The Future Impacts of Climate Change

Broadland Futures Initiative

Contents

Cover image © Mike Page

1. Introduction

The **Broadland Futures Initiative (BFI)** is a partnership for future flood risk management in the Broadland area. Our main goal is to agree a plan for future flood risk management that better copes with changing climate and rising sea level (see later pages for project information). The focus will be on what will happen from the mid-2020s onwards, however we need to start planning now to secure support and make well-informed decisions.

This document aims to inform all of us who live and work in the plan area, and those who simply enjoy visiting, about the **changes in climate** which we have already experienced, those changes which we are likely to see in the coming decades and what is being done and planned to help adapt to these changes. The **BFI plan area** includes the full extent of the Broads Authority executive area and key stretches of the coast which could influence flooding in the Broads, together with Great Yarmouth. The plan area is predominantly in east Norfolk but also crosses into north east Suffolk. These are all desirable places to live, work and visit, where the special qualities are strongly interconnected (e.g. environment supporting tourism). They are also influenced by existing flood risk management with much to gain through early adaptation to climate change.

> There is a growing sense of unity about how people can adapt to meet challenges, and seize the opportunities, of climate change. A plan for flood risk management offers an opportunity to continue this momentum and partner together for success.

This document provides **specific details** on how temperature, rainfall and sea level are expected to change, and what this could mean for flood risk. The BFI partnership is focussed on managing future flood risk. However, this document takes a **broader view** on how our climate may affect our lives so we can see how managing flooding fits in. It explores the potential impacts and opportunities of our climate to **aspects of our everyday lives**, including health & wellbeing, biodiversity and water.

Because much of what exists and happens in the BFI area is connected, flood risk management has a role in shaping and supporting **adaptation**. The BFI plan will help our places become more resilient to flood risk, where communities are not just aware of the risks but involved in adapting to the changes. The plan will support local growth which can be sustained within the changing environment.

Breydon Water Saltmarsh © Jeremy Halls

We begin in section 2 by looking at how potentially changing our approach to flood risk management through the BFI plan could help us **adapt and thrive in a changing climate**.

BFI plan area. The figure contains OS data © Crown copyright [and database right] 2020.

2. Flood risk management in a changing climate

Our places can be resilient to flood risk

The BFI plan area is well recognised for its sense of "place"; the connection between people and places, the past and the present. Improving the resilience of our places to climate change is not just avoiding risks and dealing with challenges, it is about adapting our places and lives to take advantage of the coming opportunities. Creating places which are resilient to climate change will require **working across organisational and geographical boundaries**, considering whole river catchments and the coast to deliver a wide range of actions to manage flooding and coastal change. Therefore, the BFI partnership will continue as a collaboration between the Environment Agency, Broads Authority, Norfolk and Suffolk County Councils, Internal Drainage Boards, Natural England, National Farmers Union, RSPB and Water Resources East to focus on fluvial and tidal flooding as the greatest flood risk in the area. However, the plan will also support management of coastal, surface water and any groundwater flood risk.

> Resilience is about our lives being lived and planned comfortably alongside the changing climate.

Appropriate actions can be taken at the sources of flooding (e.g. storing rainfall in the headwaters), along the network of rivers, broads and surface water flow paths, and in the wildlife habitats, communities and infrastructure at risk. With a plan area that includes the coast, actions between Eccles and Winterton can complement actions inland, so that we **join up our approach** to flood risk management. Planning across whole catchments provides the best opportunity for integrating nature-based solutions, which contribute to a better state of the natural environment than we have today.

As a BFI partnership, we need your help to work out the details (see possible actions in section 7). We anticipate a mix of engineering (i.e. structures) and non-engineering (e.g. flood warning) actions to fully manage flooding. However, engineering actions should be **as nature-based as possible** so that we work with natural processes (more detail in section 6), such as recently demonstrated through the sandscaping work at Bacton. This mixed approach will have actions that manage risk to whole areas and communities through larger schemes where appropriate. It will also improve the resilience of individual buildings and assets in other areas. The plan will address risks posed by frequent as well as potentially deeper flooding plus seek to manage saline incursions which can kill fish and impact agricultural land, and flooding by water that is of poor quality due to high nutrient and sediment content.

Beach recharge at Bacton © Hugh Venables www.geograph.org.uk

Our communities can be aware and involved

Communities are the people living, working in, and visiting the area. They include businesses and supporting infrastructure, and the natural and cultural environments which make the area unique.

Building communities which are resilient to climate change requires people to be kept **informed, motivated and able to respond** when required. When agencies plan responses before, during and after flood incidents they rely on the most up-to-date information. In this way, resources and assistance required by communities can be provided where and when they are needed. As the BFI plan develops, we will continue to provide you with the best available information through a variety of means (including online exhibitions when face-to-face events cannot be held), and to empower people where actions are best taken locally.

A key outcome of the plan is to achieve an agreed level of resilience to flood risk and where you as the communities, businesses and stewards of the environment, heritage and culture have had a say in producing the plan. The overall approach to flood risk management can be adaptive, i.e. to **plan now, so that we are best placed to adapt** as the climate changes. Many of the actions required, at least initially, may be relatively small and implemented in stages. This enables us to seek actions which are the best fit for each place but which, together, give a unified response.

This approach also enables funding to recognise, as far as possible, the range of benefits that flood risk management provides (e.g. heritage assets as well as homes) and capture these to build the business case for action. Contributions from those benefitting from flood risk management actions will be sought where government funding is not sufficient. This could be in the form of monetary contributions, or giving time and skills. The partnership wants to be **fair in how flood risk management responses are justified and paid for**.

Hunter's Yard, Ludham © Jeremy Halls

We can support sustainable growth

Norfolk and Suffolk have a diverse economy, and there are ambitious plans for growth in and around the plan area. Well-managed flood risk can **inspire confident investment and job creation** which supports sustainable growth. In particular, biodiversity is locally, nationally and internationally important and one of the key foundations for continued sustainable growth. The BFI plan could help plants and animals adapt to climate change, by supporting habitats required by existing and new species, and recognising that other species may need help relocating to more suitable environments.

Field in Brundall © Jeremy Halls

The plan can manage flood risk in line with our changing nature and support others to act sustainably. For example, livestock raising is an important local agriculture and grazing the marshes could be relatively resilient to climate change. The plan could support farmers to use land and choose crops which thrive in our future environment, continuing to supply the products we need in our lives (e.g. food, building materials and energy), whilst managing flood risk more naturally through working with natural processes. New and existing buildings and infrastructure can be more resilient, not just to flooding but to high temperatures, minimising water and power use, for example. Wider community infrastructure (e.g. transport, utilities) must also become more resilient. BFI planning, including on how land could be used, will be informed by the best up-to-date information.

Whilst the risk of both flooding and drought will increase in the future, it is possible to **store more water in times of surplus and use it more efficiently**. This requires more investment, from domestic water butts to large-scale schemes. Access to the water environment in rivers, broads and at the coast remains important, including for the recreational and tourism industries, boating and angling. Warmer, longer summers could give more tourism opportunities. The BFI plan could **support recreation** by seeking as few water and erosion control structures in the rivers and sea as possible.

Timing is important. An adaptive approach prepares us for taking actions ahead of flood risk changing. We have an opportunity now to prepare for changes that may occur more rapidly in the future.

Finally, the BFI plan could deliver adaptive flood risk management which does not further exacerbate climate change by emitting more carbon than it can lock away. Achieving these **'net zero' goals** of government, organisations and communities helps motivate good decisions between possible approaches. This also steers us towards nature-based solutions that work with natural processes and values the opportunity for lower emissions, carbon storage, and water storage. Having a plan which is adaptive, means that **action is taken at the appropriate time**, when evidence from the changing environment suggests that the next step in investment is required. The plan will consider a range of scenarios, about how fast and by how much our climate may change, so that we can transition and adapt to the impacts of climate change that actually occur. The following section summarises the currently available information on how the climate may change.

