snow feeding through to visitor attractiveness. If there are not expected to be sufficient visitors there will not be (re)investment in accommodation and over time facilities will become run down. Accommodation is different from lifts in that some will have a useful green season role that may contribute increasingly to its viability in the white season. Redevelopment of accommodation within the Buller Village limits, including the provision of a variety of type and quality of accommodation, is seen as key opportunity at Mt Buller. In 2014-15 a total of 7 new planning permit applications for development proposals with a declared estimated construction value of $21.255 million were reviewed and processed by the ARMB, compared to the 10 (with a total value of $3.086 million) processed in the previous year. At Mt Stirling there has been a recent investment in winter camping by a private company, demonstrating an on-going commitment to the mountain.

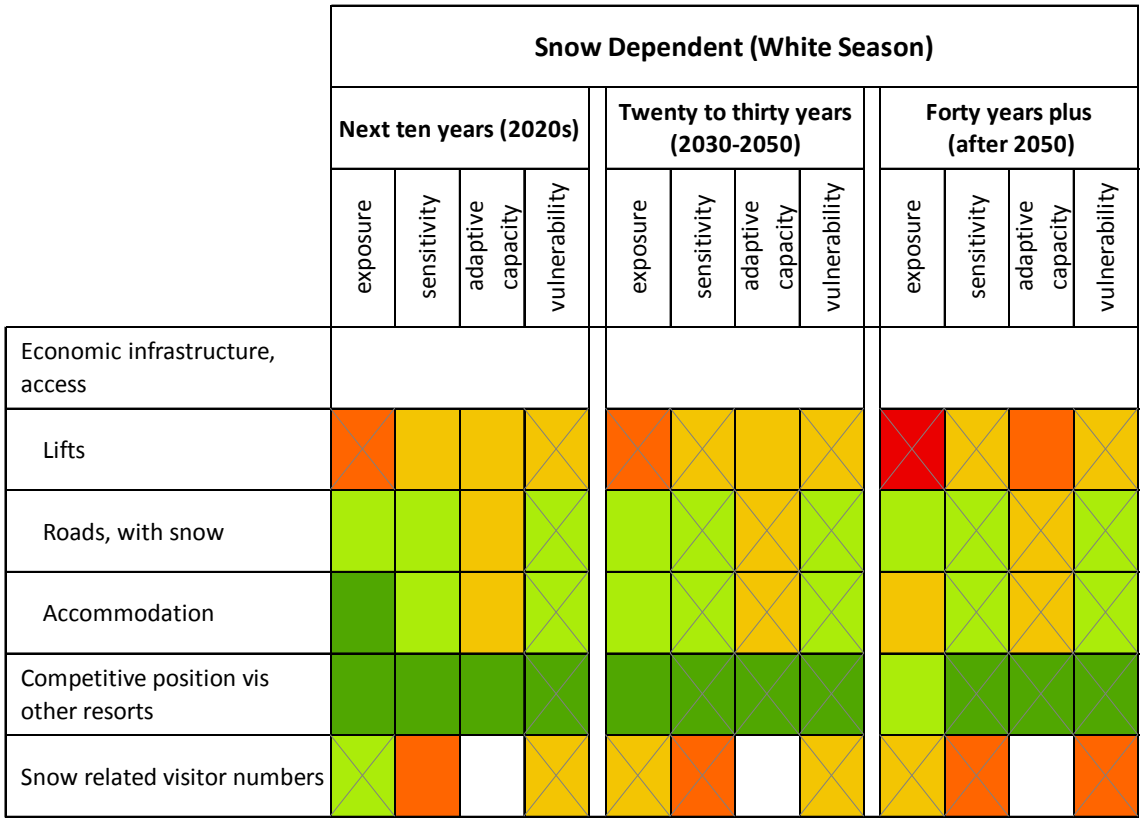
Should capacity closures occur due to decreased demand for accommodation, capacity may still meet demand and would not actually limit visitation, unlike closed lifts that restrict access. Adaptive capacity may be increased as well by appealing to more diverse markets even within the white season for those times when snow conditions are less adequate. In the short term, accommodation is likely to be maintained. In the longer term, time frames become less certain.

The **competitive position,** with respect to other resorts, recognises that as some lower altitude resorts close, some of their visitors will be displaced to the next best alternative. That position will be affected by many factors but relative altitude and capacity to continue serving snow sports by having open lifts and effective snow making will be the main determinants. Mt Buller has the added advantage of being the highest resort within a relatively easy drive of Melbourne. In the long run, competitive position may be more exposed as the three high altitude resorts begin to compete more directly against each other and the increased visitor flow from lower resorts is exhausted.

For snow related **(white season) visitor numbers** exposure is a calculated outcome from the super force affordable snow, combined with the 'limiting factor' among lifts, roads and accommodation and the influence of competitive position compared with other resorts. Sensitivity is deemed high. As with affordable snow, the adaptive capacity is taken to be captured in the contributing factors.

The overall vulnerability of visitor numbers at Mt Buller is deemed to be moderate with manageable impacts in the 2020s, but increasing in later years to significant impacts potentially requiring assistance to adjust. This is likely to be driven by increased dependence on manufactured snow which is unlikely to cover the current extent, with a corresponding reduction of lifts, limiting the capacity of the resort. Mt Stirling will be much more vulnerable due to its dependence on natural snow, with visitation likely to drop earlier, albeit from an already modest level.

FIGURE 20. SNOW RELATED VISITOR NUMBERS VULNERABILITY, MT BULLER AND MT STIRLING



The two super forces of affordable snow and visitor numbers flow through to impact on values related to the white season. The vulnerability dashboard for these values is shown in Figure 21.

Exposure of snow related **economic activity,** is directly derived from snow related visitation vulnerability. This is shown as moderately likely in the 2020s, aided by adaptation from snow making, and increasing to highly likely in later periods as snow making becomes increasingly expensive and investment in lifts becomes less viable. Stakeholder feedback suggested even higher levels of exposure are expected in all periods. Stakeholder feedback suggested even higher levels of exposure are expected in all periods.

Sensitivity, should visitation drop significantly, is taken to have a major impact on values/returns, forcing a change of approach and much diminished outcomes. This may be reduced by adaptation strategies such as diversification of economic activity away from snow sports. There are already a range of other activities available during the white season in addition to cross country skiing and snowboarding at Mt Stirling.

Ultimately adaptation potential may be more affected by non-climate change factors (market competition with other activities and general economic conditions) so while sensitivity is high, it may be a weak predictor of outcomes.

Snow related jobs exposure is equated to the vulnerability of snow related economic activity. As with economic activity, adaptation may include some diversification in employment activity that is not snow sport related but takes advantage of snow related infrastructure and activity (winter relaxation/health spas). Some of this has already occurred. Employment may also be affected adversely by unrelated trends such as automation. Vulnerability of jobs is expected to result in significant impacts potentially requiring assistance to adjust by the next decade, even assuming 'effective' adaptation to non-snow related employment.

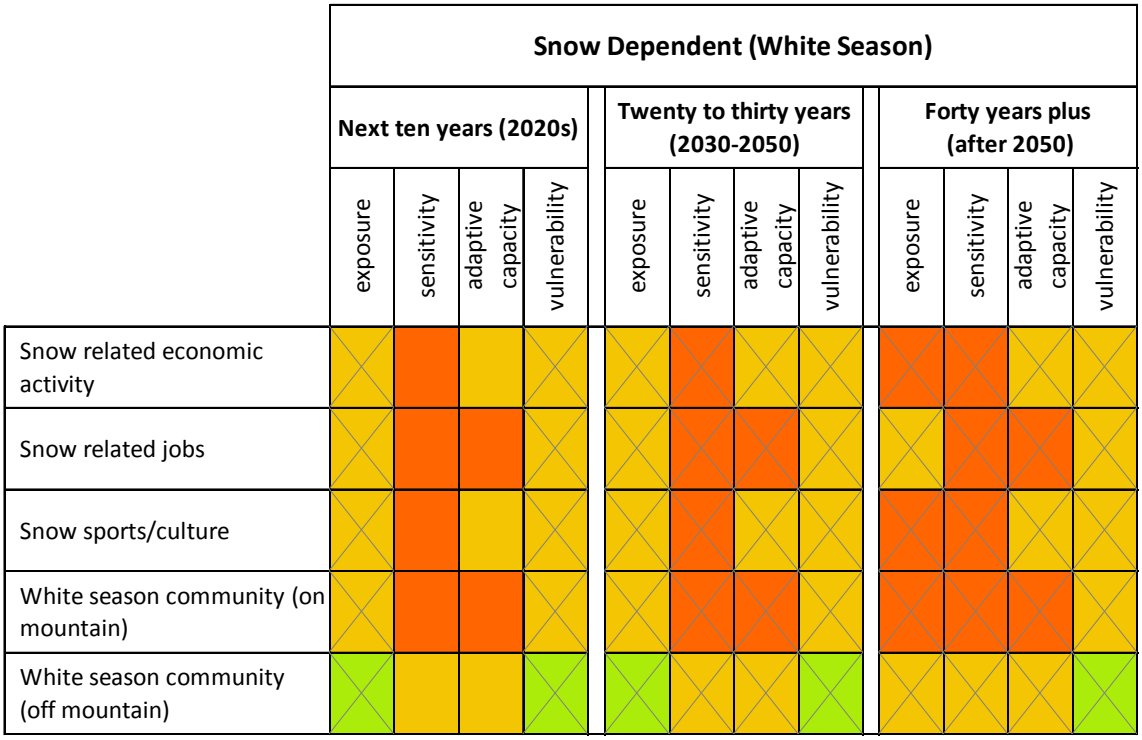
Snow sports culture exposure is taken as the vulnerability rating for snow related visitation. Here the definition of snow sports has a few facets: participation by large numbers or development of more advanced and competitive skills. More advanced and competitive skills may start to become limited in this region as snowmaking is generally less effective on the steeper slopes that advanced skills in snow sports require. Thirty percent of the slopes at Mt Buller are considered advanced.

The exposure of the **community and social base** is recognised as having distinct impacts on the communities on and off the mountain. The on-mountain community is clearly strongly affected by visitor numbers in terms of exposure. Fewer people coming to the area reduces the base on which any community is built.

Mt Buller has relatively strong connections off-resort, particularly at Mansfield, and this reflects Mt Buller's contribution to the local and regional economy. For example, stakeholders at both the Mt Buller and Mansfield workshops mentioned employment and business connections between the resort and the local off-mountain community.

At Mansfield, much was made of the differences between Mt Buller and Mt Stirling as alpine destinations. Mt Stirling caters to a more traditional / less commercially focussed set of activities and these have value to the local and regional community as well increasing off-mountain community connections. Overall vulnerability is lower than for the on-mountain community though.

FIGURE 21. WHITE SEASON COMMUNITY VULNERABILITY, MT BULLER AND MT STIRLING



The **environment** encompasses a wide range of elements and values. This dashboard treatment (see Figure 22) selects only two snow related aspects that reflect workshop input as 'indicators' of the kinds of values articulated by participants for the white season.

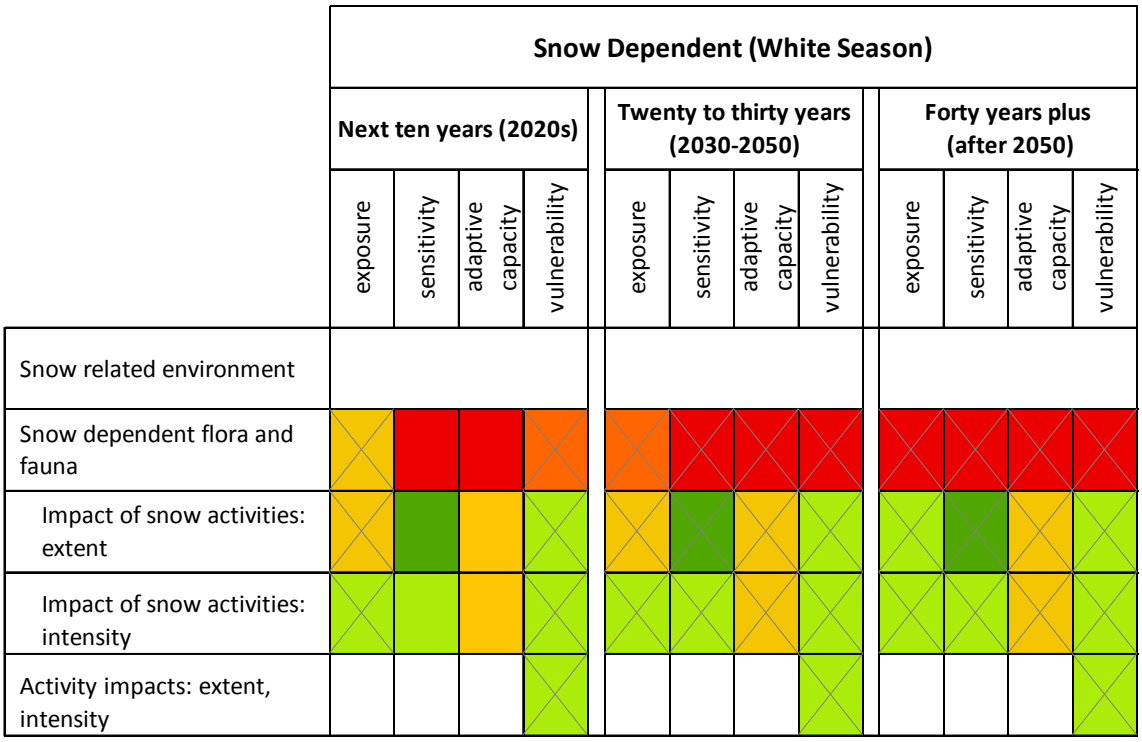
Snow dependent flora and fauna will likely be unable to respond to loss of natural snow should it go. It is unlikely that, at this location, options exist for many of these species to adapt. Snow making is unlikely to contribute to their survival both because the area covered is too small and because the area that is covered is subject to unusual conditions of management and use (relative to what they are adapted to). If the snow is lost, many of these species will be lost. The exposure of the species is taken as the same as

the vulnerability of natural snow. The sensitivity is taken to be total. The adaptive capacity is none. In practice a few species may adapt in some way to the changed conditions, but this is likely to be a minor part of the ecosystem community, and it will then be operating differently in a new context. Things will not be the same without snow and these species will be lost in the long term.

