

# Climate change and potatoes

The risks, impacts and opportunities  
for UK potato production



# Impacts on yield and water use

**Climate change will influence the way potato crops develop, grow and yield. It will also impact on the viability of rainfed potato production and demand for supplemental irrigation**

In the future, higher summer temperatures and elevated CO<sub>2</sub> levels should provide more favourable growing conditions. But reduced summer rainfall, coupled with an increased frequency of extreme events and higher energy and fertiliser costs, will inevitably threaten rainfed and irrigated yields.



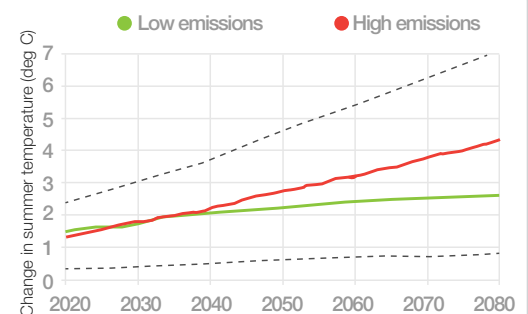
## Climate risks to production

Photosynthesis is the driving force in production and governed by incoming levels of solar radiation. However, the production potential is also influenced by temperature and water availability, technology, fertiliser and crop losses. As well as the direct impacts of climate change (i.e. rainfall and temperature), potatoes will also be particularly sensitive to various indirect effects, including changes in the agricultural potential of soils, as this affects the availability of water to plants and impinges on other land management practices (e.g. trafficability for seed bed preparation, spraying, harvesting).

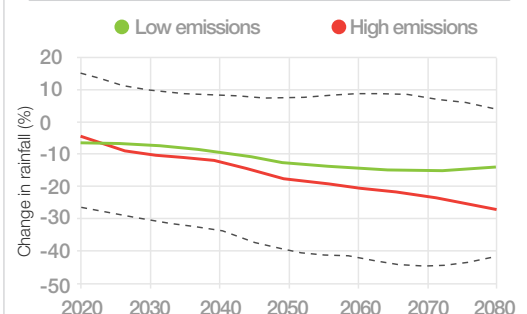
Increases in atmospheric CO<sub>2</sub> concentration will also impact on crop growth by increasing the resource efficiencies for radiation, water and nitrogen. As a consequence, for most crops grown in northern Europe including

potatoes, future warmer temperatures and elevated CO<sub>2</sub> levels are expected to result in more favourable growing conditions, although of course there will also be some negative consequences.

The latest climate projections (UKCP09) for the UK suggest drier summers with higher temperatures (Figure 1) and reduced rainfall (Figure 2). But note the uncertainty around these 'mean' projections (the dotted lines). In general, at higher latitudes a rise in temperature tends to increase the developmental rate of the crop and extends the length of the growing season, resulting in a positive impact on crop production. On the other hand, reduced summer rainfall is likely to increase soil moisture deficits reducing yield under rain-fed regimes and increasing the need for supplemental irrigation.



**Figure 1** Projected changes in mean summer temperature (2020s to 2080s), for the low and high emissions for a farm site in Suffolk. Dotted lines represent extreme probabilities.



**Figure 2** Projected changes in mean summer rainfall (2020s to 2080s), for the low and high emissions for a farm site in Suffolk. Dotted lines represent extreme probabilities.



### Future potato yields

To assess yield impacts, a potato crop growth model was used. This simulates the daily growth and development using information on climate, soil, management and cultivar. The model was first calibrated using field data from three farms (in Norfolk, Suffolk and Lincolnshire) and an experimental farm (CUF) to check that the modelled yields accurately reflected those observed on-farm. Future potato yields were then simulated for each farm for selected emissions scenarios in the 2050s.

The projections showed only minor increases in potato yield (+ 3 to 7%), mainly in response to the increased radiation levels and higher temperatures. Farm production levels were found to be limiting due to current water and fertiliser management practices. But when future production assumed an optimal (unconstrained) irrigation and fertiliser regime then future average yields on-farm increased by +13 to 16%.