3. How our climate is changing

Past, present and future

The landscape and culture of the Broadland area has long been shaped by environmental and climate change. Evidence from observations shows that the climate and, in particular, air and sea temperature, rainfall and sea level has **changed rapidly within the last 30 years**. This may already be evident as we see the timing of natural events change, such as the flowering of plants and the growing of plants and crops (e.g. grapes) previously seen only in warmer regions. Changes to our climate are anticipated to continue at an unprecedented rate, which will lead to increasing changes in our seasonal weather. These changes will impact flood risk management within the plan area, but adapting to the changes means we can be resilient to them and seize the opportunities.

> Winters will be warmer and wetter, summers will be hotter and drier and sea level will continue to rise

The Met Office's latest assessment of how the climate will change confirms that winters in the future will be warmer and wetter, summers will be hotter and drier and sea level will continue to rise. How rapidly, and to what extent, these changes occur depend on the success of global efforts to reduce greenhouse gas emissions (e.g. carbon dioxide and methane). Four future scenarios are used to describe these ongoing emissions and potential changes, ranging from one where emissions are severely reduced through to one representing very high greenhouse gas emissions. This high emission scenario currently describes our world if it continues with 'business as usual'. A range of computer models are used to estimate how the climate of the UK, including our study area, will change in these possible future scenarios. Although there are differences between the results of the different models, these are small compared with the consistency of the trends. The following pages present some of the main findings from the average of these different model results which are relevant to flood risk in the BFI plan area.

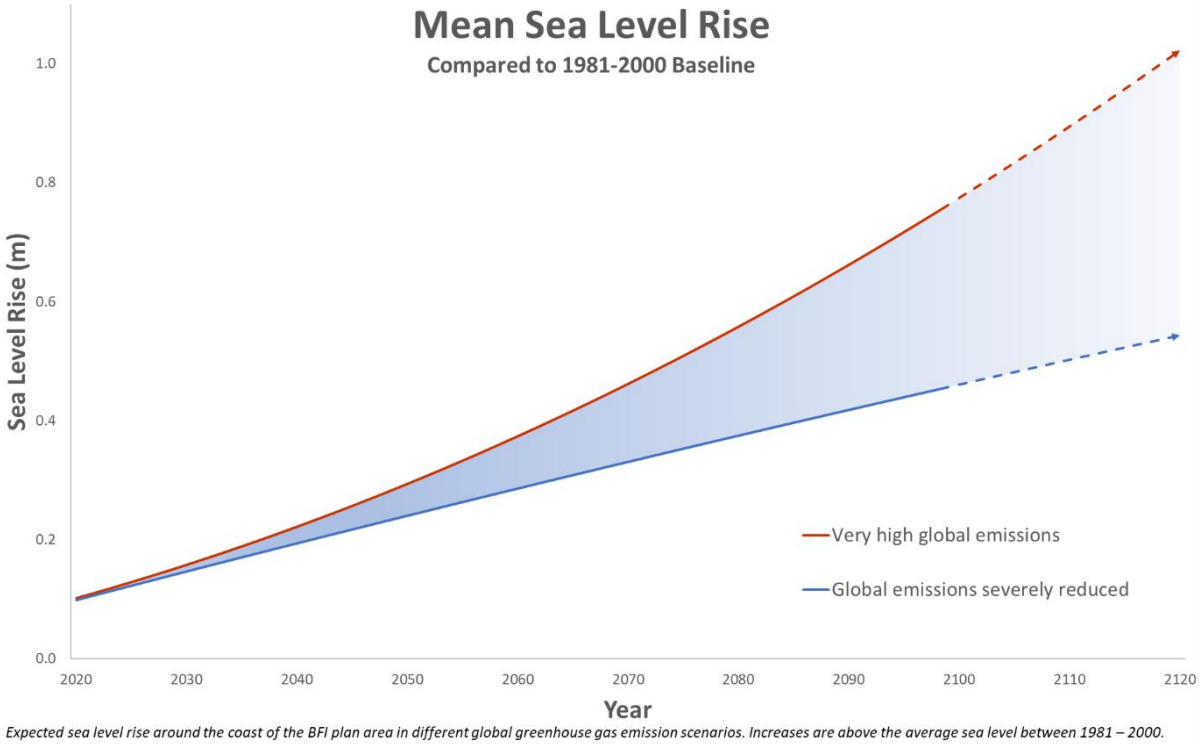
Annual sea-blite – Sueada maritima © Jeremy Halls

Sea level is rising

Sea level has already risen around the UK coast by about 0.16 m since 1900, and will rise more rapidly through the 100 year period of the BFI Plan, and beyond. If we look out to sea on a calm day in 20 years' time, the level is likely to have risen by between 0.19-0.22 m, compared with average levels between 1981-2000. In 50 years' time, the sea is expected to be 0.33-0.46 m higher and, in **100 years' time is anticipated to be 0.54-1.02 m higher**. It is also possible that we need to prepare for an upper level estimate of sea level rise of up to 1.5 m by the end of the plan period. As **most of the land in the plan area is low lying**, a rise in mean sea level of around a metre would make more land much harder to drain on a daily basis.

November 2007 surge in Reedham © BESL

Storms like Ciara and Dennis, and the storm surge which could have caused significant flooding along our coast in January 2017, remind us that the impacts of sea level rise are likely to be most apparent during **storm events rather than in calm conditions**. Even though there is uncertainty whether the weather patterns which cause tidal surges will become more common, the risk of coastal flooding will increase because any given tidal surge will occur on top of a higher sea level. Increasing risk comprises not just the potential for damage but how frequently it could occur. For example, at the mouth of the River Yare, a peak storm level which is only likely to occur with a 0.1% chance in any year today, could be 30 times more likely to occur (i.e. an annual chance of 3%) when sea levels have risen by a metre.



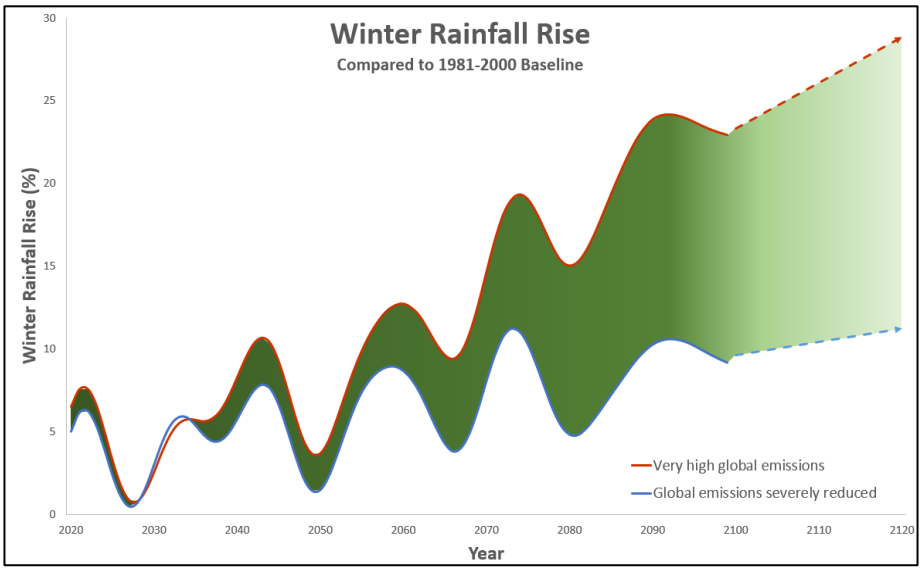
Expected sea level rise around the coast of the BFI plan area in different global greenhouse gas emission scenarios. Increases are above the average sea level between 1981 – 2000. The dashed lines go beyond the available Met Office projections to indicate how trends can continue.