Snow activities have caused impact on the environment by physical changes to slopes and vegetation, and the addition of various built form and equipment including dams, roads, trails, pipelines, etc. The use of the area changes the pattern, frequency and character of snow cover, in some areas leading to compaction or other impacts on such vegetation that remains on ski runs and pathways. As climate change reduces the areas covered by natural snow, activity may become more concentrated on areas where snow is made. This may reduce the area impacted by snow related activities. Depending on trends in visitation, this may lead to intensification of impacts on areas that are still used, until ultimately use declines should white season activity no longer be viable. If climate change proceeds to the point that there is no longer snow activities in the white season, there are issues about remediation of sites, but otherwise the impacts from activities will be reduced.

Overall, the small environmental gains of reduced impacts on the environment in the areas where snow activities occur will be a small compensation for the loss of snow dependent species.

FIGURE 22. ENVIRONMENT VULNERABILITY, MT BULLER AND MT STIRLING



All year round and non-snow related activity (green season) vulnerability/opportunities
Increasing temperatures, coupled with a general drying of soil and ground fuels, will increase the likelihood of bushfire into the future in Victoria. No specific modelling or research into the future risk of bushfire on the alpine resort locations has been conducted, but it can be assumed there will be some increased exposure to risk of loss of property and life at Mt Buller and Mt Stirling.

The resort is heavily vegetated with dry and wet forests. The most common tree in the dry forest in the Mountain Ash (slow to regenerate after a fire) and the most common in the wet forest is the Snow Gum. Approximately 300 hectares near the summit of Mt Buller has been cleared of trees or is alpine (cannot sustain trees). The main vegetation in this area is snow grasses and heath. Near the summit of Mt Stirling there is 200 hectares of alpine zone where there are no trees. With a warming environment trees may begin to establish in these areas if not kept cleared.

Large fires have approached the resort in the recent past, in both the summer of 2002/03 and 2006/07. The Resort has a number of steep escarpments and highly varying topography, has high amounts of vegetation, has poor access and limited routes for escape. These factors combine to make fire control difficult as locating and accessing fires with emergency equipment is difficult. The number of extreme fire danger days is expected to increase, as well as the overall length of the fire season. Coupled with an increase in visitors during the green season, this poses a significant management issue for the resort.

Good management means that while fires may occur more often and be more intense, direct impacts on property and people can be managed – at a cost – but not eliminated. Under Code Red conditions the resort will close to new visitors if significantly threatened by fire. This minimises the number of people in harm's way but with climate change, this could increasingly affect green season visitation. In the longer term this can lead to major impacts and changes in the use of the area as vulnerability rises.

Secondary impacts of more frequent and intense bushfires on landscape and amenity, combined with soil erosion and runoff contributing to landslides and degraded water quality, may well be much larger than the direct impacts of fire. Loss of amenity could deter visitors for a period of time after major fires.

Although fire is a natural process in nearly all Australian ecosystems, many ecosystems and species around the resort including alpine, subalpine, rainforest and riparian communities are not reliant on fire for regeneration. Maintaining or improving the resilience of natural ecosystems is therefore important. However, a change in the mix of species over time is likely.

As the atmosphere warms, it can hold more moisture, resulting in longer dry periods, and more intense precipitation events. This will have impacts upon the vegetation, water supply and prevalence of landslides.

Changed rainfall is likely to combine with bushfire impacts and changed temperature conditions to stress existing vegetation and eventually to change the ecosystems found at these resorts. There may well be periods where areas have greatly reduced vegetation cover before better adapted ecosystems become established.

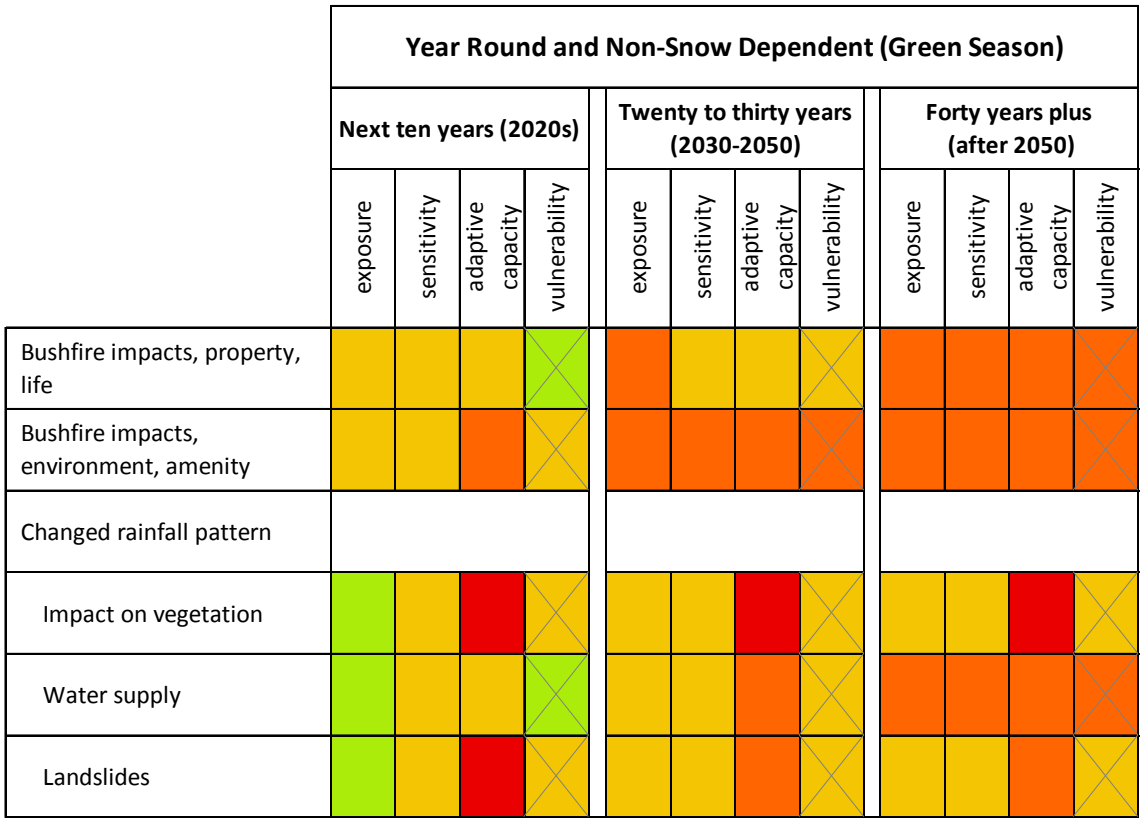
The changed rainfall pattern may have effects on both water quality and quantity. More intense rainfall events may deliver as much rain, but with greater runoff, followed by relatively dry spells in between. This may yield less available water and of poorer quality. Given constraints to Mt Buller's water supply already, future conditions could deteriorate without large investments in storage and treatment over the longer term.

Changed rainfall patterns combined with fire and loss of some vegetation are likely to lead to increased landslides. The direct effects on built assets and roads will likely be significant, particularly as there is only one option for exit. There is some limited capacity to adapt by ensuring construction avoids the highest hazard slopes, though some sections of road will likely remain exposed.

These factors all act to reduce the attractiveness of the resort and surrounding area during the green season. This will eventually be all year round, and the fire season will extend to potentially become an all year round hazard.

This assessment of green season vulnerability is summarised in Figure 23.

FIGURE 23. GREEN SEASON VULNERABILITY, MT BULLER AND MT STIRLING



Mt Stirling is the only Victorian mountain resort to receive more visitors in the green season than in the white season. Activities at Mt Stirling include four-wheel-driving, hiking, education excursions, camping, fishing, horse riding and other activities with a focus on being in nature. However, total visitation to date has not warranted the kinds of investments associated with white season visitation in the alpine resorts. To put the Mt Stirling green season visitation into perspective, it is dwarfed by the Mt Buller green season visitation by about a factor of ten. Mt Buller has also developed road and mountain biking activities, amongst other offerings.

There is a desire to expand these activities further at both mountains. However the ski lift company has retreated from green season activities after 25 years, because they found it financially unsustainable. This may change again with climate change in the long run, which could benefit these resorts as people are increasingly drawn to the mountains to escape the heat in summer.

Competition with other summer attractions and the other resorts will be a barrier. The relatively attractive setting and layout of the Buller village, combined with the early advantage of having established a growing calendar of green season activities such as bike events, fun runs and community events may provide advantages for Mt Buller and Mt Stirling in the region. Mt Buller and Mt Stirling further benefit from proximity to Melbourne.

2.6 Mt Baw Baw

Mt Baw Baw is the resort closest to Melbourne. The resort is approximately 160 km east of Melbourne – two and a half to three hours' drive. Visitors to the resort have the choice of three routes from Melbourne which pass through a range of rural Victorian communities. The approach to the foot of the mountain comes either via the Mt Baw Baw Tourist Road through Noojee and Icy Creek which is very winding, or on the unsealed South Face Road via Erica. The Mt Baw Baw Tourist Road continues from the junction of these two roads for another 5km to the resort village.

The winding roads and undulating terrain can make for an uncomfortable journey, especially for those who are not used to such conditions. While Mt Baw Baw is the closest downhill ski resort to Melbourne by distance, the indirect route of Mt Baw Baw Tourist Road and the unsealed South Face Road mean travel times from Melbourne to Mt Baw Baw are just 30 minutes less than the travel time to Mt Buller.

Mt Baw Baw is an all season alpine resort, open for green season and white season activities. The resort caters for snowboarders, skiers and snow enthusiasts during the white season and outdoor adventurers, hikers and bike riders during the rest of the year. In the white season there is a fee for access. Outside of the white season, access is free.

Development of snow related activities (white season)

The Mt Baw Baw Alpine Resort began in earnest when local Latrobe Valley community formed the Mt Baw Baw Ski Club in 1939. The resort village was founded in 1945 when the first ski hut was built a few kilometres beyond a newly extended logging road. The first tow was installed in 1955 with vehicle access achieved in the 1960's.

On the mountain today there are about 30 hectares of primarily beginner-intermediate ski runs located between 1,464m and 1,564m elevation. The terrain consists of 15 runs serviced by seven lifts which are operated by the Alpine Resort Management Board (ARMB). Of the skiable terrain, 25 percent is considered beginner, 64 percent intermediate and 11 percent advanced.

The ski resort lies to the west of the summit. The resort village is at the bottom of the lifts, offering ski in-ski out access. In addition to the downhill runs, there are a number of cross country trails offering access to other parts of the Baw Baw plateau.

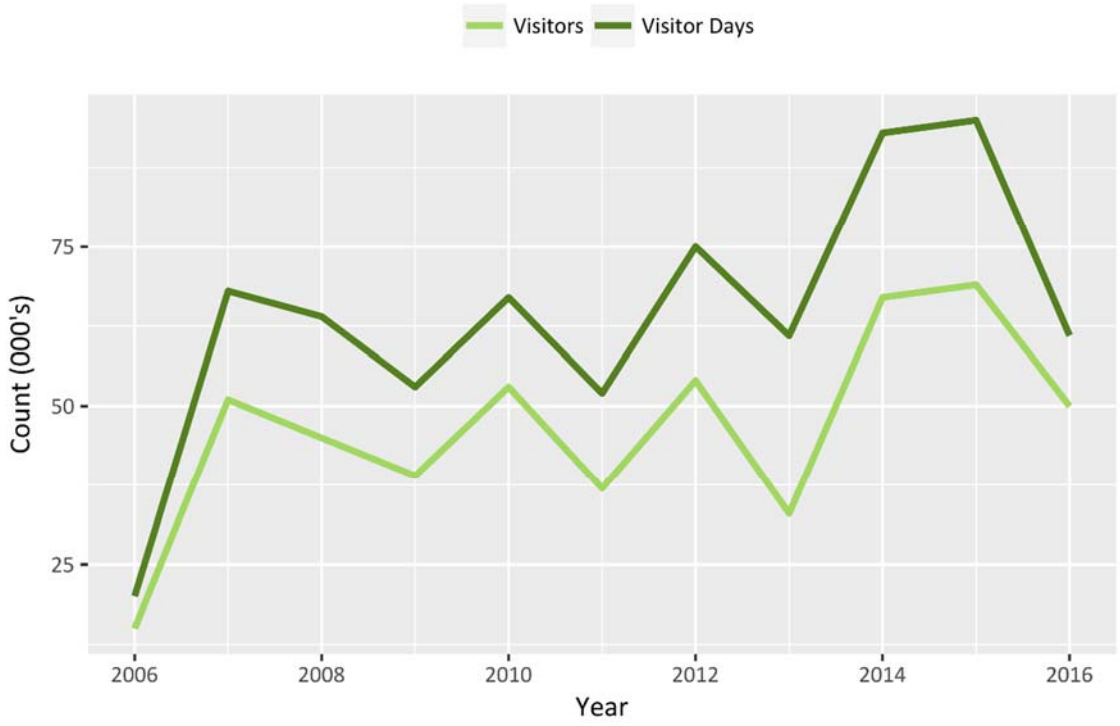
The alpine resort village caters for both day-trippers and long-term visitors, with accommodation, ski hire business, food and beverage outlets, and a medical centre. On-mountain accommodation is dominated by club lodges, which are all located centrally in the Village. Mt Baw Baw is focussed on being family friendly and affordable.

Mt Baw Baw is currently positioned to provide a low cost snow experience, with snow play, entry level skiing and snowboarding facilities, and downhill and cross-country trails. Mt Baw Baw has high visitation rates from 'first timers' and 'beginners', and has an ethnically-diverse visitor demographic. In terms of visitation in the white season, in 2016:

- 93 percent of visitors were from Victoria (compared to 82 percent for all Victorian resorts)
- 5 percent were interstate visitors (compared to 14 percent for all Victorian resorts)
- 2 percent were international (compared to 4 percent for all Victorian resorts).

The economic impact of visitation during the white season has been estimated for the Alpine Resorts Co-ordinating Council (ARCC) by EY Sweeney (2017). The 2016 contribution of Mt Baw Baw on the gross regional product of the surrounding Baw Baw Shire totalled $19 million, and supports 152 direct and 61 indirect jobs. Visitors and visitor days since 2006 are outlined in Figure 24 below.

