**Application**

The application of this research is pertinent to economic, social, and sustainability objectives within the agricultural, and specifically dairy, sector. By exploring the relationship between climate trends and the on-farm implications, and how to effectively utilise adaptation practices to mitigate negative financial and environmental consequences, the sector may become better prepared to face unprecedented change.

**Introduction**

For the UK, climate projections indicate a potential average of warmer and drier summers, and wetter winters, with increased intensity in rainfall events (Met Office, 2022). For dairy enterprises, heat stress is likely to be a growing concern, rising from 1-2 days per annum in 2014, to over 20 by 2100, holding consequences for milk yield and animal welfare (Dunn et al., 2014). The impacts on forage/crop yields are more complex, whilst expected to increase due to warmer temperatures, changes in pest and disease prevalence, grazing periods, and water availability add complexity (Cho et al., 2012; Skendžić et al., 2021; Wreford & Topp, 2020).

For dairy farms, the interdependencies of forage production, animal welfare, milk production, cost of production and farmers wellbeing prompts the need to find solutions that are not single focused but consider a whole farm approach.

The research presented builds from the study conducted by Wreford and Topp (2020), which presented a list of adaptation methods for UK livestock farmers, and reviewed the financial, capital, operational, productivity, and opportunity costs of each practice.

By utilising a case study approach, an opportunity is presented to compare published climate trends, impacts, and adaptation practices, with adopted resilient initiatives, practical barriers and solutions, under a whole-farm approach.

**Materials and Methods**

This research utilised a mixed-method approach, initiated with a review of secondary literature to build an understanding of main adaptation practices for UK dairy farmers, and the level of adoption throughout the industry.

A series of case studies were conducted globally through semi structured interviews with farmers, academics, and industry stakeholders across UK, Brazil, US, Mexico, Ireland, and India. Case studies were collected from dairy and other livestock and arable farmers in order to encourage cross-sector learnings. Interviews were conducted with representatives of key organisations such as Teagasc, Met Éireann, Cornell University, University of Georgia and Universidad Autónoma de Baja California.

The interviews centred around a series of themes, including but not limited to:

* Enterprise type and objectives
* Climate trends, past, present, and future
* Impacts of the climate
* Key adaptation practices employed and results
* Barriers to adaptation
* Accessibility of data for decision making

Transcripts were analyzed, with key findings were grouped into themes on climate risk, adaptation feasibility, and research needs.

**Results**

The case studies highlighted the demand for a support tool to aid climate resilient dairy farming. This was suggested to include climate trend data, localised environmental data, such as soil erosion risks, and recommended adaptation practices. Whilst similar tools or platforms existed, they were not widely adopted, such as US Climate Resilience Toolkit, or the Georgia Climate Project (GCP). The GCP consisted of a consortium of academics who aim to enhance the transparency of climate trend and impact data, and present risk mitigation. The direction of the platform was steered by the public, and could be utilised as a concept for the UK dairy sector.

Many case studies highlighted similarities between resilient and regenerative principles, especially regarding soil health protection, mixed livestock integration, multi species lays, and rotational/cell grazing. Rancho AgroEcologica, for example, was situated in Yucatan Mexico, and suffered from extremely degraded soil due to a long-term monocrop of cactus cultivation, heighted by drought risks. The 120-hectare ranch has seen stark improvements in soil health, biodiversity, drought resilience, and productivity, now supporting dairy, goat, sheep, poultry and fruit enterprises. Initiatives included silvopasture, mixed grazing, multi species grasses, and minimum tillage practices. Whilst the objectives of the initiatives were resilience, the initiatives fell under the umbrella of regenerative principles, and subsequently enhanced soil, biodiversity, and environmental indicators.

Lastly, the interplay of key adaptation practices in response more longer-term or fixed variables such as access to capital and land availability is an important result. Utilising genetics, such as high-yielding breeds crossed with heat tolerant native breeds, in comparison to infrastructure investments, such as high sheds with fans and misters presented as a common example. Whilst both adaptation practices contribute towards mitigating the impact of heat stress, investment into modern infrastructure and equipment is often capital intensive, whilst utilising native breeds, such as Brahman and Holstein crosses, are typically less capital intensive, but will impact milk yield significantly. Whilst the trade-offs between these two initiatives were intensified in more extreme climates, such as in Brazil and Mexico, however similar case studies, although muted, were found in more temperate climates such as Ireland and the UK. The trade-offs between adaptation recommendations must therefore be reflective of the enterprise constraints and management objectives of the farm leadership and sector objectives.

**Conclusions**

Through these case studies, a call for a climate resilience network has been established, to utilise climate data with sector resilience knowledge and support the decision making of UK dairy farmers. Whilst many resilient practices could be considered regenerative, these practices were broader than regenerative principles and need to remain flexible to suit the inherent capabilities of the enterprise.

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