Rainfall patterns are changing

The total amount of rain falling in any year is expected to decrease slightly in the next 100 years. However, seasonal patterns of rainfall will become more pronounced, with total **rainfall substantially increasing in winter and decreasing in summer**. In both seasons, it is expected to rain less often but when it does it will **rain with greater intensity**. Particularly in our urban areas (e.g. Great Yarmouth), a greater intensity of rainfall could mean more surface water flooding.

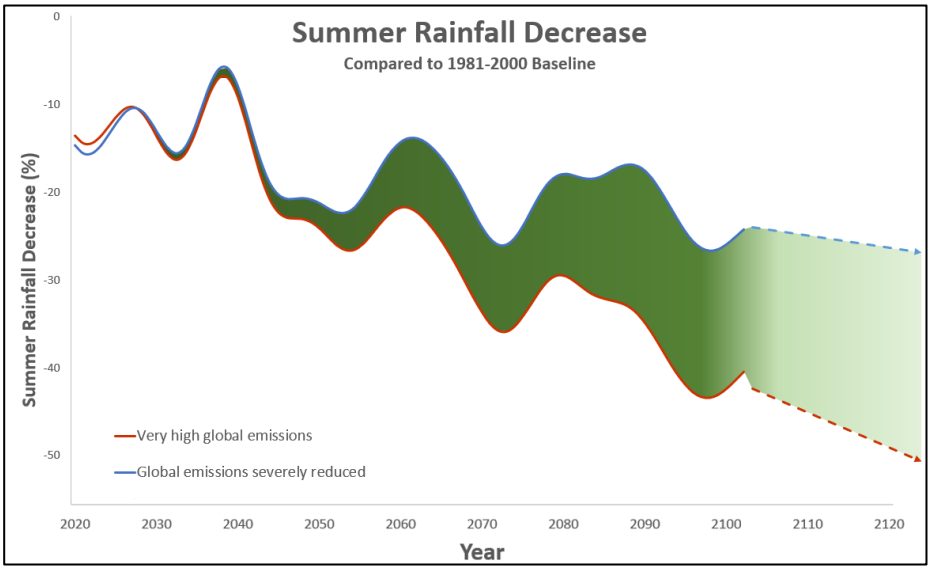
Winters in 20 years' time are expected to have 5-7% more rainfall, in 50 years' time 7-15% more and, in 100 years' time, 11-29% more than used to fall in winters between 1981 and 2000. Summers, on the other hand, will likely have 15-18% less rainfall in 20 years' time, 20-30% less in 50 years' time and **27-51% less in 100 years' time**, compared with 1981-2000.

It is possible that even greater changes in rainfall patterns could occur. However, even the minimum expected changes of 11% more rainfall in winter and 27% less rainfall in summer will require **significant changes to how water is managed**. For example, it is possible that river flows in winter will increase by 20%, whereas flows in summer will decrease by 40%, with implications for the likelihood of flooding and water available for irrigation, for example.



Expected rise in winter rainfall (left) and decrease in summer rainfall (below) across the BFI plan area in different global greenhouse gas emission scenarios. Variations are relative to the average seasonal rainfall between 1981 – 2000. The dashed lines go beyond the available Met Office projections, indicating how trends can continue.

The oscillations clearly evident in the future projections of rainfall are the result of processes such as global ocean circulation which vary on the scale of decades. The pattern of oscillations depends on the climate model. To minimize the uncertainty, the charts present results from a range of climate projections.

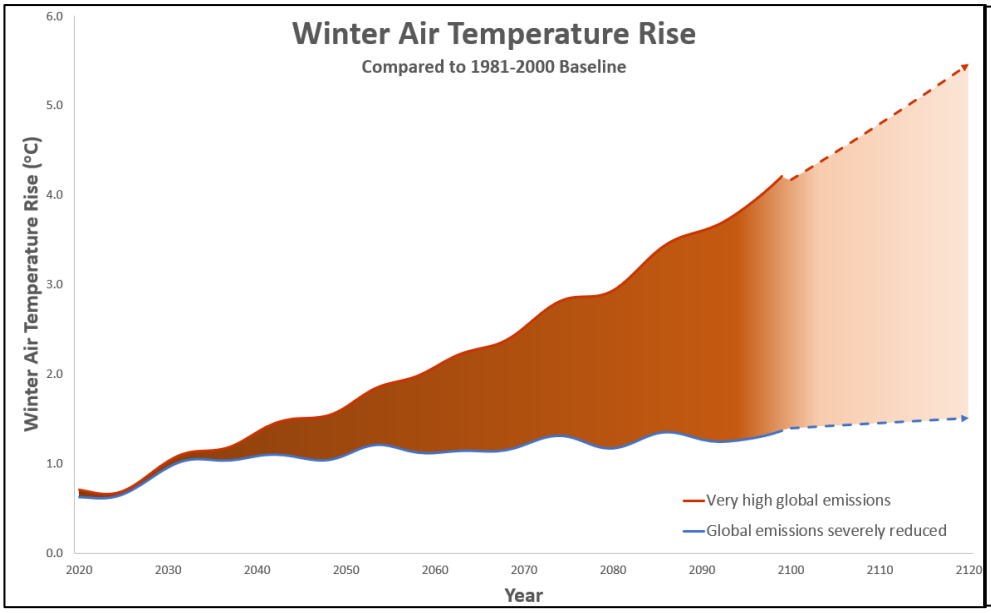


Air temperature is increasing

Our local air temperatures may change differently to global temperatures, which are driving climate change. It is expected that **air temperatures in both winter and summer will continue to increase** until at least 2120.

Average winter temperatures in 20 years' time will likely be 1.0-1.3° C higher, in 50 years' time they will be 1.2-2.5°C higher and in 100 years' time they will be 1.5-5.5° C higher than was typical in winters between 1981 and 2000. Summer temperatures in 20 years' time are expected to be 1.4-1.6°C higher, in 50 years' time 1.6-3.3°C higher and, in 100 years' time, average **summer temperatures could be 1.9-7.5°C higher** than they were in 1981-2000.

Although some of these average increases may at first appear modest, hot spells where maximum daytime temperatures exceed 30°C for two or more consecutive days will increase, and later in this century could occur up to four times per year, rather than once every 4 years as used to happen between 1981 and 2000.



Expected rise in winter (left) and summer (below) air temperatures in different global greenhouse gas emission scenarios. Increases are above the average seasonal temperatures between 1981 – 2000. The dashed lines go beyond the available Met Office projections, indicating how trends could continue.

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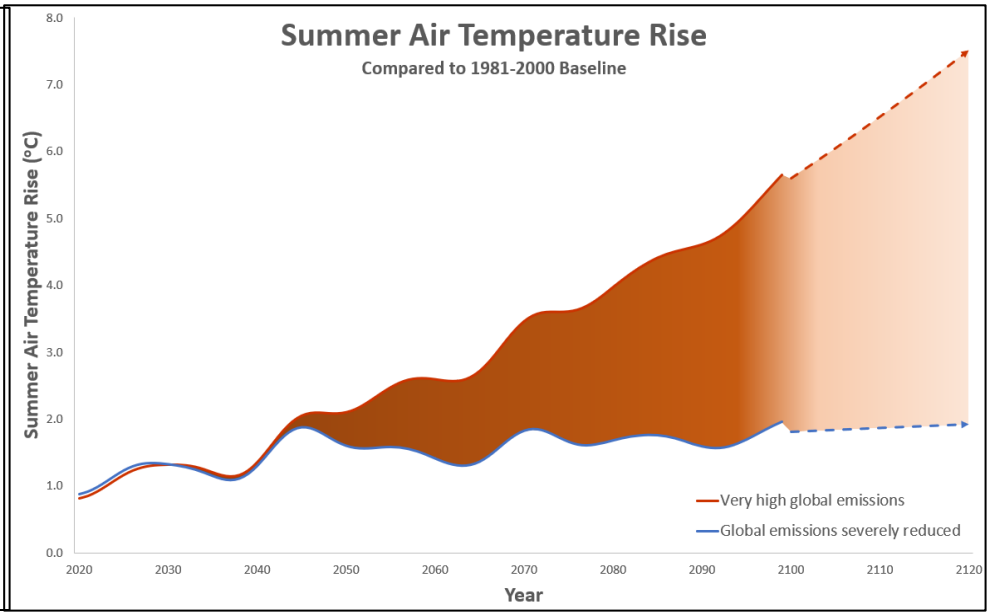


4. How could our climate affect flood risk?

Introduction

The BFI plan area is affected by flooding in different ways, from the approximately 60% which is below today's mean sea level and unable to drain by gravity, to the higher ground which is at risk in storm surges, river and surface water floods. Land nearer the coast can also be impacted by extreme waves and breaches in sand dunes or structures. Flood waters can be deep, fast flowing and saline, and events can occur frequently, allowing little time for recovery. Rising sea level and more intense rainfall could affect all of these and possibly introduce additional issues like groundwater rising nearer to the land surface. The following pages interpret how the climate described in section 3 could influence future flood risk.