FIGURE 24. MT BAW BAW WHITE SEASON VISITATION (2006-2016)



Source: ARCC (2016). Victorian Alpine Resorts Entry Statistics

Non-snow related activities (green season)

Mt Baw Baw also attracts visitors to participate in downhill mountain biking, bushwalking and family friendly bush activities. There is a purpose-built downhill track located on the south western side of the mountain, facing out towards the ocean. The course has hosted the Victorian Downhill Championships as well as a number of state rounds. Mt Baw Baw has also developed a 'dry slope', allowing for beginner snowboard and ski lessons all year round.

According to visitation data (EY Sweeney, 2017a) for Mt Baw Baw, 42,635 people visited in the 2016/17 green season. At Mt Baw Baw during the green season:

- 99 percent of visitors were from Victoria (compared to 89 percent for all Victorian resorts)
- 0.5 percent were interstate visitors (compared to 10 percent for all Victorian resorts)
- 0.5 percent were international (compared to 1 percent for all Victorian resorts).

The total green season visitor numbers were not significantly less than the white season visitor numbers, however were spread over a much longer period. In terms of the economic contribution of the green season, Victorian visitors on average have been found to spend $191 per day. This includes spending on food, shopping, travel, accommodation and other miscellaneous expenditures. This daily spending is lower than the white season where the average daily spend by Victorians is $393 per day. The average length of stay is also longer in the white season compared to the green, at 1.2 days compared to 1.0.

In total EY Sweeney (2017a) found that the contribution of Mt Baw Baw's green season on the gross regional product of the surrounding Baw Baw Shire totalled $6 million, and supports 50 direct and 20 indirect jobs, or about one third of that of the white season. In part this may reflect the limited services and facilities offered during the green season (similarly to all alpine resorts).

Vulnerability assessment

The vulnerability of Mt Baw Baw resort is assessed in two parts:

- Snow related activities (white season)
- All year round and non-snow related activities (green season)

The initial review of vulnerability assumes that available adaptive capacity is effectively deployed. In practice this may not occur. At the end of the review the effect of diminished adaptive effectiveness is shown, typically arising due to poor governance or inability to access the necessary resources.

Snow dependent activity (white season) vulnerability

As with all alpine resorts in Victoria, the success of the white season recreation market is critically dependent on having enough reliable, accessible and affordable snow. The first five rows of the vulnerability dashboard (Figure 25) contribute to the vulnerability of the snow dependent (white season) super force – the **availability of affordable snow**.

Natural snow is expected to decline in amount and reliability with climate change. In the first decade of the 2000s, there were about 80 days per year of natural snow cover of one centimetre or more. In the 2020s, this is predicted to be about 32-71 days per year. Between the 2050s and 2070s, natural snowfall is likely to reduce to the point that there will be only transient natural cover each year. Maximum snow depth is also expected to decline to zero over this period. How quickly this occurs depends on global success in reducing emissions.

Natural snow is highly sensitive to climate change. This sensitivity results directly in the loss of snow. Short of weather modification, there is no adaptive capacity to restore natural snow across the region. As a low-altitude resort, Mt Baw Baw will lose natural snow cover sooner than higher altitude resorts.

Snowmaking at Mt Baw Baw provides adaptive capacity to both natural snow variability and unreliability, and to the expected overall reduction in natural snow. At times during the 2015 season there was no natural snow cover, but snowmaking allowed the resort to remain operational for snow sports, with three lifts operating and around 500-1,000 daily visitors. At other times of the season there was predominately natural snow, and only minor snow making.

The capacity to make snow is broadly dependent on the availability of water, energy and suitable snow making conditions in order to be both technically feasible and cost effective. Mt Baw Baw is already in a situation where natural falls are supported by snowmaking. There are concerns regarding the adequacy of the capacity for snowmaking, and the capability to provide full coverage of the required areas as and when required. Current snowmaking coverage is limited to ten hectares and the snowmaking infrastructure is ageing.

At Mt Baw Baw, **water supply** for snowmaking is limited to a small catchment. Water is required for both snowmaking and potable water supply for domestic purposes. The water catchment for the resort (Dam Valley) is located in a protected valley slightly elevated above the village. The village is supplied by surface water from within the catchment by means of rain runoff and snowmelt. A weir has been constructed on the stream below Dam Valley to capture water and direct it to a draw off pipe which then transports water into two x 400,000 litre concrete storage tanks which service the village.

Water availability may be affected over time with changing climate affecting the pattern of rainfall. More extreme events and less regular rainfall may diminish the available water. While some water is likely to be available in the reservoir, the calls on water downstream may affect availability to divert stream water into storage, and the use of potable water, for use in snowmaking if downstream and potable uses are deemed to be higher priority. This will occur at a time when the requirement of water for snowmaking is likely to be rising. Sensitivity to lack of water is relatively high – if water is not available you cannot make snow. However, it is not absolute in that you can make some snow with what water is available and the likelihood of no water at all is quite low. Thus, over time, exposure to limits on water will rise, albeit

judged not to be to high levels, while adaptive capacity may fall – bigger storage may not improve actual supply in dry years.

Energy is required to make snow. The amount of energy required will rise initially for snow guns as average operating temperatures rise and then further if there is a shift from conventional snow making to using snow factories, as may be expected to occur over the longer term. All electrical power required within the resort is supplied by three LPG fuelled generators. The use of generators results in the cost of electricity to consumers being significantly greater than a direct grid connection. Indicatively, the cost of energy supplied to Mt Baw Baw per kilowatt-hour is three times as high as the grid price of power, and in recent times has escalated at 20 percent per annum (four year average), with charges passed on to consumers.

Additionally, the energy load for the resort varies dramatically across the seasons. Green season demand is quite low whilst the demand on energy during the snow season can reach the maximum capacity of the gas generators, resulting in power outages. Increased snow making effort will require increased generation capacity over time. A surge in demand in the green season can also lead to power outage.

The amount of energy required will rise dramatically if there is a shift from conventional snow making to using snow factories, which is expected to occur over the course of the first time horizon (the next ten years, the period through the 2020s) and then rise steeply in the second time horizon (the next twenty to thirty years, the 2030s to 2050s). The cost of generating electricity from LPG is already high and may rise further if the cost of fossil fuels increases due to some form of carbon pricing in the future, something that is more likely as time passes. The resort has already implemented reduced services mid-week throughout the green season in order to reduce utility costs.

On the other hand, the cost of energy generation from renewables has continued to fall and is expected to fall further, albeit at a declining rate. Supporting this is a fall in battery costs for energy storage. Resort plans have already identified developing green energy to reduce greenhouse gases and reduce energy costs as an initiative. Using renewables, particularly solar, in short winter days for peak winter loads is challenging but may help stabilise long term energy costs. Wind, small hydro and other options may be more practical. The evaluation of energy cost and availability for snow making has a high level of uncertainty beyond the first time horizon.

Snow making conditions affect the cost of snow making, potentially quite dramatically. Currently at Mt Baw Baw snowmaking equipment allows for production of good quality snow at low temperatures when humidity is low. This has allowed natural snow to be supplemented. However conditions are likely to become increasingly restricted for conventional snow making as the climate warms, offering fewer operating hours, on average, as each decade passes. Initially more machines operating during the fewer hours available may meet needs – while adding to peak generating capacity as required.

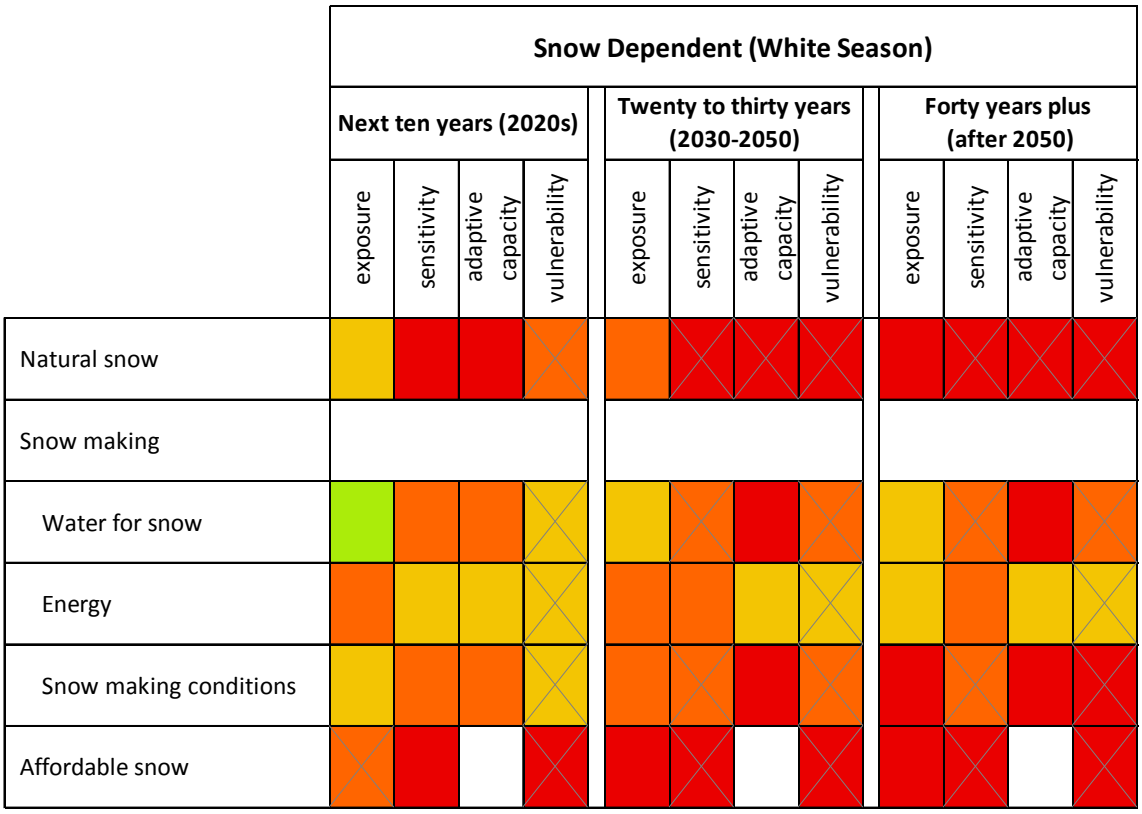
Later, a transition to snow factories capable of operating in almost any conditions will be necessary to continue making snow, particularly to ensure snow is available near the start of the season. But these require a much higher energy input. Thus the adaptive capacity becomes increasingly constrained over time, even with some expected technological advancement. Among all of the Victorian alpine resorts, Mt Baw Baw has the poorest conditions for snow making. The individual elements in this assessment have not been fully unpicked, which raises the likely exposure to deteriorating snow making conditions over time and reduces the adaptive capacity. Over time this leads to increasing costs for snow making, even if water and energy are available and not otherwise cost prohibitive.

The calculated exposure to **loss of affordable snow** is a combination of the preceding conditions. It is represented as the combination of the calculated vulnerability of natural snow combined with the highest calculated vulnerability for the factors affecting snow making.

For Mt Baw Baw, in each time horizon snow making conditions have the highest (or equal highest) vulnerability and thus contribute to the ultimate vulnerability of the exposure to loss of affordable snow. This will occur as investments and operating costs for snow making can no longer be sustained due to

high costs (on average over a number of seasons). This will eventually leading to a loss of snow making capacity. Mt Baw Baw is vulnerable to the loss of affordable snow starting from the 2020s, with ever increasing certainty thereafter. Given its current dependence on snowmaking to ensure snow cover and already significant operating losses, it may already be regarded as having unaffordable snow.

FIGURE 25. AFFORDABLE SNOW VULNERABILITY, MT BAW BAW



The next super force evaluated is snow related (white season**) visitor numbers** (dashboard shown in Figure 26). While clearly driven in part by the first super force, affordable snow, the economic infrastructure affecting access may also act to influence vulnerability of visitor numbers.

The exposure of **lifts** as infrastructure becoming unavailable is based on estimates of available affordable snow. If investors do not consider that snow will be available, and provide conditions that will be attractive to visitors needing lifts, then they will not invest. A failure to invest would have a strong impact on access to any snow that is available. With no/few operating lifts there will be fewer visitors.

There are seven lifts at Mt Baw Baw operated by the ARMB, of which none are chairlifts. They depend on snow cover along the tow line to be operable. The most recent investment in a new lift occurred in 2003. There may be some adaptive capacity in the form of selecting different lift options, or consolidating lifts to areas where snow is made most cost effectively. Establishing a new toboggan run to cater for increasing snow play visitors may provide visitors with alternative activities which require less lifting infrastructure.

This adaptive capacity may decline over time once these options are fully exploited. Mt Baw Baw faces a range of significant issues relative to asset age and operating cost that require careful assessment in terms of returns and therefore (re)investment justification.

Roads are not expected to be affected as directly by climate change. White season risk to roads is likely to shift from closure due to snow to closure due to flooding and landslides. While road closures may occur from time to time, the climate change impacts are not seen as lasting or deep in their impact. Adaptation may occur by building or repairing roads in ways making them less susceptible to landslides

or flooding. While the incentive to maintain the section of road up to the resort may decline if visitor numbers drop too low, vulnerability of roads do not appear as a limiting factor for visitation at Mt Baw Baw.