**For growers, climate change presents an opportunity to increase potato yield, but getting the right amount (and timing) of both water and fertiliser applications will be key. To achieve this, growers will need better information to manage climate uncertainty and match crop demands to environmental conditions.**

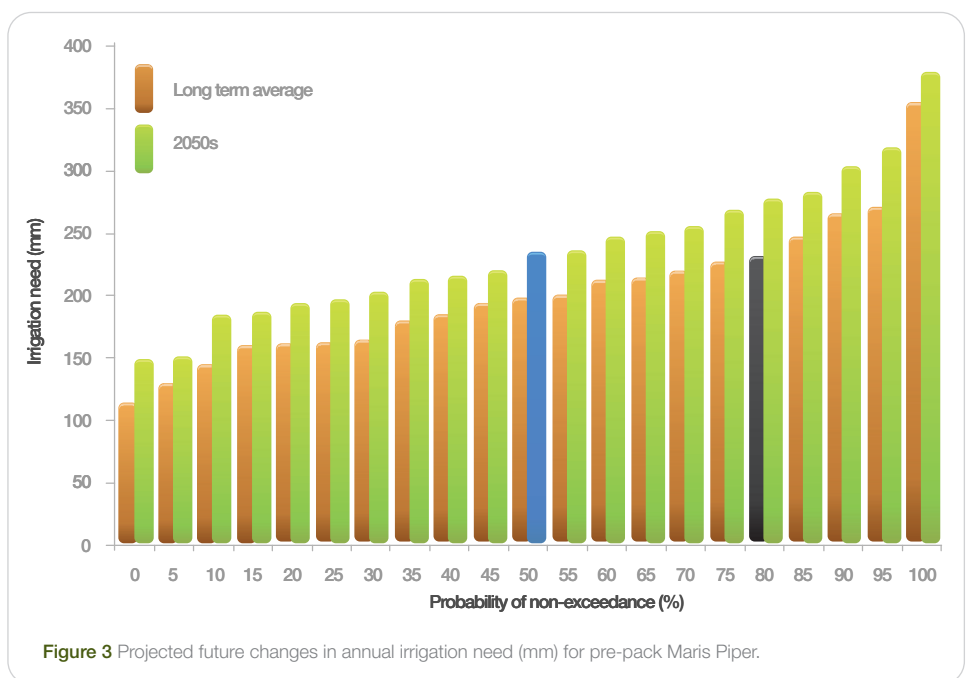


Figure 3 Projected future changes in annual irrigation need (mm) for pre-pack Maris Piper.

### Future irrigation needs

Changes in climate mean supplemental irrigation is likely to become more widespread, particularly on varieties where scab control for skin finish is important. For a pre-pack Maris Piper, the combined effects of reduced rainfall (-7 to -12%) and increased crop evapotranspiration led to a significant increase in future irrigation need (depths applied), ranging from +14 to 30% (Figure 3).

Clearly, these increases could have major cost implications – both on production (water and energy), water resources and existing infrastructure (e.g. reservoirs, pumps). Current irrigation system capacities are typically designed for a 'design' dry year (i.e. 80% probability of non-

exceedance). But Figure 3 shows that a future 'average' year (i.e. blue 50% probability) could be much drier than a current 'design' dry year (i.e. black 80% probability).

**Without adaptation, existing irrigation schemes could have insufficient capacity to meet future irrigation needs in approximately 50% of years, with serious consequences for potato yield, quality and farm income.**

# Impacts on land suitability and soil management

**Climate change will affect the agricultural potential of soils by modifying soil water balances, with consequences for potato land suitability, trafficability and workability**

Changes in soils and agroclimatic conditions will influence cultivar choice, agronomic husbandry practices, and the economics of production. If rainfed production becomes limiting due to excessive droughtiness, then securing access to water for irrigation will become essential.

## Land suitability classes

Four classes are frequently used by soil scientists and growers to assess land suitability for potato production - well, moderate, marginal and unsuited. *Well suited* has a high and sustainable production potential from year to year with adequate opportunity to establish the crop in average years at or near the optimum sowing time. Harvesting is rarely restricted by poor ground conditions. *Moderately suited* is where potential production is variable from year to year due to a shortage of soil water to sustain full growth, or poor conditions at crop establishment. *Marginally suited* has a potential production that is variable from year to year with considerable risks, high costs, or difficulties in maintaining continuity of output, due to climate interacting with soil properties, disease or pests. For potatoes, the criteria for *unsuited land* relate mainly to climate, gradient and stoniness.

Three factors are then used to distinguish between unsuited and suitable land; namely, potential soil moisture deficit (which reflects agroclimate conditions), accumulated temperature and slope.