Land at or below mean sea level

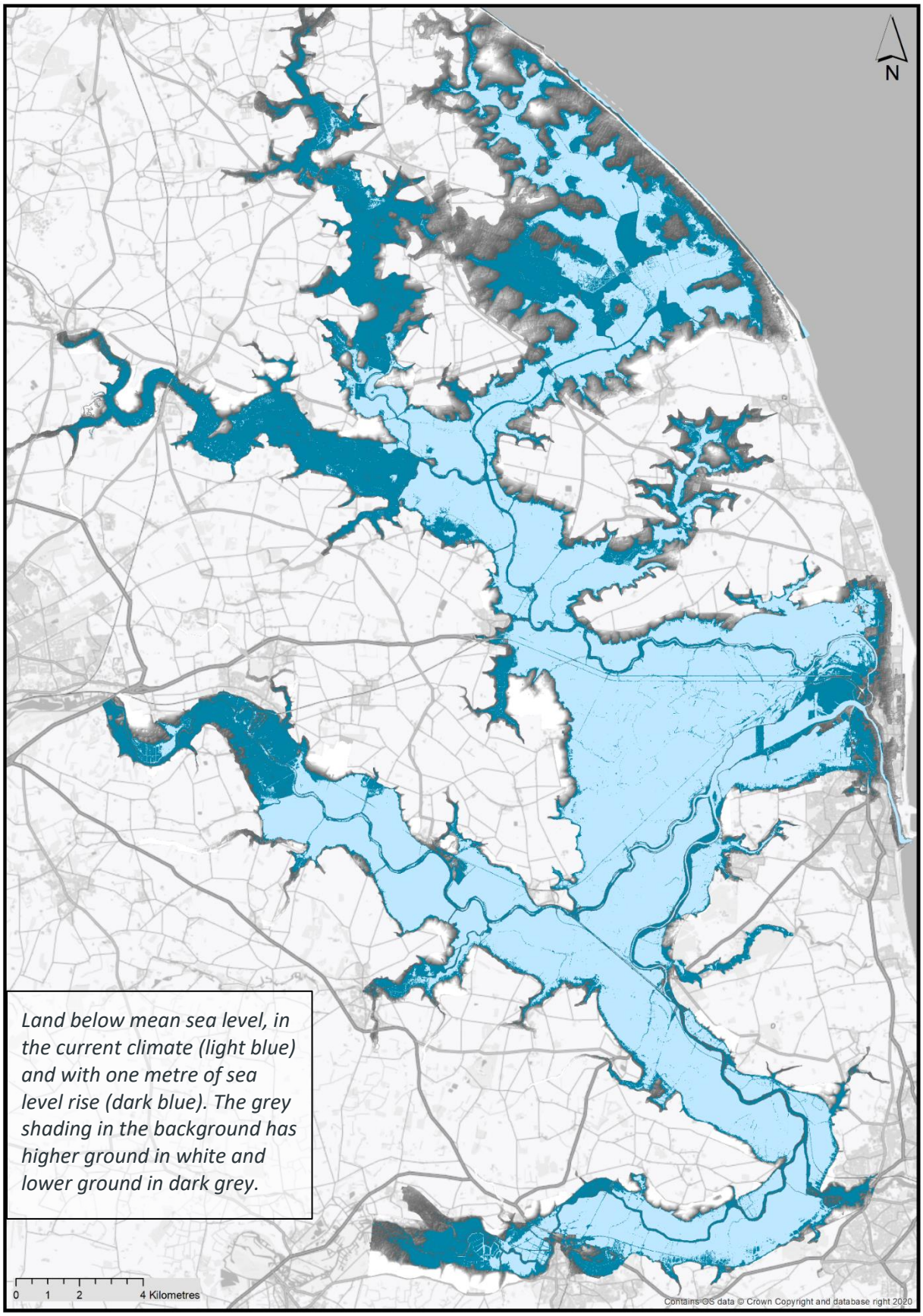
If the sea level rises by one metre by the end of the plan period, 75% of land in the plan area could be below this level.

The land currently at or below mean sea level mainly lies within areas where flooding is managed by risk management structures, i.e. walls, embankments, ditches and pumps. The map on the following page shows how this pattern of land at or below mean sea level could change as sea level rises by one metre, from light blue now to dark blue in the future. The map does not suggest that this land will be permanently wet, in the same way that not all low lying land is at the moment. However, more **infrastructure will be required if these larger areas are to be kept dry**. It is also possible that long-term land drainage may lower some land levels (e.g. peat) which would make the situation worse.

The transition between the two blue areas will occur gradually through the 100 year period of the BFI plan. When sea level has risen by 0.5 m (which could occur as early as 2070 or as late as 2120), the additional land below mean sea level will still be largely within areas already served by various structures. However, some areas along the upper Ant, and the Bure to Hoveton, could be below the raised sea level.

Langley pumping station © Peter Doktor

By the time sea level rises by 1.0 m, which could occur by 2120, **most of the land currently behind flood risk management structures, as well as the majority of the floodplains of the Ant, Bure, Yare and Waveney in the plan area, will be below sea level**.



Land below mean sea level, in the current climate (light blue) and with one metre of sea level rise (dark blue). The grey shading in the background has higher ground in white and lower ground in dark grey.

Land at risk in flood incidents

As well as rising sea level making regular drainage from low lying land and watercourses more difficult, the increase in high tide levels and intensity of rainfall-runoff into rivers, all increase the risk of flooding incidents.