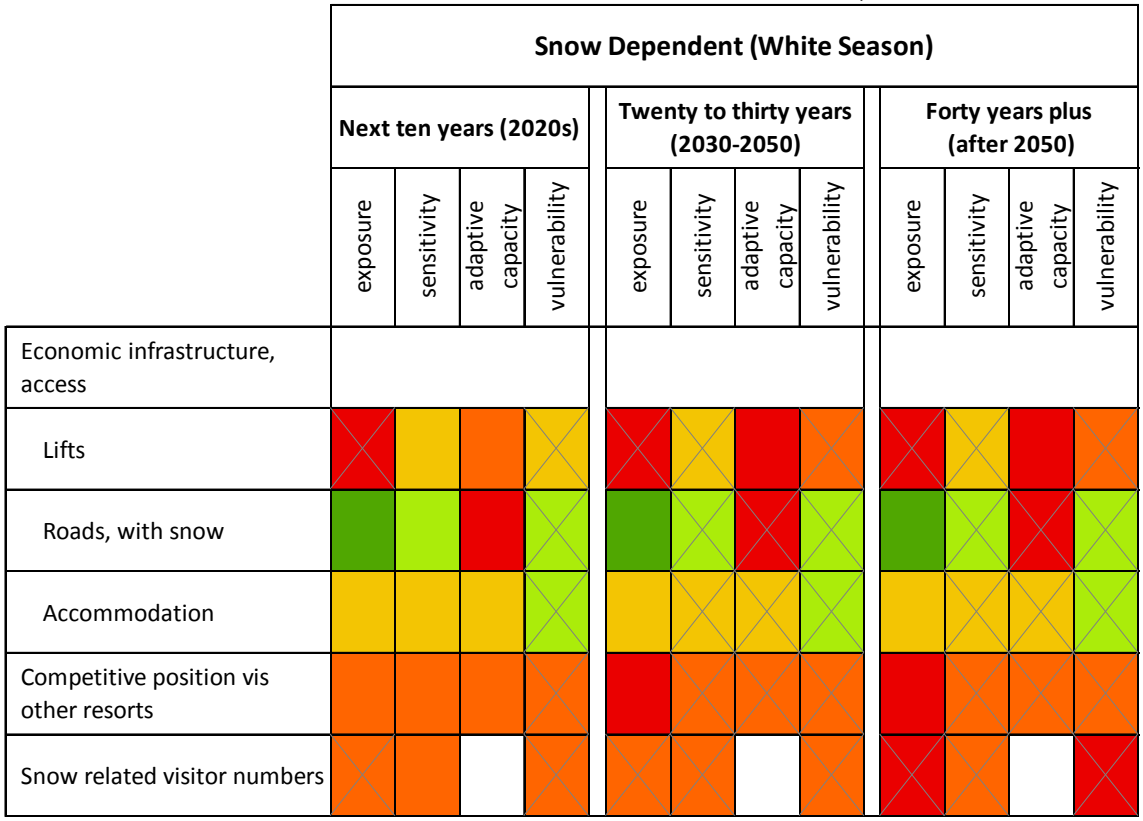
Accommodation is affected by snow, again as a feedback like lifts. If there are not expected to be sufficient visitors there will not be (re)investment in accommodation and over time facilities will become run down or parts of it will close. Capacity closures that still meet demand don't necessarily limit visitation, unlike lifts that may close off access. Adaptive capacity may be increased by appealing to more diverse markets, even during the white season, to respond to times when snow conditions are less adequate. If accommodation is given a greater role in the green season it may contribute to its viability in the white season.

There has been attempts to privatise all or parts of the operations at Mt Baw Baw. The State Government has invested heavily in capital expenditure at the resort, in part to enhance the resorts' attractiveness to private operators. Despite numerous attempts – private sector involvement has proven to be unsuccessful. This demonstrates a lack of confidence in the long-term viability of the Mt Baw Baw Alpine Resort.

The **competitive position,** with respect to other resorts, recognises that as snow conditions deteriorate in lower altitude resorts, some of their visitors will change to the next best alternative. Mt Baw Baw is expected to increasingly lose some snow sport visitors to other Victorian alpine resorts. The general recent upward trend in numbers has been underpinned by financial support for, among other things, snowmaking.

For snow related **(white season) visitor numbers** exposure is a calculated outcome from the super force affordable snow, combined with the 'limiting factor' among lifts, roads and accommodation and the influence of competitive position compared with other resorts. Competitive position is considered the limiting factor. Sensitivity is deemed high. As with affordable snow, the adaptive capacity is taken to be captured already. Mt Baw Baw is vulnerable to decline in white season visitor numbers which is expected to result in major impacts. External assistance is needed to assist with the adjustment, the status quo is unsustainable and a new focus/values/priorities will be required, starting as early as the next decade.

FIGURE 26. SNOW RELATED VISITOR NUMBERS VULNERABILITY, MT BAW BAW



The two super forces of affordable snow and visitor numbers flow through to impact on values related to the white season. The vulnerability dashboard for these values is shown in Figure 27.

Exposure of snow related **economic activity** is directly derived from snow related visitation vulnerability. Sensitivity is taken to be high which may be reduced by adaptation strategies such as diversification of economic activity away from snow sports. In practice this may be more greatly affected by non-climate change factors (market competition with other activities, general economic conditions, changing demographics) so while sensitivity is high, it is not a directly predictive relationship. The government has been subsidising the essential operating costs of Mt Baw Baw since 2004. Without this contribution, the economic future of the resort is already doubtful. Vulnerability of economic activity is expected to result in major impacts, with external assistance needed to adjust by the next decade. By the 2050s, without major adaptation, snow related economic activity will be lost in this season.

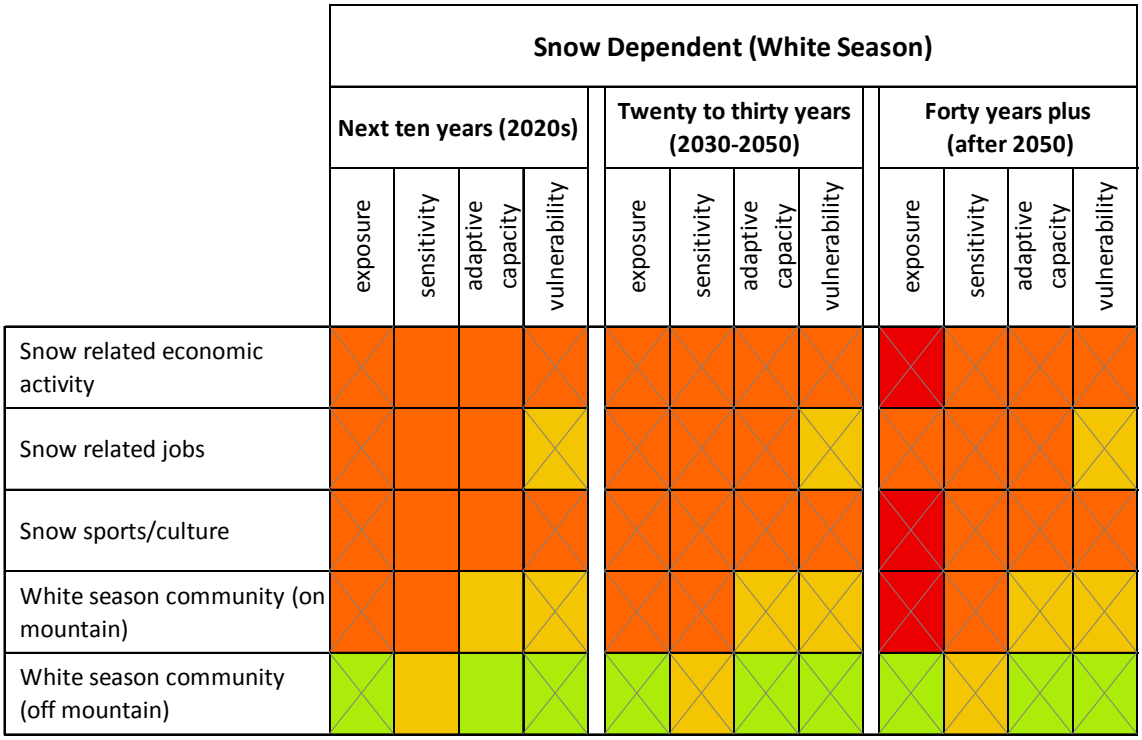
Snow related jobs exposure is equated to snow related economic activity vulnerability. As with economic activity, adaptation may include some diversification in employment activity that is not snow sport related but takes advantage of snow related infrastructure and activity (winter relaxation/health spas) although the current facilities are not readily conducive to this. Employment may also be affected adversely by unrelated trends such as automation. Vulnerability of jobs is expected to result in significant impacts requiring assistance to adjust by the next decade, even assuming effective adaptation to non-snow related employment. In the longer term snow related employment will cease.

Snow sports culture exposure is taken as the vulnerability rating for snow related visitation. Here the definition of snow sports has a few facets: participation by large numbers or development of more advanced and competitive skills. More advanced and competitive skiers and snowboarders are not generally attracted to Mt Baw Baw. Increasingly, Mt Baw Baw will retain only casual visitors with a loose attachment to snow sports, more likely engaging in occasional snow play with little cultural commitment. Snow sports culture can expect major impacts in the next decade, largely lost in the longer term in this resort.

The exposure of the **community and social base** is most strongly focussed on the resort as the nearby regional towns have relatively weak links to Mt Baw Baw. The on-mountain community is largely based around the private lodges. These are strongly affected by their capacity to maintain active members. Fewer people coming to the area reduces the base on which this community is built. Some lodges are now opening up to allow non-members to stay, but this may have the effect of weakening the sense of community among members. Lodges with significant activity beyond the white season and with long traditions of visitation and identification with the area will persist somewhat even if the quality of snow activities declines, thereby reducing sensitivity. If this community is strong in its own right, and has a shared value, then new activities, events etc. may develop beyond those based on snow activity. Thus, the on-mountain community can expect major impacts requiring assistance to adjust in the short term and a likelihood of non-recoverable loss in the longer term.

The off-mountain community is taken to have a low level of exposure and be moderately sensitive should change occur on the mountain. While significant impacts are possible, they have a good capacity to adapt. Thus, their vulnerability is expected to be potentially significant with some assistance needed to adjust.

FIGURE 27. WHITE SEASON COMMUNITY VULNERABILITY, MT BAW BAW



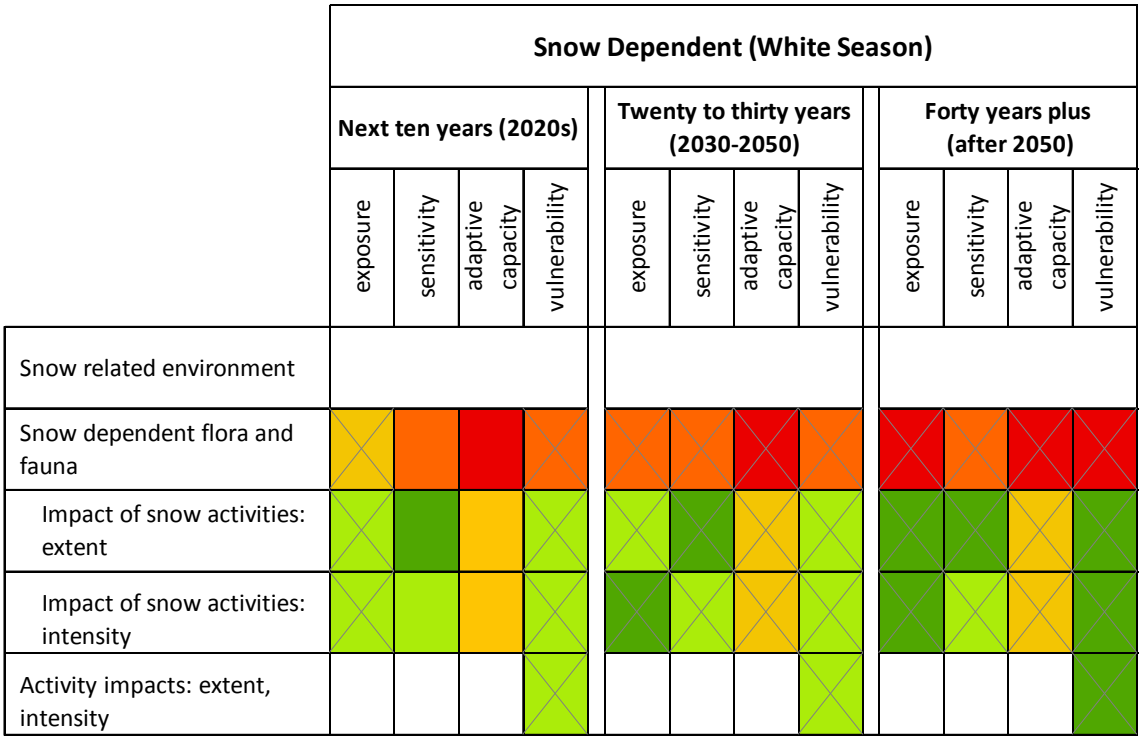
The **environment** encompasses a wide range of elements and values. This dashboard treatment (see Figure 28) selects only two snow related aspects that reflect workshop input as 'indicators' of the kinds of values articulated by participants for the white season.

Snow dependent flora and fauna will likely be unable to respond to loss of natural snow should it go. It is unlikely that, at this location, options exist for many of these species to adapt. Snow making is unlikely to contribute to their survival both because the area covered is too small and because the area that is covered is subject to unusual conditions of management and use (relative to what they are adapted to). If the snow is lost, many of these species will be lost. The exposure of the species is taken as the same as the vulnerability of natural snow. The sensitivity is taken to be total. The adaptive capacity is none. In practice a few species may adapt in some way to the changed conditions, but this is likely to be a minor part of the ecosystem community, and it will then be operating differently in a new context. Things will not be the same without snow and these species will be lost in the long term.

Snow activities have caused impact on the environment by physical changes to slopes and vegetation, and the addition of various built form and equipment including dams, roads, trails, pipelines, etc. The use of the area changes the pattern, frequency and character of snow cover, in some areas leading to compaction or other impacts on such vegetation that remains on ski runs and pathways. As climate change reduces the areas covered by natural snow, activity may become more concentrated on areas where snow is made. This may reduce the area impacted by snow related activities. Depending on trends in visitation, this may lead to intensification of impacts on areas that are still used, until ultimately use declines should white season activity no longer be viable. If climate change proceeds to the point that there is no longer snow activities in the white season, there are issues about remediation of sites, but otherwise the impacts from activities will be reduced.

Overall, the small environmental gains of reduced impacts on the environment in the areas where snow activities occur will be a small compensation for the loss of snow dependent species.

FIGURE 28. ENVIRONMENT VULNERABILITY, MT BAW BAW



All year round and non-snow related activity (green season) vulnerability/opportunities
Increasing temperatures, coupled with a general drying of soil and ground fuels, will increase the likelihood of bushfire into the future in Victoria. No specific modelling or research into the current risk of bushfire on the alpine resort locations has been conducted, but it can be assumed there will be increased exposure to risk of loss of property and life from fire at Mt Baw Baw.

Good management, including reducing fire hazards around the resorts, providing shelters and ensuring good warnings and information to those using roads to reach or leave the resorts will be essential ways to adapt. This means that while fires may occur more often and be more intense, direct impacts on property and people can be managed – at a cost – but not eliminated. Once out of the single 5km resort road, access from two directions provides some flexibility of escape.

While the generally low intensity of development and population reduces the risk to property and people, it also reduces access as roads are sparse and the steep terrain makes access more difficult. This means that when fires start, gaining control may be much harder.

Fire protection at Mt Baw Baw is a responsibility of the ARMB. The Mt Baw Baw and Lake Mountain 2030 Discussion Paper identifies that Mt Baw Baw may face an increased risk of bushfires due to shorter snow seasons, less rainfall over the year and drier and warmer ground conditions.Increasing green season visitation means the level of risk to human life from wildfire may be higher in the future.