These identify areas where either climatic conditions (extreme cold and/or wet areas) and/or soil characteristics (stoniness and sloping relief) would limit production. Finally, the 'suitable' land class (i.e. well, moderate, or marginal) is then determined according to its trafficability and droughtiness, the former measured as machinery work days (MWD) and the latter from data on soil available water.

## Current land suitability

By combining all these variables with national datasets on soils and climate, it is possible to map current land suitability for rainfed potatoes - and then compare this against the locations of PCL registered growers involved in rainfed production (Figure 4).

## Future land suitability

By imposing data on climate change, a map showing 'future' land suitability can be produced (Figure 5). This shows that in many areas, rainfed production will become increasingly risky. However, with supplemental irrigation, around 85% of the total arable land in central and eastern England would remain suitable for production, although most of this is in catchments where water resources are already over-licensed and/or over-abstracted. The expansion of irrigated cropping is thus likely to be constrained by water availability. The growth in water demand due to the switch from rainfed to irrigated cropping is

likely to be much larger than the increase in need of the currently irrigated potato crops.

**In some regions rainfed production will become limiting – our results suggest that by the 2050s, the area of land that is currently well or moderately suited for rainfed production will decline by 74% and 95% under the “most likely” climate projections for the low and high emissions scenario, due to increased droughtiness.**

## Grower implications - variety choice

The full impacts of climate change on land suitability are clearly more complex than the basic maps shown here, but the results agree well with qualitative judgement. For example, based on PCL data, the cost of production would not be covered by the crop value when maincrop yields fall below 30 t/ha. This would set a limit for rainfed production in the dry regions and those having coarse and easily drained soils. A restricted water supply during crucial times can also damage tuber quality to the extent that certain varieties would be rejected by the market. This would force growers to shift to varieties less susceptible to scab or towards the processing market. Any reduction in irrigation availability or reduction in rainfall would severely affect the profitability of crops such as Maris Piper and Maris Peer, where skin finish is crucial for packing. Determinate

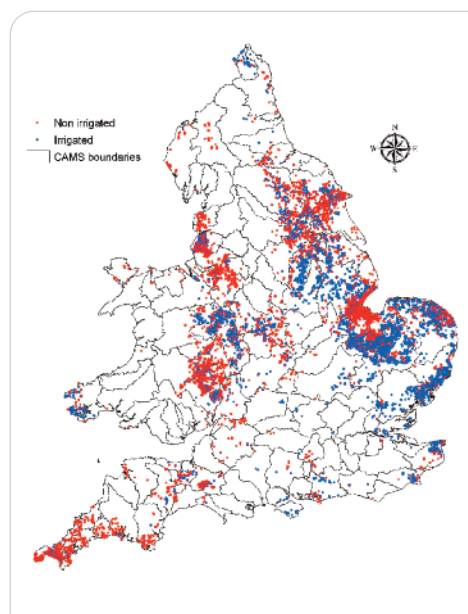


crops, i.e. those that only produce a limited leaf area and have short periods of active root growth and some less-determinate varieties are very sensitive to water restrictions during mid-late canopy expansion. Current widely grown examples include Estima, Lady Rosetta and Saturna. Absence of rain or irrigation during these periods can cause premature senescence with a large yield loss. For this reason, rainfed or limited irrigation production with these varieties under

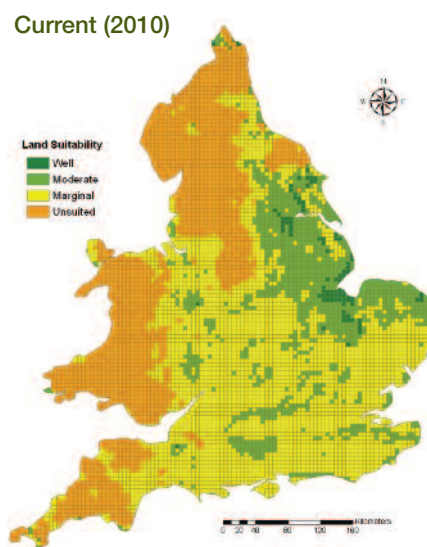
these climate change projections is likely to be reduced for risk of crop failure. However, the yield response to irrigation of many of these varieties is large so they will continue to be grown where irrigation is less limited.