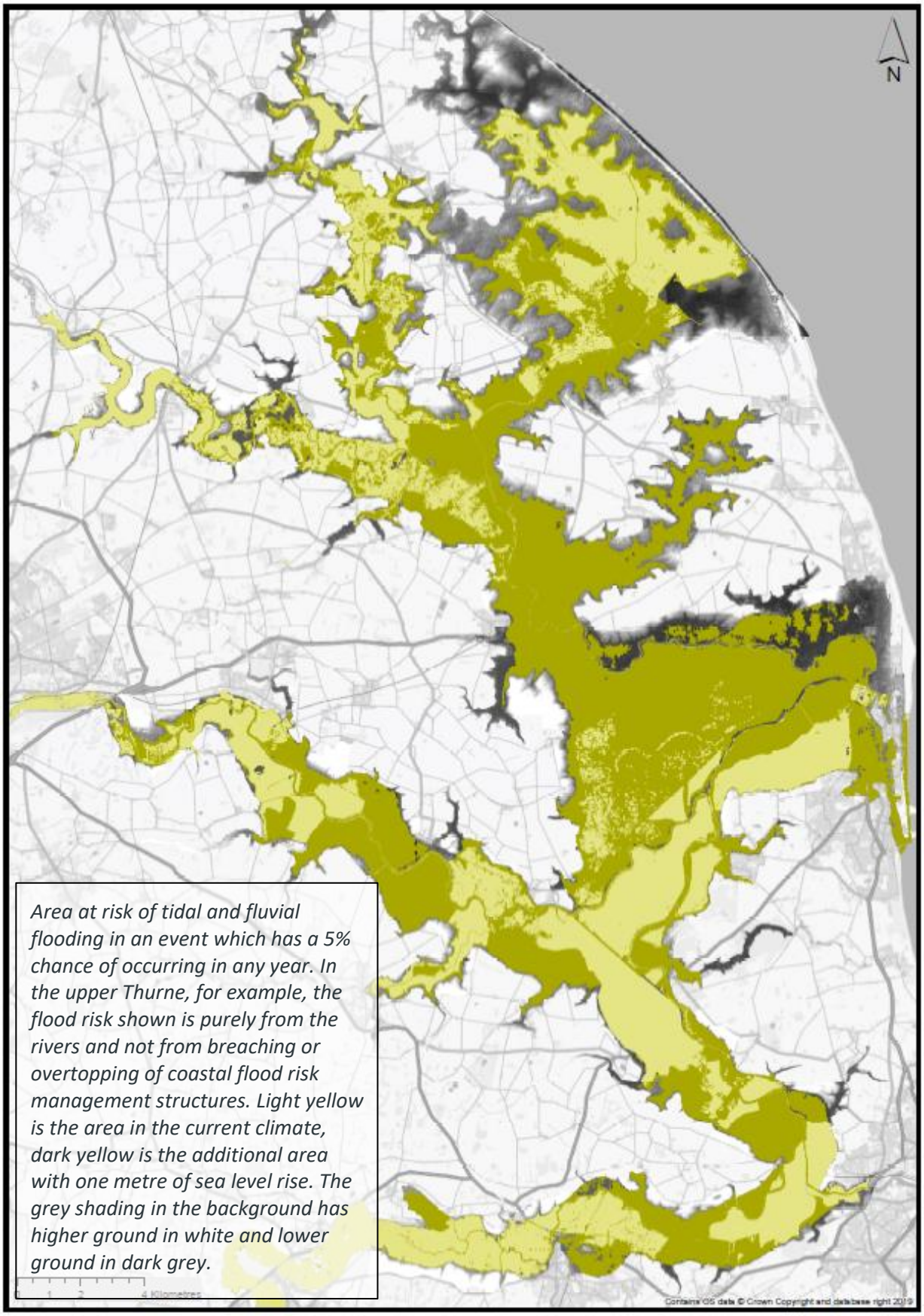
The map on the following page shows in light yellow that approximately 30% of the BFI plan area is *currently* at risk of tidal and/or fluvial flooding during an incident which has a 5% chance of occurring in any year. This map does not suggest that the whole light yellow area shown would be flooded at the same time but that any location in this area is at risk of flooding. The same map also shows in dark yellow how this 'at risk' area could expand to cover 70% of the plan area, when sea level has risen by one metre and river flows have increased by 20%. This increase is anticipated even with the existing infrastructure continuing to operate.

> One metre of sea level rise and 20% increases in flood flows in rivers would put the majority of land in the floodplains of the Ant, Bure, Yare and Waveney in the plan area at higher risk of flooding.

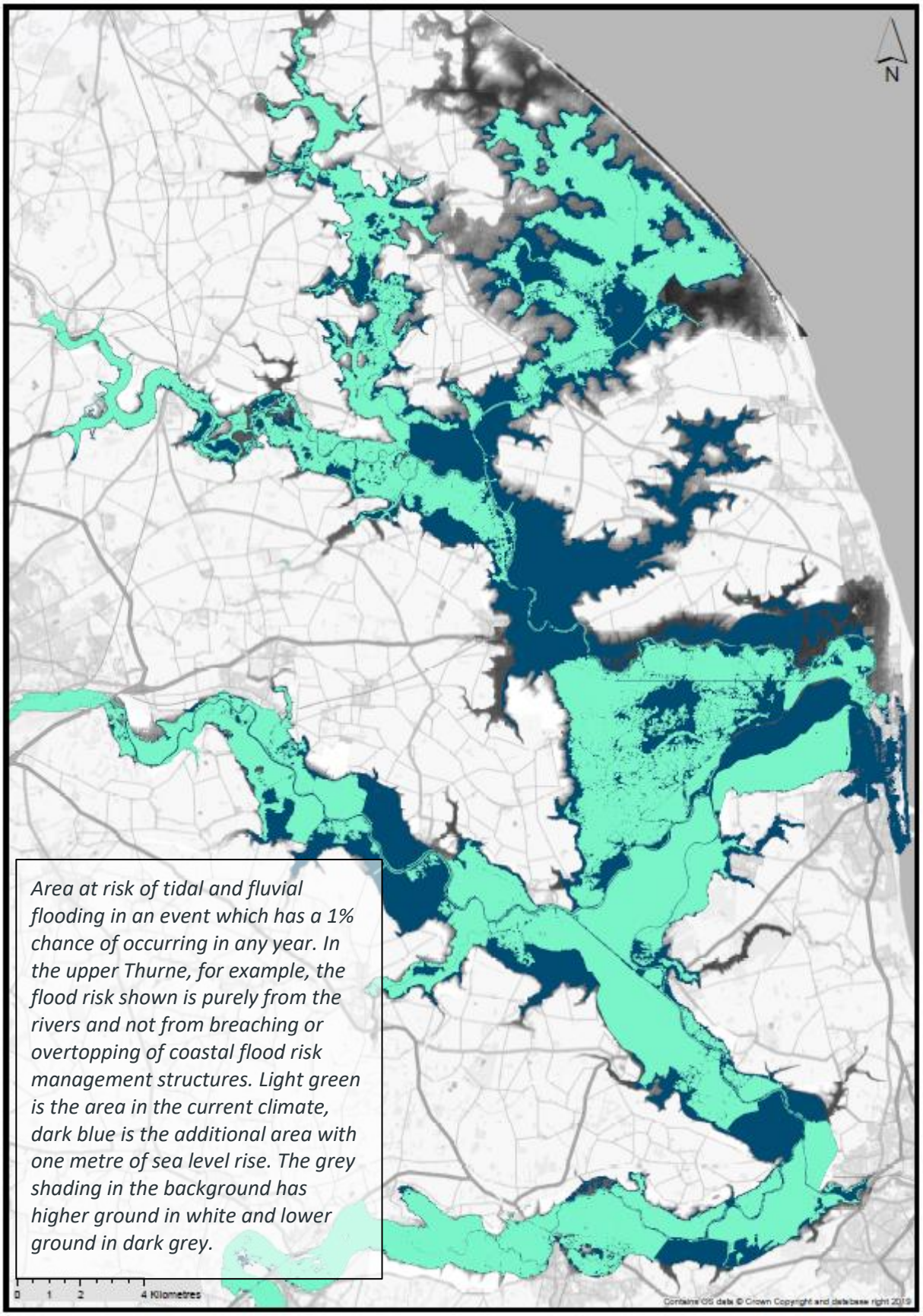
The second map shows a similar comparison, this time for a fluvial and/or tidal incident which has a 1% chance of occurring in any year. During this rarer incident, the current extent of risk in light green is 40% of the plan area, but this will expand to cover 70% of the plan area with one metre of sea level rise, as shown in dark blue.

By 2120 it is possible that **the majority (70%) of the BFI plan area is at risk of flooding** in fluvial and/or tidal incidents which have a 5% or less chance of occurring in any year. It is only the ground levels of the plan area rising towards the edges of the floodplain, which keeps area at risk of flooding from expanding further.

Haddiscoe Cut Overtopping November 2007 © Jeremy Halls



Area at risk of tidal and fluvial flooding in an event which has a 5% chance of occurring in any year. In the upper Thurne, for example, the flood risk shown is purely from the rivers and not from breaching or overtopping of coastal flood risk management structures. Light yellow is the area in the current climate, dark yellow is the additional area with one metre of sea level rise. The grey shading in the background has higher ground in white and lower ground in dark grey.