The secondary impacts of more frequent and intense bushfires on landscape and amenity, combined with soil erosion and runoff contributing to landslides and degraded water quality, may well be much larger than the direct impacts of fire. Loss of amenity directly after a fire could deter visitors for a period of time.

Increased fire frequency and intensity will lead to the loss of less fire resistant species, if it exceeds these species' capacity to cope. The exposure is likely to increase over time, as is the sensitivity as the ecosystem tends to degrade from repeated assault. The capacity to influence these natural responses to increased fire frequency is limited.

Rainfall is expected to decrease, but more significantly the rain that does fall will be in more intense short bursts with longer rain free periods in between. This will further stress vegetation. Exposure will rise over the three future periods, as will the sensitivity. Much vegetation is expected to have a limited capacity to adapt, but over the long term, the vegetation that survives will be that which is most able to deal with the changed climate.

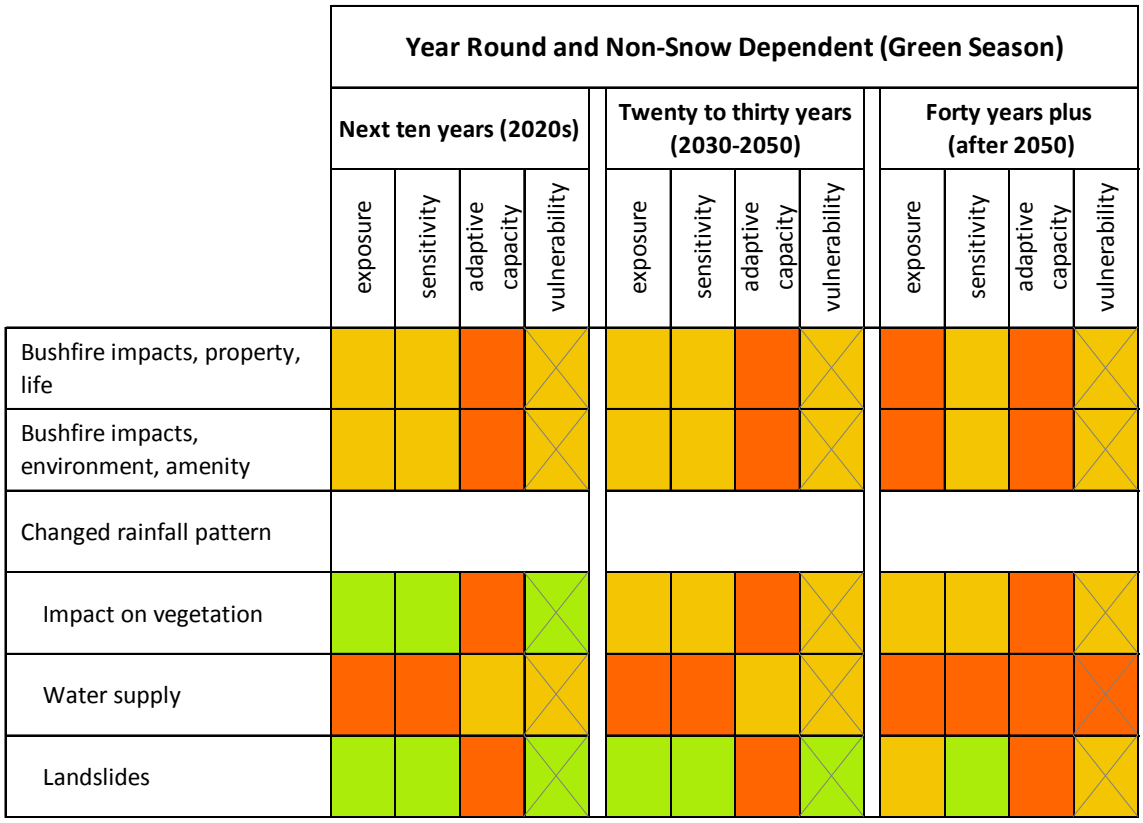
Water supply will be more highly exposed, potentially less able to provide the needs of communities with less reliable stream flow, and muddy flood waters during downpours. Against this, there will be adaptive capacity by building dams, filter beds and other potentially costly engineering solutions.

Changed rainfall patterns, combined with fire and loss of some vegetation, are likely to lead to increased landslides. The direct effects on built assets and roads will likely be manageable, particularly for Mt Baw Baw as there are two options for exit should one of the roads be closed. There is some limited capacity to adapt by ensuring construction avoids the highest hazard slopes, though some sections of road will likely remain exposed.

These factors all act to reduce the attractiveness of the resort and surrounding area during the green season. This will eventually be all year round, and the fire season will extend to potentially become an all year round hazard.

This assessment of green season vulnerability is summarised in Figure 29.

FIGURE 29. GREEN SEASON VULNERABILITY, MT BAW BAW



Actions proposed in the resort annual reports and strategies include:

- Develop green season nature based recreation activity events which return positive net revenue. This will focus on maximising the existing trail structures for walking and hiking.
- Implement Stage 1 Mountain bike course incorporating downhill free flow trail
- Construct new innovative mountain biking terrain park
- Further develop the arts and culture projects to include diverse range of opportunities and activities.

In the long run, climate change could potentially benefit the resort as people are increasingly drawn to the mountains to escape the heat in summer. Competition with other summer attractions will be a barrier, as will competition with other alpine areas with better access and more amenities.

2.7 Lake Mountain

Lake Mountain resort is located only one and a half hours drive from Melbourne, making it the closest resort in terms of travel time to Melbourne. Lake Mountain is a scenic 30-minute drive from the town of Marysville. The resort is only accessible by one road.

The resort complements other regional tourism offerings and natural attractions such as Steavenson Falls and the Black Spur – Yarra Valley to High Country touring route. It is also within close proximity to the Yarra Valley, which provides a strong food and wine offering.

Development of snow related activities (white season)

The Lake Mountain Alpine Resort covers 2,400 hectares of skiable area located between 1,340 and 1,480 metres above sea level. There are currently no lifts at Lake Mountain, with cross country skiing being the key activity. The resort has one of the most-extensive cross-country trail networks in the world. There are also three toboggan parks and the resort is considered family-friendly and perfect to 'experience' snow. 84 percent of visitors to Lake Mountain engage in tobogganing, snow play, sightseeing, and spending quality time with family or friends by, compared to 15 percent across all Victorian alpine resorts. Lake Mountain is a day-trip destination from Melbourne (unless staying in the towns nearby) as it has no overnight accommodation.

The village has a range of facilities open during the day including a cafe, equipment hire, ski school, and bistro. Bushfires on 7 February 2009 caused considerable damage at Lake Mountain. Much of the forested area was burnt, and almost all buildings except the main Day Visitor Centre/Ski Hire/Bistro were destroyed.

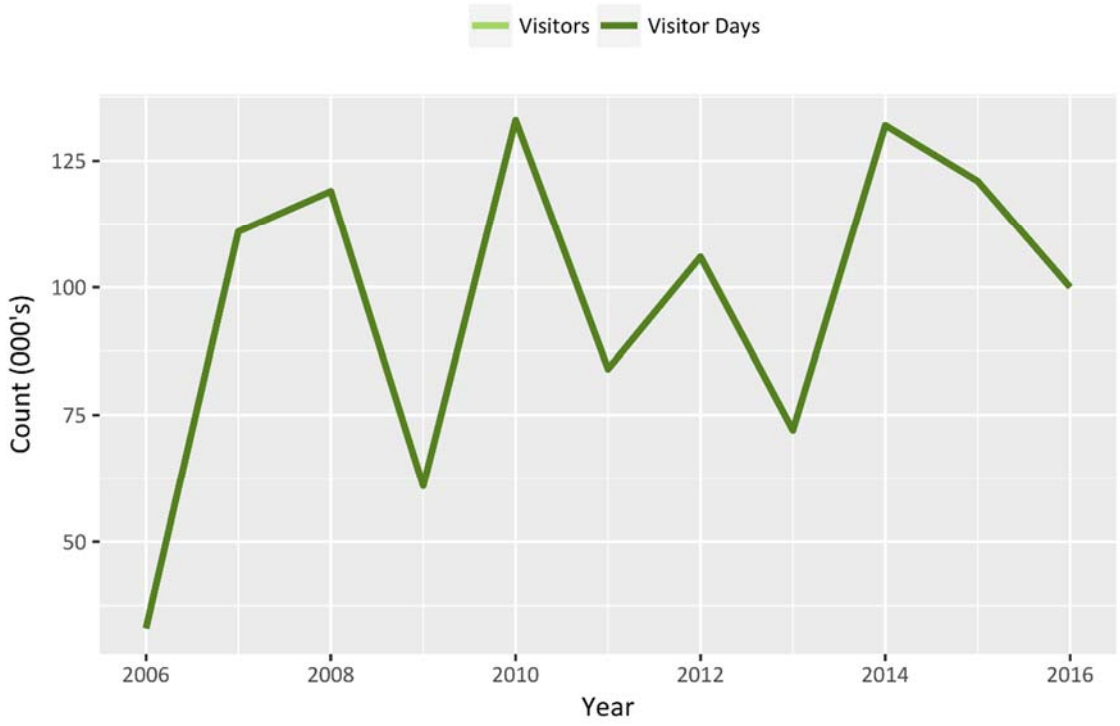
In terms of visitation in the white season at Lake Mountain, in 2016:

- 90 percent of visitors were from Victoria (compared to 82 percent for all Victorian resorts)
- 3 percent were interstate visitors (compared to 14 percent for all Victorian resorts)
- 7 percent were international (compared to 4 percent for all Victorian resorts).

The economic impact of visitation during the white season has been estimated for the ARCC by EY Sweeney (2017). The contribution of Lake Mountain on the gross regional product of the surrounding Murrindindi Shire totalled $17 million, and supports 159 direct and 48 indirect jobs.

Visitors and visitor days since 2006 are outlined in Figure 30.

FIGURE 30. LAKE MOUNTAIN WHITE SEASON VISITATION (2006-2016)



Source: ARCC (2016). Victorian Alpine Resorts Entry Statistics

Non-snow related activities (green season)

Lake Mountain also attracts visitors who participate in non-snow related activities. The resort has striven to enhance its green season offer including adventure activities, wild flower walks, mountain biking and cycling. Lake Mountain is a popular destination for road cyclists due to the challenging climbs up to the resort. The café remains open all year round to accommodate bushwalkers and bike riders.

According to visitation data (EY Sweeney, 2017a), Lake Mountain received 46,631visitors accounting for 46,631visitor days. At Lake Mountain during the green season:

- 95 percent of visitors were from Victoria (compared to 89 percent for all Victorian resorts)
- 3 percent were interstate visitors (compared to 10 percent for all Victorian resorts)
- 2 percent were international (compared to 1 percent for all Victorian resorts)

The total green season visitor numbers were about half the white season visitor numbers, and also spread over a much longer period. In terms of economic contribution of the green season, Victorian visitors were estimated to spend on average $136 per day. This includes spending on food, shopping, travel, accommodation and other miscellaneous expenditures. This daily spending is lower than the white season where the average daily spend by Victorians is $243 per day.

EY Sweeney (2017a) found that the total contribution of Lake Mountain to the gross regional product of the surrounding Murrindindi Shire totalled $4 million, and supports 37 direct and 11 indirect jobs, or about one quarter of the impact of the white season.

Vulnerability assessment

The vulnerability of Lake Mountain Alpine Resort is assessed in two parts:

- Snow related activities (white season)
- All year round and non-snow related activities (green season).

The initial review of vulnerability assumes that available adaptive capacity is effectively deployed. In practice this may not occur. At the end of the review the effect of diminished adaptive effectiveness is shown, typically arising due to poor governance or inability to access the necessary resources.

Snow dependent activity (white season) vulnerability
As with all alpine resorts in Victoria, the success of the white season recreation market is critically dependent on having enough reliable, accessible, affordable snow. The first five rows of the vulnerability dashboard (Figure 31) contribute to the vulnerability of the snow dependent (white season) super force – the **availability of affordable snow**.

Natural snow is expected to decline in amount and reliability with climate change. In the first decade of the 2000s, there were about 74 days per year of natural snow cover of one centimetre or more. In the 2020s, this is predicted to be about 30-66 days per year of at least one centimetre of natural snow cover per year. This is unlikely to be sufficient to support skiing activity most years but would be sufficient for some snow play at times. Between the 2050s and 2070s, natural snowfall is likely to reduce to the point that there will be only transient natural cover each year. How quickly this occurs depends on the level of greenhouse gas emissions that occur globally. Maximum depth is also expected to decline to zero over this period.

Natural snow is highly sensitive to climate change. This sensitivity results directly in the loss of snow. Short of weather modification, there is no adaptive capacity to restore natural snow across the region. As a low-altitude resort, Lake Mountain will lose natural snow cover sooner than higher altitude resorts.

Snowmaking at Lake Mountain provides adaptive capacity to both natural snow variability and unreliability and to the expected overall reduction in natural snow. Lake Mountain is already in the situation where reliable seasons cannot be obtained unless natural falls are supported by snowmaking. There is evidence that snowmaking at Lake Mountain has been a successful adaptive method in recent years. During the 2015 white season, more than 120,000 visitors experienced the resort. Without snowmaking, the resort would only have been able to provide toboggan slopes for less than 10 days, which would likely have resulted in less than 60,000 visitors to the resort. Snowmaking produced 25,848 cubic metres in 2015 compared to 10,666 cubic metres in 2014.

In 2015, the Board articulated a need to seek additional funds to invest further in snowmaking equipment with a preference for a snowmaking factory that has a capacity to make snow in above zero temperatures and to be less negatively impacted by humidity. This has since been acquired.

The capacity to make snow is broadly dependent on the availability of water, energy and suitable snow making conditions in order to be both technically feasible and cost effective.

At Lake Mountain **water supply** required for snowmaking purposes is the primary water demand. The level of demand is dependent on the climate conditions and requirements for artificial snow production, and varies from year to year. The Lake Mountain water supply system sources water from Taggerty River. Water is diverted from Taggerty River at a small concrete weir to three storage tanks via a gravity syphon system. Water supply arrangements in place at Lake Mountain are sufficient to meet current water demands for snowmaking. There is no reticulated potable water supply, with all potable demands supplied with bottled water. Non-potable water is reticulated for use in buildings for cooking and provision of bathrooms and toilets.