Production in rainfed areas is thus likely to change to varieties that are able to either (a) survive early drought periods, so that they can use rainfall later in the season (e.g. Maris Piper, King Edward,

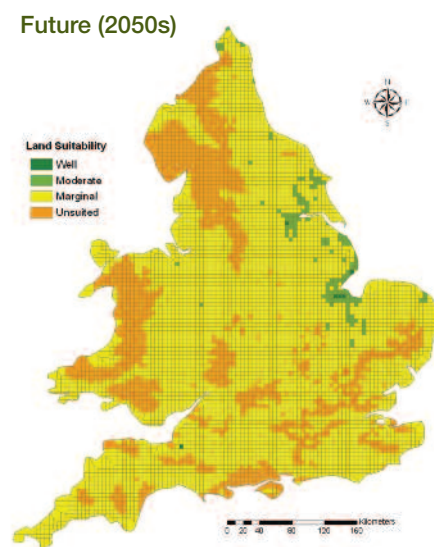
Markies, Russet Burbank or Rooster) or (b) partition dry matter towards tuber production during periods of drought rather than canopy production which makes them more efficient in producing yield per unit of water (e.g. Hermes or Desiree).



**Figure 4** Current location of PCL registered rainfed and irrigated potato production in England and Wales.



**Figure 5** Projected changes in land suitability for rainfed potato production from the current baseline (2010) to the future (2050s). Notice how the areas of well suited land for rainfed potatoes (green areas) shrink dramatically.



# Adaptation – coping with greater climate uncertainty

**Climate change is likely to exacerbate many of the current challenges already facing the potato sector. The key to tackling these will be in adaptation – securing access to the relevant skills, resources and knowledge to increase production efficiency, improve management and embrace new technology**

## Crop management

As with all climate change impact assessments, growers need to be wary of the results and interpret them with caution. It is nevertheless important to consider the range of adaptation options and responses available, then weigh up the risks and plan accordingly.

The outputs from our crop modelling assumed unchanged farm practices in the future, but in reality there will of course be some degree of autonomous adaptation even if not planned adaptation. For potatoes, this could include earlier planting and harvest dates, changing to better adapted varieties, less dependence on soils with low water holding capacities, crop movement to regions with more suitable agroclimate conditions and water availability, and probably the uptake of GM technology.

## Changes in soil management

Climate change is likely to lead to the dates of the last spring frosts becoming earlier and autumn frosts becoming rarer and/or later, thereby extending the growing season. Planting could therefore take place earlier as the thermal environment experienced by crop canopies would be more favourable. However, soils would still be at field capacity, leading to the same problems in workability that growers currently experience during March and April in many regions of the country. Reduced rainfall and higher temperatures will result in a depletion of organic matter, increasing the risk of structural damage to sensitive soils. Harvesting windows would become longer, thereby reducing the risk of adverse soil conditions causing harvesting problems or crop damage.

## Land management

The land suitability maps clearly show that growing rainfed potatoes in England and Wales will become increasingly risky as a result of climate change, and limited to a few favourable areas. In contrast, with irrigation the land suitability hardly changes and most of the current rainfed potato production could remain in its present location, if it could be irrigated. Although only around 1% of water abstraction in England and Wales is used for irrigated agriculture, there is limited prospect of the industry obtaining significant additional licensed quantities for the summer months in the face of competing demands. However, many existing licences are unused or underused, so water transfers or abstraction licence trading between farms may be an option, though there are environmental arguments against re-activating “sleeper” licences in stressed catchments.

## Water management

Licences are still available for high flow (off-season) abstraction in most catchments, and recent years have seen a significant increase in winter filled on-farm reservoirs for irrigation use in the summer. Though expensive, this gives the grower greater security of supply. It seems likely that this will become the preferred irrigation water source for potatoes and other high value vegetables in the south and east of England. But there are still relatively few examples of adaptation to climate change in the UK agricultural sector, and that many apparent adaptive actions have actually been in response to legislative or other pressures, rather than purposeful (deliberate) adaptations to perceived climate change per se, but nevertheless they may still be useful climate change adaptations. The current growth in on-farm reservoirs would appear to fall into this category.

## Investing in water efficiency

Once irrigation water is assured but expensive, it will become sensible to invest more heavily in water efficiency measures; better application methods, including drip and precision irrigation, and scientific scheduling methods will become standard. Earlier planting and harvesting would reduce water use per unit area, but with some varieties growers might prefer to use the longer growing season to increase yield. There has been a steady increase in average potato yields over the last 40 years; with national consumption roughly constant this has led to a gradually reducing area planted; whether this trend can be intensified and how far it could counteract increasing water demand is not yet clear. Others have suggested that irrigated production might move north and west as an adaptation to climate change. Given that most of the current locations remain suited to irrigated production this may be a slow process. Many growers have sizeable investment in fixed assets, and may therefore prefer to remain at their present locations renting land from neighbours with unused or partially used licences as a preferred way forward.