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Coastal change could accelerate

The maps on the previous pages have demonstrated that the extent and depth of flood incidents will increase with climate change. The frequency with which we could see flooding to a certain level will also increase. For example, an extreme coastal storm, with an annual chance of 0.1% in today's climate, could generate a peak sea level of about 4 m at Great Yarmouth. This same peak sea level could occur approximately 30 times more frequently (i.e. annual chance of 3%) when sea level has risen by one metre.

Therefore, whether we consider the same frequency incidents becoming larger in magnitude, or the same magnitude incidents occurring more frequently, **higher sea levels will mean storms have a greater impact on the coast and adjacent land**. The general trend for erosion along the coast between Eccles to Winterton is likely to continue, and possibly accelerate as sea level rises. If the current approach to protection along this frontage (and in other areas) is continued, risk management structures will need to be stronger and higher, increasing costs and other impacts.

Saline incursions can extend far inland during surge tides and have caused substantial fish death (e.g. November 2007 and December 2013) and damage to biodiversity and agriculture. More work is needed to understand to what extent climate change will mean surge tides push saline water further up the rivers. Similarly, further understanding is required on how groundwater levels and salinity across the study area could change with climate and what implications this may have for land drainage.

Cliffs eroding south of Happisburgh © Evelyn Symak www.geograph.org.uk

5. How else could climate change affect us?

Agriculture and land use

Farming has long shaped and managed the landscape of the plan area, and plays a significant role in terms of food production and employment. The weather influences every decision a farmer or grower takes. Climate change has the potential to impact farming and dependent businesses in many and complex ways.

Warmer temperatures offer opportunities for arable farming, including longer growing seasons, higher crop yields and a greater variety of crops. However, higher sea levels and more flooding with saline water could damage crops and reduce yields by reducing soil quality. Warmer summers will also result in drier soil which is more susceptible to erosion in intense rainfall. Crops will require more irrigation, putting further pressure on water resources.

> "Wet farming" is part of regenerative agriculture that uses wet and re-wetted peatlands productively.

One way agriculture might become more resilient to these impacts is to maximise **environmentally sensitive farming and livestock management** within the wider patchwork of agricultural activity. Reed and sedge have been harvested from the Broads fens for thatching for centuries although 90% of thatch is currently imported. Significant opportunities in the area for "Regenerative Agriculture" - farming and grazing practices that rebuild soil organic matter and restore degraded soil biodiversity – are being realised. They aim to continue to produce what we need, but using approaches more suited to the changing climate and environment. Future land use may see a greater mix of food production, biomass crops, tree planting in hedgerows and valley sides, and peat restoration, with each performing a necessary service to feed us, provide energy or capture and store carbon to mitigate climate change. The BFI plan could see how **flood risk management supports, and benefits from, different land uses**.

Cattle Grazing, Thorpe Marshes NR © Jeremy Halls

Biodiversity and the environment

The internationally and nationally designated habitats and the range of species which are either unique to the area or have their largest UK populations here, underline the importance of biodiversity. However, **climate change could alter some of the area's special characteristics**. For example, freshwater areas could be flooded more frequently, for longer, and with saline or poor quality water. These impacts could alter habitats and vegetation, which mean new species are established, whilst others may relocate, and some are in danger of being lost.

Wet woodland © Jeremy Halls

There are **opportunities for new habitats and species** particularly for birds due to their mobility. For example, the shallow lagoon and reedbed area of Hardley Flood has gradually evolved since flood management structures on the River Chet were decommissioned following the 1953 floods. Its value to wetland birds is now recognised, alongside other international sites, by its designation. Cetti's Warbler first bred in the UK in the 1970's with the population expanding in recent decades as winters have become milder. Little Egret, Spoonbill and Great White Egret have successfully bred in Norfolk, benefitting from climate and wetland environments. Some invertebrates have colonised from the near continent and further afield, including many species of moth and dragonfly. For example, breeding colonies of Willow Emerald damselfly and Lesser Emperor now breed in the plan area, with the latter being able to tolerate brackish conditions. However, similar opportunities can also be taken by invasive non-native species, which need to be appropriately managed.

Some **mobile species could adapt to the changing climate by relocating**, either within the local area, or further afield. This requires sufficient, suitable habitat which can support the populations at 'steeping stone' locations. This is particularly important for invertebrates, who are less mobile than birds. Organisations (e.g. Environment Agency, Natural England, RSPB and local Wildlife Trusts) have worked together for successful relocation of three species; fen raft spider, greater water parsnip and compressed-leaved pondweed. Any relocation out of the BFI area would mean a loss of local biodiversity, identity and special characteristics.

Swallowtail butterfly at Strumpshaw © Jeremy Halls

For some species already low in numbers and requiring specific habitats, there is a **high risk of extinction in the BFI area**, if the habitats are susceptible to climate change. For example, some species depend on good quality freshwater habitat which does not regularly flood with saline or nutrient rich water. The iconic Swallowtail butterfly is mobile but can only range around 30 miles from the Broads, where no suitable milk parsley habitat exists. The milk parsley is itself rare, and does not occur in the wider agricultural landscape. Extinction of this unique British subspecies would represent a significant biodiversity and cultural loss. The BFI Plan could consider **flood risk management opportunities that help create new, more sustainable habitats** for species, particularly those with a stronghold in the Broads.

Health and wellbeing

Our overall health and wellbeing is linked to us being comfortable with our climate, as this helps us to build the communities, economy and the lifestyle that we desire.

Warmer weather could encourage us to spend more time outside, enabling the renowned **landscapes of the coast and Broads to further support a thriving recreation and tourism industry**. Therefore, whilst we must avoid the harmful effects of heatwaves and sun damage to skin, there are recreational and tourism opportunities across the area which the BFI recognises and could support. Buildings can be adapted to provide greater cooling, including through shading, building orientation and different materials, rather than air conditioning which would mean greater demand for energy. These measures could be considered alongside methods used to construct flood resilient buildings, which could incorporate nature-based solutions (e.g. green roofs) where possible.

A serious impact of increased flooding is the heightened risk of injury and threat to life. Whilst the plan area is relatively flat, fast flowing water remains dangerous and even shallow flowing water can knock a person over, or move a car. The **trauma and stress people experience during flooding** leads to high levels of anxiety and distress. Following a flood, buildings are damp and susceptible to mould, with these being associated with up to a 50% increase in breathing related problems. Resilience can be improved through preparation, e.g. signing up for flood alert systems and having an evacuation plan.

Although the climate of south-eastern England could change to be like that of northern Spain, this does not mean regular calm, sunny conditions. **Extreme weather could occur more frequently and our infrastructure and behaviour must adapt appropriately.** For example; footpaths near to water and along embankments may be at risk of closure during and after flooding; higher water levels could limit boat navigation more regularly as clearance under bridges reduces; increased aquatic plant growth may require greater management; and changing water conditions may lead to different fish species being present, affecting angling.

Climate change could have both positive and negative influences on our health and wellbeing. The BFI plan could promote climate resilient infrastructure, and nature-based solutions in particular, to help build climate resilient places which benefit our health and wellbeing.

Upton marshes, Norfolk © Jeremy Halls

Water supply and water quality

Water is always a primary concern when climate change is discussed. The potential impacts are wide-ranging, including concerns over availability of water for people and business, and the quality of water in the rivers and broads which could be affected by salinity and contaminants. Many valued environmental features rely on good quality water from rainfall, rivers and groundwater.

With more rain falling in winter than summer, and in more intense events, we need better **balance in our water resource system**, including through storing water for later reuse. Flood storage areas could capture runoff from high rainfall and floods before it disappears out to sea. This water is needed to supply the growing population, as well as increased agricultural demand particularly during warmer, drier, summers. **Collaborative working between different sectors is required** to tackle the closely connected issues of water resources, flood risk management and water quality. This can improve the environment and support development.

In terms of water quality, **saline incursions into the mainly freshwater ecosystems have major impacts** on biodiversity, agriculture and other important activities (e.g. angling). In 2013, freshwater fish were killed by high tides surging up the river Thurne and in 2007, storms drove high tides up the Yare, resulting in one of the worst incidents of fish deaths in 15 years.