Water availability may be affected over time with changing climate affecting the pattern of rainfall. More extreme events and less regular rainfall may diminish the available water. Calls on water downstream may affect availability to divert stream water into storage, for use in snowmaking if downstream uses are deemed to be higher priority. This will occur at a time when the requirement of water for snowmaking is likely to be rising. Sensitivity to lack of water is relatively high – if water is not available you cannot make snow. However, it is not absolute in that you can make some snow with what water is available and the likelihood of no water at all is extremely low. Thus, overtime, exposure to limits on water will rise, albeit

judged not to be to high levels, while adaptive capacity may fall – bigger storage may not improve actual supply in dry years.

Energy is required to make snow. The amount of energy required will rise initially for snow guns as average operating temperatures rise and then further if there is a shift from conventional snow making to using snow factories, as may be expected to occur over the longer term. Mt Buller has already installed their first snow factory. Lake Mountain is not connected to the national electricity grid, with diesel generators providing all of the resort's energy. The current dependence on diesel-powered generators is costly and carbon emission impacts are greater in comparison to grid electricity supply, limiting potential returns that could be reinvested in additional facilities and products.

The amount of energy required will rise dramatically if there is a shift from conventional snow making to using snow factories, which is expected to occur over the course of the first time horizon and rise steeply in the second one. The cost of electricity from diesel is already high and the cost of fossil fuels may rise if there is some form of carbon pricing in the future, something more likely as time passes.

On the other hand, the cost of energy generation from renewables has continued to fall and is expect to fall further, albeit at a declining rate. Supporting this is a fall in battery costs for energy storage. Using renewables, particularly solar, in short winter days for peak winter loads is challenging but may help stabilise long term energy costs. Alternatives such as small hydro, wind and biodiesel are being explored. The evaluation of energy costs for snow making has a high level of uncertainty beyond the first time horizon.

Snow making conditions affect the cost of snow making, potentially quite dramatically. Currently at Lake Mountain conventional snowmaking equipment enables production of good quality snow at below zero temperatures when humidity is low, providing coverage on slopes, trails and play areas. Lake Mountain also has capacity through its flake ice production unit to make artificial snow in somewhat warmer and more humid weather than the traditional snow fan gun technology provides. However the capacity of the flake ice machine is only sufficient for a limited area. Although the quality of the snow is lower, it still allows the toboggan and play areas to be operational, and this is acceptable to some target markets but not experienced downhill snow sports enthusiasts. This may allow Lake Mountain to continue to attract clientele even with the deteriorating snowmaking conditions in the 2020s but as the resort at lowest altitude, it will remain at a disadvantage.

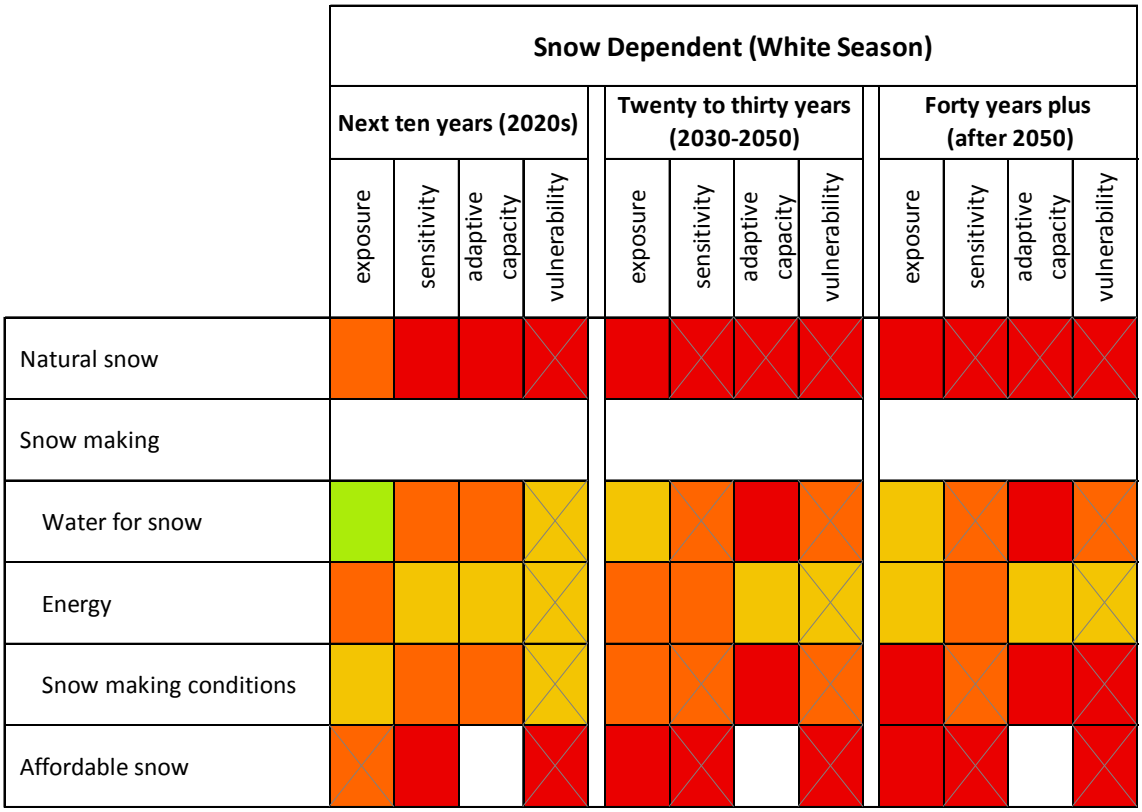
Conditions are likely to become increasingly restricted for conventional snow making as the climate warms, offering fewer operating hours, on average, as each decade passes. Initially more machines operating in the fewer hours available may meet needs – while adding to generating capacity required.

Later a transition to a high proportion of snow made by snow factories capable of operating in almost any conditions will be necessary to continue making snow. Thus the adaptive capacity becomes increasingly constrained over time, even with some expected technological advancement. We have not fully unpicked these individual elements in this assessment, simply raising the likely exposure to deteriorating snow making conditions over time while reducing the adaptive capacity. Over time this leads to increasing costs for snow making, even if water and energy are available and not otherwise cost prohibitive.

The calculated exposure to **loss of affordable snow** is a combination of the preceding conditions. It is represented as the combination of the calculated vulnerability of natural snow combined with the highest calculated vulnerability for the factors affecting snow making.

For Lake Mountain, snow making conditions have the highest (or equal highest) vulnerability in each time horizon and thus contribute to the ultimate vulnerability of the exposure to loss of affordable snow. This will occur as investments in snow making are no longer sustainable on costs (on average over a number of seasons) leading to a loss of snow making capacity. Lake Mountain is vulnerable to the loss of affordable snow starting from the 2020s, with ever increasing certainty thereafter. Arguably the regular operational losses already being experienced suggest that snow is not affordable already.

FIGURE 31. AFFORDABLE SNOW VULNERABILITY, LAKE MOUNTAIN



The next super force evaluated is snow related (white season**) visitor numbers** (dashboard shown in Figure 32). While clearly driven in part by the first super force, affordable snow, the economic infrastructure affecting access may also act to influence vulnerability of visitor numbers.

Cross-country skiing, snow play and some tobogganing are the only snow sports activity provided for at Lake Mountain and do not require lifts.

Roads are not expected to be affected as directly by climate change. While road closures may occur from time to time, the climate change impacts are not seen as lasting or deep in their impact. Adaptation may occur by building or repairing roads in ways that make them less susceptible to landslides or flooding. While the incentive to maintain the section of road up to the resort may decline if visitor numbers drop too low, even though monitoring and management of the road by VicRoads has identified areas of risk where remediation and repair will be required to maintain safe access to the resort, vulnerability of roads to climate change impacts never appear as a limiting factor for visitation at Lake Mountain.

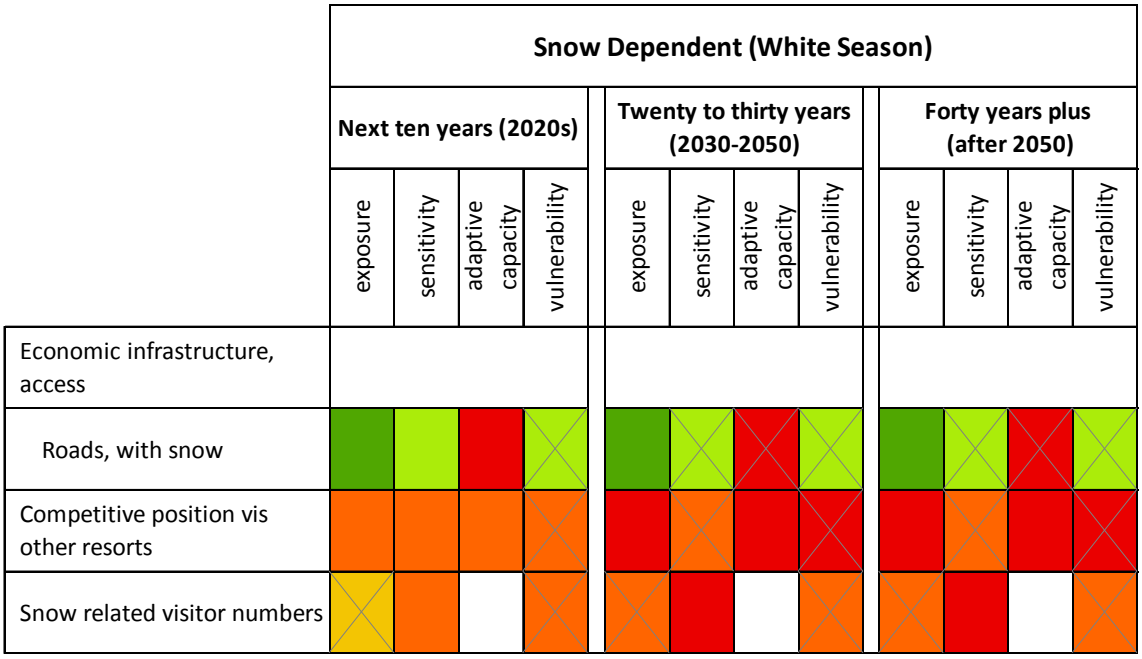
There is no accommodation provided at Lake Mountain so this is not assessed for vulnerability.

The **competitive position,** with respect to other resorts, recognises that as snow conditions deteriorate in lower altitude resorts, some of their visitors will move to the next best alternative. Lake Mountain is expected to increasingly lose some visitors to other Victorian alpine resorts. However as the main appeal of the Lake Mountain experience is the opportunity to just play and experience the snow, and approximately 40 percent of visitors are either 'never beens' or had 'tried once before', the loss of visitors may be slower in the next ten years than Mt Baw Baw, which relies more on snow sport enthusiasts. In the longer term it is likely that Lake Mountain will lose visitors apart from opportunistic visitors after occasional dumps of snow.

For snow related **(white season) visitor numbers** exposure is a calculated outcome from the super force affordable snow, combined with the 'limiting factor' among lifts, roads and accommodation and the influence of competitive position compared with other resorts. Sensitivity is deemed high, but increasing as snow is no longer provided in later years, due to snow being the only attraction at this resort. The adaptive capacity is taken to be captured in the contributing factors.

Overall, Lake Mountain's vulnerability to a decline in visitor numbers is expected to result in major impacts. External assistance will be needed to adjust and a new focus/values/priorities required if any white season activity is to be retained, starting as early as the next decade. By the 2050s Lake Mountain's competitive position against other resorts will be lost due to the loss of snow, with snow visitation almost certainly lost (in particular cross country skiing). The current visitor trend of gradually rising numbers could only be sustained by increasing subsidy of the resort and snow making, or a change or more non-snow related winter visitation.

FIGURE 32. SNOW RELATED VISITOR NUMBERS VULNERABILITY, LAKE MOUNTAIN



The two super forces of affordable snow and visitor numbers flow through to impact on values related to the white season. The vulnerability dashboard for these values is shown in Figure 33.

Exposure of snow related **economic activity** is directly derived from snow related visitation vulnerability. Sensitivity is taken to be high which may be reduced by adaptation strategies such as diversification of economic activity away from snow sports. In practice this may be more greatly affected by non-climate change factors (market competition with other activities, general economic conditions) so while sensitivity is high, it is not a directly predictive relationship.

The government has been subsidising the essential operating costs of Lake Mountain since 2004. Without this contribution, the economic future of the resort is doubtful. There is no visitor accommodation (with some limited staff accommodation). The nearest accommodation is located in Marysville, which is approximately 20 kilometres from the resort. The resort is unique insofar as there are currently no private leaseholders within the alpine resort. Given the lack of accommodation or private leaseholders at Lake Mountain, the revenue base is almost entirely variable and is totally reliant on white season visitation, which is susceptible to the level of snow fall and winter conditions. This lack of private investment demonstrates feedback from a lack of confidence in on-going natural snow falls to attract visitors. Vulnerability of economic activity is expected to result in major impacts, with external

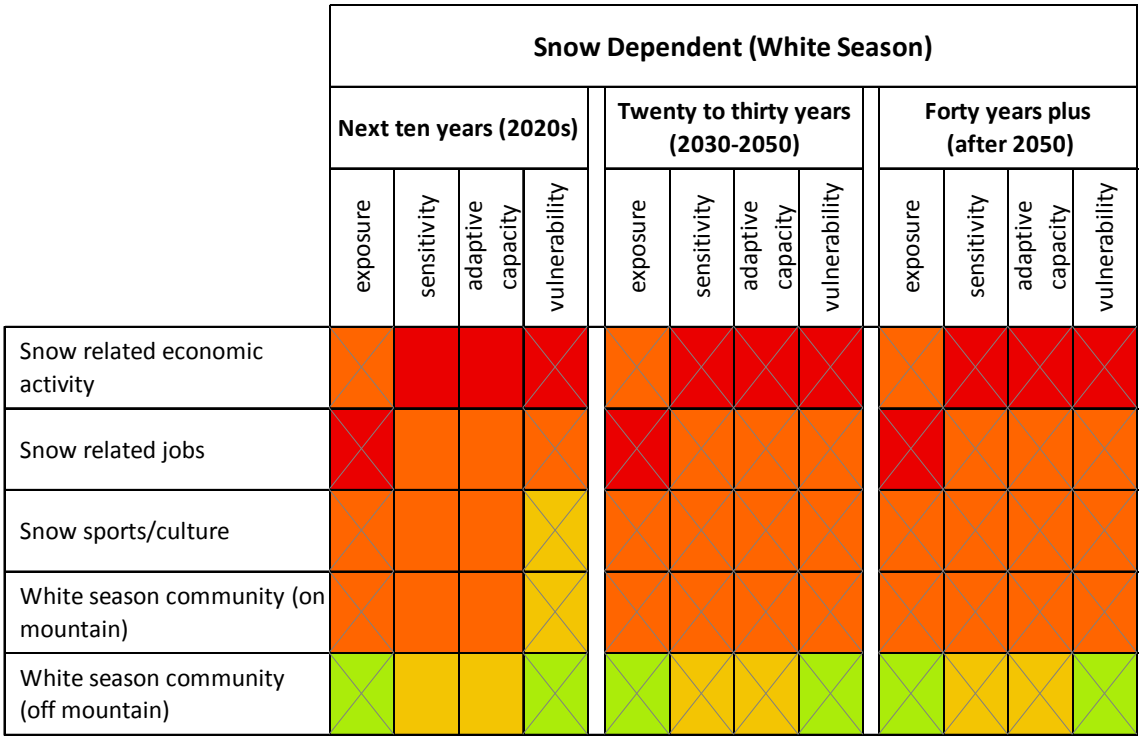
assistance needed to adjust by the next decade. By the 2050s, without significant adaptation, economic activity will be lost in this season.