### Short term coping or long term planning?

Greater uncertainty in seasonal weather patterns means growers need to consider short-term coping strategies as well as longer-term strategic developments to reduce their vulnerability to changing water availability. How they respond will depend to a large extent on their perception of risk and the opportunities that climate change presents to their business. Farmers generally have two options; either to reduce their water needs or try to secure additional water supplies.

Options to reduce on-farm water needs include investing in improved irrigation technology (scheduling) and equipment to increase application uniformity and efficiency, using weather forecasting to increase the effective use of rainfall, encouraging deeper rooting of crops, introducing lower water use or drought tolerant crop varieties, decreasing the overall irrigated area, or modifying soil structure to improve soil moisture retention.

Options to obtain more water include purchasing land with water, obtaining additional licensed capacity and building on-farm storage reservoirs (either individually or shared with neighbouring farms), installing rainwater harvesting equipment, re-using waste water from farm buildings, or switching water supplies to public mains where feasible.

**Many of these potential adaptations are already ‘no regret’, in that they already make sense by solving existing water resource issues, which then contribute to a farms' future adaptability.**

### Dealing with uncertainty

It is important to remember that the potential impacts of climate change are based on long term projections – they are not predictions of what ‘will’ happen but rather projections of what ‘might’ happen. There is a large degree of inherent ‘uncertainty’. Figure 6 shows, for example, the projected changes in annual rainfall

at Cambridge together with the uncertainty (error bars). The important message here is that the uncertainty is greater than the projected future change – in August, for example, it is projected that rainfall might decline by around 20%, but it could range from -50% to +40%. This makes adaptation planning very difficult, particularly where large investments are being considered (e.g. reservoirs).

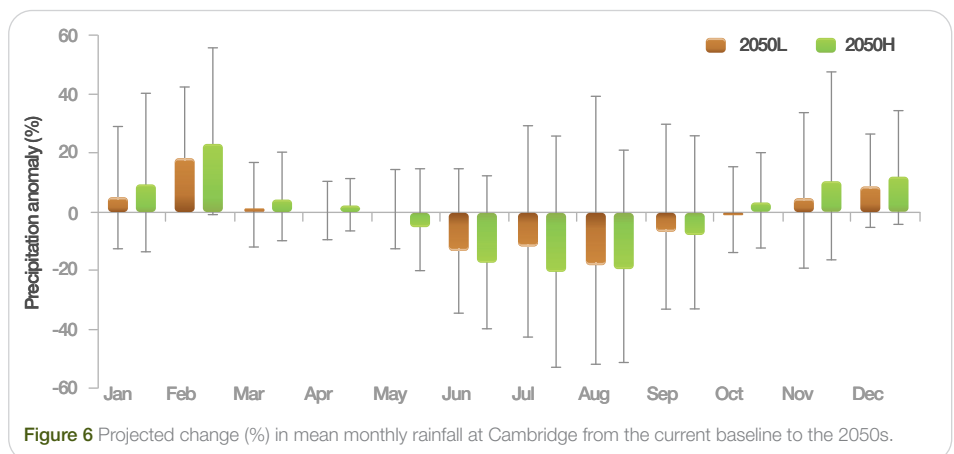


Figure 6 Projected change (%) in mean monthly rainfall at Cambridge from the current baseline to the 2050s.

### Non-climate risks and building adaptive capacity

It is important to recognise that the UK potato industry also faces a range of ‘non-climate’ risks which many would argue present a much greater and more immediate threat than climate change. Growers have a challenging period ahead, trying to maintain productivity whilst controlling spiralling farm costs, particularly in relation to energy, whilst also demonstrating compliance with regulations associated with environmental protection, food safety and bio-security.

In this context, coping with immediate economic, environmental, technological and societal pressures (i.e. non-climate risks) means that farmers are less inclined to give climate change the priority it deserves as a key business risk. But climate change will exacerbate many of the current challenges already facing the UK potato sector. Building adaptive capacity is needed to provide better grower access to new skills and knowledge to increase production efficiency. This will require new collaborations between individual growers, the PCL, and other public and private sectors.

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**Copies of this booklet can also be downloaded from the Potato Council website [www.potato.org.uk](http://www.potato.org.uk)**

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