Exactly how climate change will impact these saline incursions is not well understood. However, many **important wildlife species have a low tolerance to changes in salinity**. For example, 60% of the most important species for conservation in the Broads require fully freshwater conditions and are unlikely to tolerate water which is more brackish. In fact, only 13% of these species would tolerate mild to moderately brackish conditions. And over half of them are vulnerable to higher water levels.

Although some of these issues are beyond the BFI plan's direct influence, flood management actions which align more closely with the changing environment can contribute to good land and water management. As the partnership develops the BFI plan, we are working closely with those seeking to balance water demand and supply, and maintain freshwater quality.

Irrigating a field off Colney Lane © Copyright N Chadwick www.geograph.org.uk

6. Climate mitigation and adaptation

What is mitigation and adaptation?

> A goal of adaptation is to become more resilient, and able to cope with – and even thrive under – climate change.

Mitigating climate change refers to **actions which reduce or prevent emission of greenhouse gases**, e.g. using less resources or renewable energies. The UK government and many BFI partner organisations have set targets to mitigate emissions and become 'net zero' in the coming decades, i.e. they have committed to emitting no more greenhouse gas into the atmosphere than they remove. Many of these actions also help us adapt to the consequences of climate change which can't be prevented. **Adaptation is a process which should be planned and helps us cope with, and take advantage of, the impacts of climate change.** Adaptation incorporates changes to all aspects of life that can reduce impacts of flooding. The BFI plan has an excellent opportunity to work with natural processes to manage flooding, reduce greenhouse gas emissions (mitigation) and become resilient to the changes posed by climate change (adaptation). The following illustrate some current examples.

Natural flood management

Carlton marshes © Jeremy Halls

Natural Flood Management techniques include reducing soil compaction for better infiltration, less runoff and erosion; woody debris dams upstream in a watercourse to slow the flow of water and encourage infiltration and uptake by vegetation; and storing water in wetlands and other natural features. These approaches **provide wildlife habitat, store carbon and improve the overall value of the environment**. These techniques are already being used upstream on the River Yare at Marlingford, with woody debris structures in the channel and channel banks lowered to provide greater connection with the floodplain, and on the River Bure at Buxton where new natural flood storage has been created. The Broadland Catchment Partnership has installed various natural techniques to capture, slow and improve the quality of run-off from fields and roads, including traps to reduce sediment loading into the River Wensum.

Peat **helps mitigate climate change through storing carbon**. Restoring damaged peat allows these benefits to continue. Wetland habitats which can form peat are a prominent feature of the plan area. As is being recognised elsewhere, such as Fingringhoe and Wallasea in Essex, wetlands including salt marshes also store carbon. The schemes in Essex have been collaborations between partners and landowners, responding to the coastal squeeze of the coast and creating new habitat for birds and wildlife, as well as better flood management.

Sustainable Drainage Systems (SuDS) is the term given to natural flood management techniques which are applicable in urbanised areas. Planted areas for water to pond, green roofs for buildings, paved surfaces which are permeable and water butts are some of the

techniques used to **mimic natural processes**, storing and making water available for reuse, and decreasing the flow of water from urban areas to rivers and the sea.

Collaborative water management

Flood storage areas are opportunities for **collaboration across many sectors to manage flooding and improve availability of good quality water**. A scheme has recently been completed on Halvergate Marshes involving the Broads Internal Drainage Board, RSPB and other landowners, with each partner achieving adaptation to climate change. Floods in 2012 and droughts from 2009-11 highlighted the challenges of sustainable water management, and that adaptation was needed for the marshes to remain a haven for wildlife and traditional agriculture. The scheme extended a carrier for freshwater deeper into the marshes. Watercourse capacity was improved and water control structures installed to maximise supply of freshwater in and drainage out of the area, with as little pumping as possible. The RSPB created new habitat and the security of a quality water supply meant farmers have adapted their businesses and accessed additional investment.

Berney Marshes Nature Reserve © Jeremy Halls

Development planning

Buildings can be adapted to climate change including by making them more resilient to flooding (e.g. fitting flood doors, using flood-resilient materials). Traditional Broadland buildings by the riverside are often timber framed and able to be periodically raised on supports as the soft ground below settles. On the coast at Trimingham, the Parish Council and community worked hard with North Norfolk District Council to 'roll back' the village hall and four properties from eroding areas. A similar scheme was undertaken in Happisburgh, where properties were relocated away from an 'at risk' area.

'Net zero' greenhouse gas emissions

Norfolk and Suffolk are recognised for leading the transition to an economy where carbon emitted to the atmosphere is balanced with that captured and stored from it. It is the only place in the UK where all forms of energy resources and generation exist together, including being at the heart of the world's largest market for offshore wind energy. This shift to a 'net zero' economy is already changing our behaviour, for example as a population, we are reducing our power use and considering buying electric cars. Similarly, the **UK government's commitment to 'net zero' emissions by 2050, and cascading commitments from BFI partners (including the Environment Agency), will influence how flood risk**

Scroby Sands Wind Farm © Jeremy Halls

management is delivered. For example, the carbon impact of new schemes is already considered alongside cost, environmental benefits and other factors when deciding between options for flood risk management.

An adaptive plan for flood risk management

As these examples show, and as the overview of new approaches in section 2 of this document suggests, adapting flood risk management to climate change will require us to consider a range of interconnected issues and responses.

An adaptive plan can be viewed as a **series of possible actions over time** which are planned for but only implemented when they are known to be necessary and the best option. The plan will be proactive but flexible, to accommodate the speed and severity of climate change which is not fully known. Each possible action in the plan will be useful for a period, and as the end to the effectiveness of one action is anticipated, a decision point is reached. This decision point is an opportunity to **review how the climate and other conditions are changing and decide on the next action**.

If we don't fully consider how our climate could change we may get the impression that existing approaches can continue to be adjusted indefinitely, for example raising walls and embankments higher and higher. Such incremental actions may get us so far and would mean that we get maximum benefit from existing infrastructure. However, there may come a point when this will no longer be possible or sufficient and a wider transformation of our approach is required. The BFI plan will consider the **need for both incremental and transformational change**.

Sunrise over the North Sea © Jeremy Halls

7. How can I be involved?

The BFI Partnership is working with others to plan approaches to flood risk management. We are considering different matters that are linked to flood risk management and approaches which will help us realise the potential opportunities of climate change. This period of planning is a great **opportunity to reflect on how things have been done, contribute to the debate on future approaches, and see how we can all work together** to achieve our vision.

Since 2019, the partnership has been building our stakeholder database which is now close to 300, with a blend of organisations, parish councils, businesses and members of the public. We want this group to continue to grow and for your voice to count. Therefore, if you're passionate about the Broadland area and want to help shape the future, we encourage you to look at the various documents available online, watch the videos, spend time in the virtual exhibition space and take part in our online survey. The **feedback and information you provide now will help shape the objectives of our plan**.

Former Bridge Stores, Acle Bridge © Jeremy Halls

Climate change presents challenges and opportunities which require a strong and united response and there is something that each and every one of us can do. As a partnership, we are interested in **offers of time, leadership and other resources** that you can provide. In time, the BFI plan will set out how to improve resilience to flooding and climate change. The following actions are just a starting point:

- Encourage your Parish Council and other relevant bodies to engage with the BFI plan for adapting to climate change - inspire them to take a long-term view when planning for climate change and sea level rise.
- Raise awareness and talk with others about climate change, how the area may change over time and the ways to adapt - promote the BFI materials and support the activities!
- Adapt your own home and workplace (e.g. fitting local flood protection measures, use water more efficiently and store rainwater to water your garden) and make sure to sign up to Floodline Warnings Direct (https://www.fws.environment-agency.gov.uk/app/olr/register).
- Keep up to date with the latest predictions for climate change and developments in the science.
- Calculate your carbon footprint online and make lifestyle choices that lower this footprint.