Snow related jobs exposure is equated to snow related economic activity vulnerability. As with economic activity, adaptation may include some diversification in employment activity that is not snow sport related but takes advantage of snow related infrastructure and activity (winter relaxation/health spas) although there are few facilities currently conducive to this. Employment may also be affected adversely by unrelated trends such as automation. Vulnerability of jobs is expected to result in significant impacts requiring assistance to adjust by the next decade, even assuming effective adaptation to non-snow related employment.

Snow sports culture exposure is taken as the vulnerability rating for snow related visitation. The Lake Mountain snow culture is entirely one of participation by large numbers of casual visitors, with some cross country skiers during better conditions. Advanced and competitive downhill skiers and snowboarders are not attracted to Lake Mountain. Increasingly Lake Mountain will attract only casual visitors with a loose attachment to snow sports, more likely engaging in occasional snow play with little cultural commitment. Snow sports culture will be largely lost in the longer term in this resort.

The exposure of the **community and social base** is centred on the regional town of Marysville, as there is no permanent population or accommodation at the resort. Marysville directly services white season visitors to Lake Mountain and once complemented the resort with approximately 3,000 beds and commercial services. However the town, like the resort, is being re-built after being heavily destroyed by the Black Saturday bushfires. A new 101-room Hotel opened in Marysville in February 2015, and approximately 16 other accommodation providers have rebuilt, or commenced the rebuilding process since 2010, including hotels, caravan parks and Bed and Breakfast accommodation. Therefore, the local community in Marysville is linked to the resort and affordable snow to a high degree due to the economic connections. However the town does not exclusively rely on the resort so there is some adaptive capacity. At Lake Mountain resort, there is a perception that all values are almost certainly exposed to and will be subject to major impacts from climate change in the short to medium.

FIGURE 33. WHITE SEASON COMMUNITY VULNERABILITY, LAKE MOUNTAIN



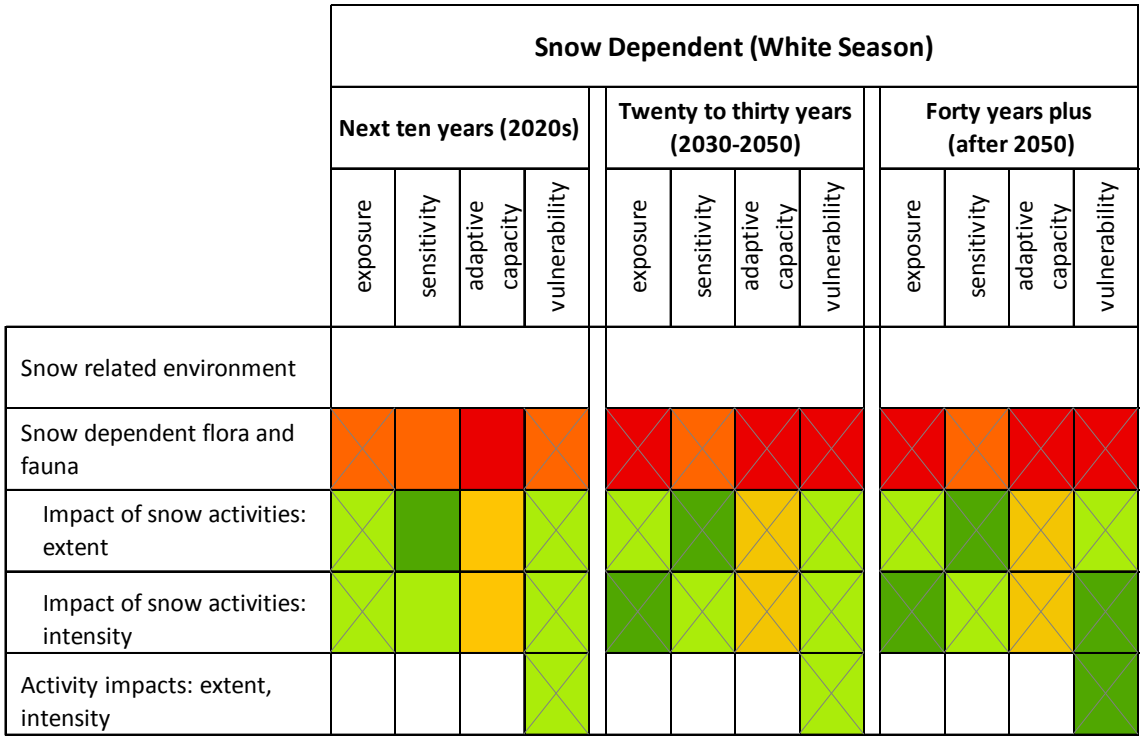
The **environment** encompasses a wide range of elements and values. This dashboard treatment (see Figure 34) selects only two snow related aspects that reflect workshop input as 'indicators' of the kinds of values articulated by participants for the white season.

Snow dependent flora and fauna will likely be unable to respond to loss of natural snow should it go. It is unlikely that, at this location, options exist for many of these species to adapt. Snow making is unlikely to contribute to their survival both because the area covered is too small and because the area that is covered is subject to unusual conditions of management and use (relative to what they are adapted to). If the snow is lost, many of these species will be lost. The exposure of the species is taken as the same as the vulnerability of natural snow. The sensitivity is taken to be total. The adaptive capacity is none. In practice a few species may adapt in some way to the changed conditions, but this is likely to be a minor part of the ecosystem community, and it will then be operating differently in a new context. Things will not be the same without snow and these species will be lost in the long term.

Snow activities have caused impact on the environment by physical changes to slopes and vegetation, and the addition of various built form and equipment including dams, roads, trails, pipelines, etc. The use of the area changes the pattern, frequency and character of snow cover, in some areas leading to compaction or other impacts on such vegetation that remains on ski runs and pathways. As climate change reduces the areas covered by natural snow, activity may become more concentrated on areas where snow is made. This may reduce the area impacted by snow related activities. Depending on trends in visitation, this may lead to intensification of impacts on areas that are still used, until ultimately use declines should white season activity no longer be viable. If climate change proceeds to the point that there is no longer snow activities in the white season, there are issues about remediation of sites, but otherwise the impacts from activities will be reduced.

Overall, the small environmental gains of reduced impacts on the environment in the areas where snow activities occur will be a small compensation for the loss of snow dependent species.

FIGURE 34. ENVIRONMENT VULNERABILITY, LAKE MOUNTAIN



All year round and non-snow related activity (green season) vulnerability/opportunities
Increasing temperatures coupled with a general drying of soil and ground fuels will increase the likelihood of bushfire into the future in Victoria. No specific modelling or research into the future risk of

bushfire on the alpine resort locations has been conducted, but it can be assumed there will be increased exposure to risk of loss of property and life from fire at Lake Mountain.

Good management, including reducing fire hazards around the resorts, providing shelters and ensuring good warnings and information to those using roads to reach or leave the resorts will be essential ways to adapt. This means that while fires may occur more often and be more intense, direct impacts on property and people can be managed – at a cost – but not eliminated. Once out of the single 10 km resort road, access from two directions provides some flexibility of escape. Increasing green season visitation means the level of risk to human life from wildfire may be higher in the future.

While the generally low intensity of development and population reduces the risk to property and people, it also reduces access as roads are sparse and the steep terrain make access more difficult. This means that when fires start, gaining control may be much harder.

The Lake Mountain Resort suffered extensive damage in the 2009 fires and the surrounding natural environment was also heavily impacted. Following the bushfires, a new visitor centre (day shelter building) was constructed, creating new facilities and service offering to visitors

The secondary impacts of more frequent and intense bushfires on landscape and amenity combined with soil erosion and runoff contributing to landslides and degraded water quality may well be much larger than the direct impacts of fire.

Areas of Snow Gum in the alpine-zone were reduced significantly in the fires and survival rates were extremely low. It was estimated that only 2 percent of understorey remains unburnt surrounding the resort. This increases sensitivity to further fires in the next ten years as species regenerate. Increased fire frequency and intensity will lead to loss of less fire resistant species, if it exceeds these species capacity to cope. The exposure is likely to increase over time, as does the sensitivity as the ecosystem tends to degrade should it face repeated assault. All though the forest will take some time to regenerate, some native wildflowers have flourished because of the bushfires, due to natural adaptability.

Rainfall is expected to decrease, but more significantly the rain that does fall will be in more intense short bursts with longer rain free periods in between. This can further stress vegetation. Exposure will rise over the three future periods, as will the sensitivity. Much vegetation is expected to have a limited capacity to adapt, but over the long term, the vegetation that survives will be that which is most able to deal with the changed climate.

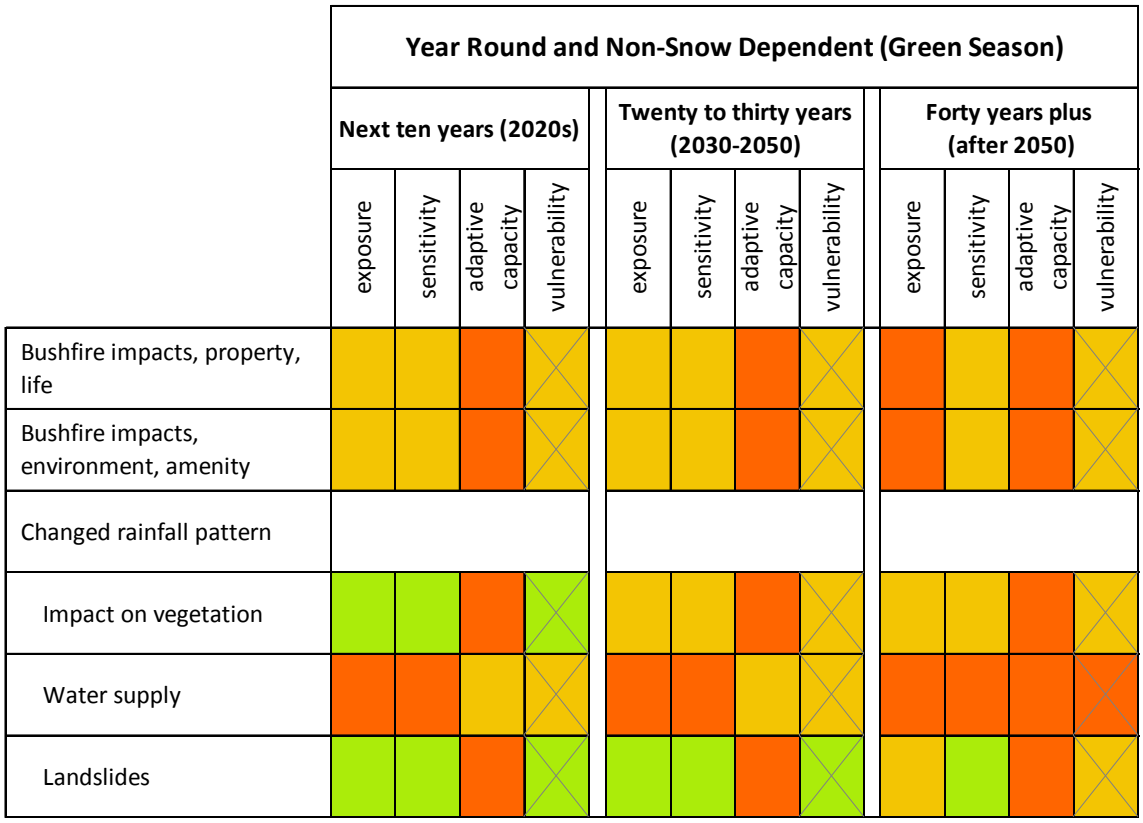
Water supply will be similarly exposed, but potentially less able to support the needs of communities with less reliable stream flow, and muddy flood waters during downpours. Against this, there will be adaptive capacity by building dams, filter beds and other potentially costly engineering solutions.

Changed rainfall patterns, combined with fire and loss of some vegetation, are likely to lead to increased landslides. The direct effects on built assets and roads will likely be manageable. There is some limited capacity to adapt by ensuring construction avoids the highest hazard slopes, though some sections of road will likely remain exposed.

These factors all act to reduce the attractiveness of the resort and surrounding area during the green season. This will eventually be all year round, and the fire season will extend to potentially become an all year round hazard.

This assessment of green season vulnerability is summarised in Figure 35.

FIGURE 35. GREEN SEASON VULNERABILITY, LAKE MOUNTAIN



While there is overall less immediate threat from climate change to the green season compared to the white season, it is still present. Green season visitation numbers at Lake Mountain have been variable and are also linked to weather and environmental factors. For instance, visitation immediately after the 2009 bushfires was very low, due to concerns of bushfire risks, limited infrastructure, activities and accessibility. Visitation has been recovering, though there has been noticeable public interest in the regeneration of the natural environment post-fires, and visitors to Lake Mountain are seeking education during their visits.

Climate change in the long run could even benefit the resort as people are increasingly drawn to the mountains to escape the heat in summer. Competition with other summer attractions will be a barrier, as will developing a marketable product, and competition with other alpine areas with more amenities.