8. Summary

Our climate, which has always shaped the landscape and culture of Broadland, is continuing to change. As those who live, work and visit the area, we have an opportunity to adapt our approach to flood risk management to better align with the changes which are anticipated. The graphic on the following page summarises how and when we can expect our sea level and temperatures to rise, and rainfall patterns to change. It highlights that it will be our children and grandchildren who will experience the full impacts of climate change as well as the choices which we make now.

The climate is changing and we are working together to find solutions: come and join us!

The changes could be significant but there is time now to plan for them. Understanding the impacts provides us with motivation and information to adapt, so that we can all **take advantage of the opportunities and improve resilience to the risks**. For example, flood risk will increase but collaboration between those managing flood risk, water resources and the environment has already demonstrated that natural approaches help us manage flood risk, store freshwater that is required in hotter, drier summers, and improve our environment.

Many of us are already adapting our lives to climate change. For example, insulating our homes so we use less energy and watering our gardens from water butts to use less water. In the same way, the BFI plan will seek to deliver flood risk management that achieves 'net zero' i.e. actions which emit no more greenhouse gas into the atmosphere than they remove. The plan will present opportunities to both **mitigate further consequences of climate change and adapt to those that are too late to avoid**.

The BFI partnership is working with the local community to develop an adaptive flood risk management plan which will likely include engineering and non-engineering actions. Decisions as to whether we continue unchanged, prepare for something different or actually implement a different approach will be based on regular reviews of key indicators, including sea level rise. Adaptation for the whole area will likely comprise many smaller, coordinated, adaptations. These could include innovative actions like building some new houses with elevated floor levels or on stilts but, in the near future, will typically mix approaches already seen across the area in a way that provides flexibility for future change. The detail of actions required in the longer-term will be less certain but the **plan will include actions that may be required, depending on the speed and severity with which our climate changes**.

Horsey Boat Dyke © Jeremy Halls

Broadland
Futures Initiative

Because of the following changes to our climate, we are developing a plan to adapt how we manage flood risk:

Summer

1.9°C-7.5°C
hotter
Summer air temperatures by 2120 will have risen by at least 1.9°C and could be as much as 7.5°C higher.

27-51%
decrease in rainfall
Summer rainfall by 2120 will have decreased by at least 27% and could have decreased by as much as 51%.

Winter

1.5°C-5.5°C
warmer
Winter air temperatures by 2120 will have risen by at least 1.5°C and could be as much as 5.5°C higher.

11-29%
increase in rainfall
Winter rainfall by 2120 will have increased by at least 11% and could have increased by as much as 29%.

0.54 -1.02 m higher
By 2120, sea level will have risen by 0.54m and possibly by as much as 1.02m.

Changes are central estimates from scenarios where global emissions are severely reduced, and where global emissions are very high. Changes are relative to average values between 1981 and 2000.

9. What is Broadland Futures Initiative?

The Broadland Futures Initiative (BFI) is a partnership for future flood risk management in the Broadland area. Our main goal is to agree a framework for future flood risk management that better copes with our changing climate and rising sea level. The focus is to define a flood risk management plan for Broadland over approximately the next 100 years putting people at the heart of decision making.

BFI has been set up by organisations responsible for managing flood risk, working together with partners. The Environment Agency, Natural England, County and District Councils, Internal Drainage Boards, Broads Authority, National Farmers Union, Water Resources East, the Royal Society for the Protection of Birds (RSPB) and the Wildlife Trusts will work together in developing the plan.

Elected members representing local communities will be the decision makers. This will be a democratic process, with local politicians making the core decisions in order to agree the future flood risk management plan, having considered the latest projections on our changing climate.

The plan will be developed over a number of stages. This document is part of establishing the background to the plan. For more information about the BFI and how it's organised see our Frequently asked questions document.

Other documents to be produced during this initial stage are shown below. Some of these are aimed at the general public while others are more technical in nature. They will be available through the BFI website: https://www.broads-authority.gov.uk/looking-after/climate-change/broadland-futures-initiative

Aerial image of Hickling Broad © Mike Page

- Origins of the plan area
- Sources and nature of flood risk
- Coastal processes review
- Current approaches to flood risk management
- The influence of flood risk management
- Strategic plans and documents review
- Existing key data sources and indicators
- The result of initial stakeholder survey
- Objectives for the plan
- The methodology for options appraisal and preferred options selection
- Strategic environmental assessment scoping
- Frequently asked questions

10. Glossary

Biodiversity: Variety of plant and animal life in the world or in a particular habitat. A high level of plant and animals is usually considered to be important and desirable and is referred to as being biodiverse.

Broadland Futures Initiative (BFI): A partnership formed to agree a framework for future flood risk management in the Broadland area. The strategy aims to better cope with our changing climate and rising sea level. Planning has started now with the strategy to be implemented from the mid-2020s onward.

Catchment: Area where water is collected by the natural landscape. Each river has a catchment area that drains to it.

Climate Change: Any significant long-term change in the expected patterns of average weather of a region (or the whole Earth) over a significant period of time.

Coastal Squeeze: Coastal squeeze is the loss of natural habitats or deterioration of their quality arising from structures or actions preventing the landward transgression of those habitats that would otherwise naturally occur in response to sea level rise, in conjunction with other coastal processes. Coastal squeeze affects habitat on the seaward side of existing structures.

Embankment: An artificial, usually earthen, structure, constructed to prevent or control flooding, or for various other purposes including carrying roads and railways.

Erosion: Process by which particles are removed by the action of wind, flowing water or waves (opposite is accretion).

Flood Risk Management: Flood risk management aims to reduce the likelihood and/or the impact of floods. Experience has shown that the most effective approach is through the development of flood risk management programmes incorporating the following elements:

- **Prevention:** preventing damage caused by floods by avoiding construction of houses and industries in present and future flood-prone areas by adapting future developments to the risk of flooding, and by promoting appropriate land-use, agricultural and forestry practices;
- **Protection:** taking measures, both structural and non-structural, to reduce the likelihood of floods and/or the impact of floods in a specific location;
- **Preparedness:** informing the population about flood risks and what to do in the event of a flood;
- **Emergency response:** developing emergency response plans in the case of a flood;
- **Recovery and lessons learned:** returning to normal conditions as soon as possible and mitigating both the social and economic impacts on the affected population.

Greenhouse Gases: Those which trap thermal energy from the sun in our atmosphere, resulting in warming. The most abundant greenhouse gas is carbon dioxide (although others include methane and nitrous oxide), and the predominant source of increasing carbon dioxide has been the burning of fossil fuels (coal, oil and natural gas).

Habitat: Natural home or environment of an animal, plant, or other organism.

IDB: Internal Drainage Boards are independent locally funded and operated public bodies. There are currently around 100 IDBs in England which consist of elected members. They are responsible for reducing flood risk for both rural and urban communities (including protection of businesses and infrastructure) and they also have duties in protecting and enhancing valuable wildlife habitats.

Overtopping: When water exceeds the height of a flood risk management structure or ground and so spills over the top of it.

Projected: To extend beyond something else/ to forecast something in the future based on present trends.

Regenerative Agriculture: Farming and grazing practices, for example minimum tilling of the soil, using biological rather than artificial fertilisers and well managed grazing, that rebuild soil organic matter and restore degraded soil biodiversity.

Risk: Combination of the probability that an incident will occur and the consequence to receptors associated with that incident.

Stakeholder: An individual or group with an interest in, or having an influence over, the success of a proposed project or other course of action.

Storm surge: Rising of the sea as a result of wind and atmospheric pressure changes associated with a storm.

Transitional: Relating to or characteristic of a process or period of change/transition. Moving from one state to another.

Wetland: Transitional habitat between dry land and deep water. Wetlands include open water, fresh and salt water marshes, swamps, peatlands (including fens), flood meadows, river and stream margins.