3 CONCLUDING REMARKS

The climate changes that have been measured to date, combined with the modelled future climate changes, foreshadow that snow related activities in all parts of the alpine region will be greatly affected in the medium to long term. This will be most evident and severe first at lower altitudes, with the southern resorts already being affected and further substantial impacts expected as soon as the next decade.

Most resorts will benefit from snowmaking to some extent in the next decade, particularly where the investment can pay off over a relatively short time frame. Snowmaking has the substantial benefit of improving reliability of snow cover, and has arguably been a factor in increased visitation over the past few years, with or without long term change in natural snowfall. Resorts at higher elevations can continue this strategy for perhaps a decade or two longer than those at lower altitudes, depending upon the effectiveness of global greenhouse gas emission reductions.

Natural snow fall will decrease, on average, over the next few decades. This will increase the amount of manufactured snow required, while at the same time warming conditions will increase the energy and equipment costs of making a cubic metre of snow. Different resorts will be limited by different factors: water supply; high energy cost or limited supply; or just the high operating cost of making snow in unfavourable conditions relative to the willingness or ability of visitors to pay. This is likely to leave one or two better positioned resorts still viable from making snow after the others no longer are. These resorts will also benefit from having less competition – visitors seeking snow sports and related activities will be drawn to those remaining sites.

The challenges facing snow related activities may well be offset by an upswing in green season activities and visitation. These will be more economically challenging than snow based activities. They will not be strongly focused on the elevated resorts but will be spread across many locations in the region. Spending per visitor per day is typically lower, and likely to remain so. The higher resort areas may have an advantage in being cooler than surrounding towns, adding to their appeal in a hotter world. However, the season for this particular attraction may be as short as, or shorter than, the current white season, making economic viability for commercial investments a challenge.

Adaptation can reduce the economic costs of climate change and the impacts on people, communities and, to a lesser extent, the culture of the region. However, even with successful snow making or an increase in green season visitation, the setting of the resorts will change dramatically. Snow covered vistas across the region will initially be much diminished and eventually all but gone, with the patches of white largely confined to those created by machines, some even covered by a roof. The native flora will be stressed and some species lost, changing the character of the area. Fires, burning more often, more fiercely and over a longer period each decade will consume water and leave their burnt scars over larger areas. Many species will not recover, adding further to the change. The more frequently burned landscape will be susceptible to the increasingly intense but less frequent rainfalls that add erosion scars to the burned vegetation. Many of the natural values will be lost. Adaptation will not save them.

For the alpine resorts the transition from the current situation to the future condition will depend in large part on the effectiveness of adaptation action. This will arise from a combination of the imagination and motivation of the participants, their access to resources and the effectiveness of governance arrangements to coordinate and implement the actions required. The dashboards presented for each resort are displayed showing the expected outcome if adaptation is fully effective. Below is a table presenting a summary of the main outcomes for each resort, for two time periods: the 2020s and beyond 2050 comparing those findings with the outcome if adaptation is totally ineffective. In

practice neither 'perfect adaptation' nor 'total failure to adapt' are likely to occur, but this serves to highlight the degree of benefit of effective adaptation. The reliability of projections beyond 2050 can be questioned given the many uncertainties about technology, energy costs and social preferences that will emerge over the next 30 years.

FIGURE 36. SUMMARY OF VULNERABILITY RESULTS BY RESORT – MAXIMUM ADAPTATION EFFECTIVENESS

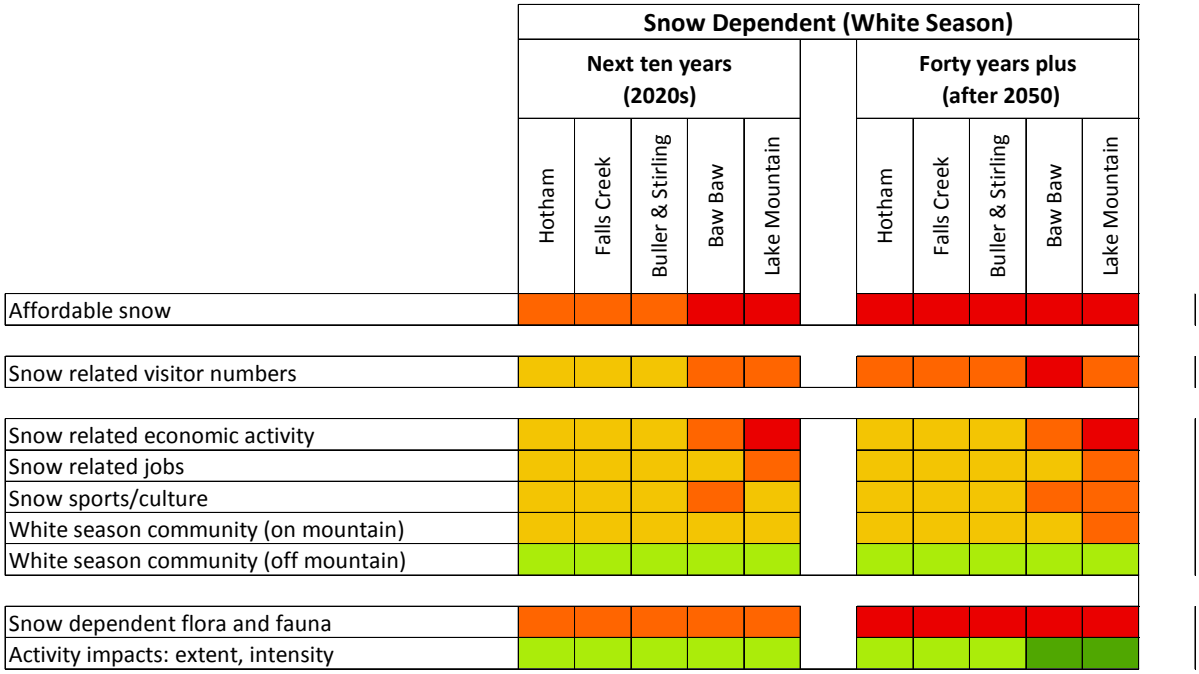
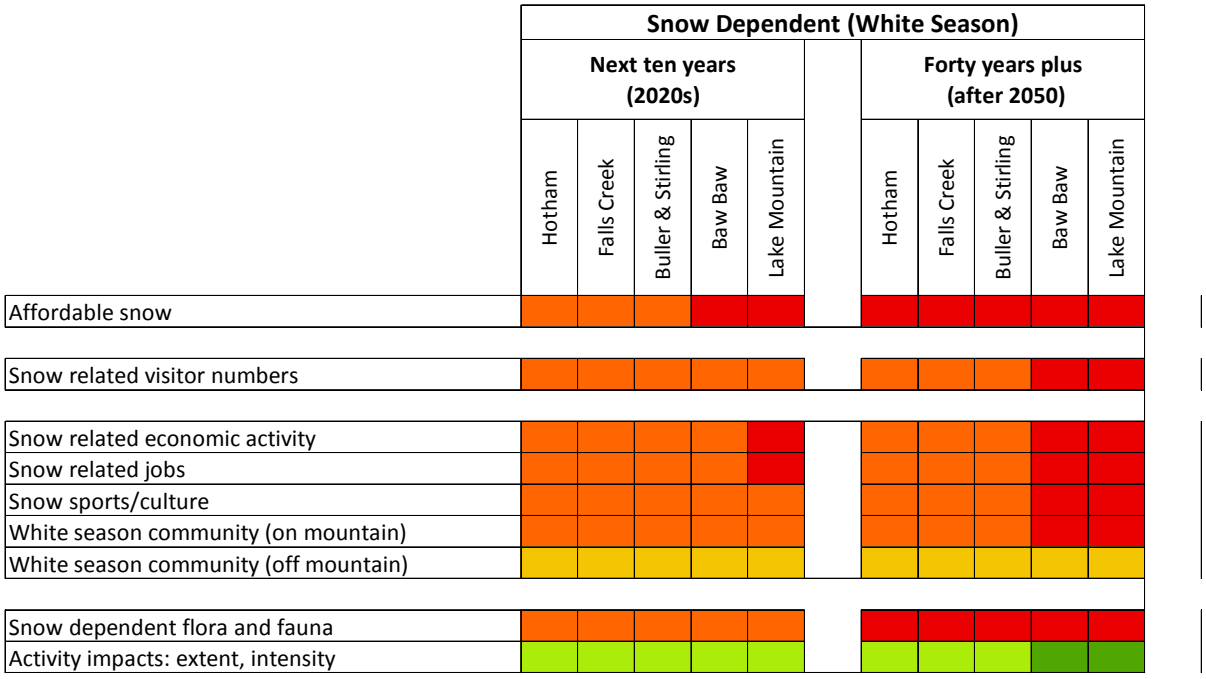


FIGURE 37. SUMMARY OF VULNERABILITY RESULTS BY RESORT – NO ADAPTATION EFFECTIVENESS



This report notes – and it bears repeating – that the trajectory of climate change for the next 20 years or so is now largely set, but the extent of climate change over the longer term can still be influenced substantially. Outcomes shown for 2050 are only a stepping stone along the way to even more extreme conditions if global emissions continue on a 'business as usual' basis. If the global community can reach, and preferably exceed, the Paris Agreement targets and keep global temperature rise to about 1.5 degrees C, then the conditions of the 2040s may be close to the warmest long term conditions. This may just allow snow sports to continue at the higher resorts, other conditions permitting, and supplementing modest amounts of natural snow with snow making leading to a sustainable snow culture in the alpine region.

4 APPENDIX A

The dashboard visualisation uses inputs to display a colour representation of the vulnerability of different forces and values to direct and indirect effects of climate change. Vulnerability is taken as the product of exposure (likelihood) and sensitivity (degree of impact expected), reduced by adaptive capacity.

Behind the coloured representation, input values are represented by numbers from 1 to 5. The product of exposure and sensitivity thus results in a number from 1 to 25. Taking the square root brings this back again to a number ranging from 1 to 5, as displayed with a corresponding colour.

The adaptive capacity is a measure of how well the vulnerability can be tempered. Some effects are simply not able to be addressed by adaptation: for example, we cannot restore natural snowfall if it declines under climate change (snow making is addressed separately). On the other hand, in the realm of economic activity, and social and community values we generally have much more flexibility to respond. Adaptive capacity can reduce exposure (e.g. moving out of harm's way) or sensitivity (e.g. making structures more fire resistant).

Adaptive capacity is given a value from 1 to 5, and this is used to modify the product of exposure and sensitivity. Total adaptive capacity reduces vulnerability to zero while total lack of adaptive capacity leaves the calculated value of vulnerability unchanged.

The final factor is one of effectiveness. While there may be capacity to adapt, it may not be successfully implemented. Fully effective implementation gives adaptive capacity full effect, whereas reducing effectiveness adjusts to a lower value, potentially to zero, leaving the full vulnerability exposed.
The formula used in the vulnerability column is the same in (almost) every instance. It is:

$$Vulnerability = \left(\sqrt{exposure \times sensitivity} - 1\right) \times \left(1 - (1 - effectiveness) \times \left(1 - \frac{(adapt\ capy - 1)}{4}\right)\right) + 1$$

Where:

- Exposure, value from 1 (negligible) to 5 (nearly certain)
- Sensitivity, value from 1 (totally insensitive) to 5 (highly sensitive)
- Adaptive capacity, value from 1 (capable of adapting to eliminate vulnerability) to 5 (incapable of any adaptation)
- Effectiveness, value from 0 (fully effective) to 1 (fully ineffective)

The exceptions to this formula occur where:

- adaptive capacity is not assessed as it is included in previous rows (Affordable snow, Snow related visitor numbers). The formula simplifies to

$$Vulnerability = \left(\sqrt{exposure \times sensitivity}\right)$$

- The impacts of two values for activity impacts are aggregated. The formula here is:

$$Vulnerability\ (extent, intensity) = \left(\sqrt{vulnerability\ (extent) \times vulnerability(intensity}\right)$$

Some cells, for exposure, sensitivity or adaptive capacity, do not permit user input. These fall into two categories:

1. Default values. These are assumed to be consistent with those set in other cells. Unless explicitly mentioned in the text, the default assumption is that sensitivity and adaptive capacity may not vary significantly over time. In this case the value set for the 2020s time period is used in later periods without modification.
2. Outcome dependencies. These calculations provide a rough model of the relationships between major components of the system. They are not refined enough to provide realistic quantitative results, but act to flag and ensure dependencies between elements show up and are treated with some consistency. Certain exposures are assumed to be related to vulnerabilities calculated in rows above for the same time period, (or in one case, face the same exposures). These include:

$$Exposure\ (affordable\ snow) = \left(\sqrt{maximim(vuln\ water\ for\ snow, vuln\ energy, vuln\ snow\ making\ conditions) \times vuln\ natural\ snow}\right)$$

$$Exposure\ (lifts) = Vuln\ affordable\ snow$$

$$Exposure\ (snow\ related\ visitor\ numbers) = \left(\sqrt[3]{max(vuln\ lifts, roads\ with\ snow, accommodation)\ \times\ vuln\ competitive\ position\ \times\ vuln\ affordable\ snow}\right)$$

$$Exposure\ (snow\ related\ economic\ activity) = Vuln\ snow\ related\ visitor\ numbers$$

$$Exposure\ (snow\ related\ jobs) = Vuln\ snow\ related\ economic\ activity$$

$$Exposure\ (snow\ sports/culture) = Vuln\ snow\ related\ visitor\ numbers$$

$$Exposure\ (white\ season\ community\ (on\ mountain)) = Vuln\ snow\ related\ visitor\ numbers$$

$$Exposure\ (white\ season\ community\ (off\ mountain, Lake\ Mountain, Baw\ Baw)) = (Vuln\ snow\ related\ visitor\ numbers - 1)\ \times .25 + 1$$

$$Exposure\ \big(white\ season\ community\ (off\ mountain, Hotham, Falls\ Creek, Buller)\big) = (Vuln\ snow\ related\ visitor\ numbers - 1)\ \times .5 + 1$$

$$Exposure\ (snow\ dependent\ flora\ and\ fauna = Exposure\ (natural\ snow)$$

$$Exposure\ (impact\ of\ snow\ activities, extent) = 5 - Vuln\ Snow\ related\ visitor\ numbers$$

$$Exposure\ (impact\ of\ snow\ activities, intensity) = \left(\sqrt{(5 - Vuln\ Snow\ related\ visitor\ numbers) \times (5 - Vuln\ affordable\ snow}\right)$$

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