Institution: Aberystwyth University

Unit of Assessment: 6 Agriculture, Veterinary and Food Science

Title of case study: Influencing Bioenergy, Land Use and Net Zero Policy

Period when the underpinning research was undertaken: 2009-2020

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Professor Iain Donnison	Programme Leader; Professor	8 October 2007- present
Professor John Clifton-Brown	Principal Investigator; Reader; Professor	8 October 2007- present
Dr Kerrie Farrar	Principal Investigator	8 October 2007- present
Dr Paul Robson	Research Scientist; Senior Research Scientist	1 April 2008- present

Period when the claimed impact occurred: 2018-2020

Is this case study continued from a case study submitted in 2014? N

1. Summary of the impact (indicative maximum 100 words)

Aberystwyth University (AU) research has influenced UK Government policy on biomass cropping and land use for achieving net zero targets. AU researchers informed, through their publications, and contributed advice, to the UK's Climate Change Committee (CCC) reports on *Biomass in a Low Carbon Economy (2018)* and *Land use: Policies for a Net Zero UK (2020)*. Both these reports informed the CCC's 6th Carbon Budget (2020). AU researchers have also continued to contribute to land use policy through their advice to the UK Government and the National Farmers Union (NFU) on biomass availability, and on meeting net zero targets.

2. Underpinning research (indicative maximum 500 words)

For the UK to achieve its 2050 net zero target, it will require farming and land-based solutions, including the use of perennial biomass crops to generate bioenergy combined with carbon capture, and storage (BECCS). Some industrial sectors such as aviation, heavy industry, and ruminant livestock agriculture are difficult to fully decarbonise. Therefore, to achieve ambitious net zero targets, greenhouse gas removal technologies such as BECCS are required to offset these residual emissions. Perennial biomass crops are relatively new crops, and there is limited understanding of their productivity in different environments, or of the impacts of land use transitions to and from them.

The underpinning research comes from Aberystwyth University researchers providing evidence on biomass crops and land use to help the UK Government develop a net zero policy. For example, AU researchers provided evidence in the form of crop models, research papers and reviews, with 84 peer reviewed manuscripts on biomass crops in the reference period. Moreover, our researchers were members of two Climate Change Committee (CCC) advisory groups and helped inform UK policy on the role of biomass crops in a low carbon economy, on the practical implementation of net zero involving land use, and its communication.

AU researchers have studied important knowledge gaps and provided evidence to assist policymakers on: (i) the potential opportunities from the deployment of perennial biomass crops to achieve UK net zero targets, and (ii) the environmental impacts of the conversion of farmland to perennial biomass crops. This has included biomass productivity modelling on Miscanthus (e.g. the MISCANMOD and MISCANFOR models [3.1] an important tool for estimating the contribution that Miscanthus as a perennial biomass crop can make towards bioenergy and now net zero targets), and studies of land use transitions to and from both Miscanthus and short rotation coppice willow as the main perennial biomass crop types in the UK. Before the largescale planting of biomass crops occurs, as required to deliver on net zero, the environmental impacts of land use change need to be understood, and this is a particular area where AU research and policy advice has led to impact. AU researchers carried out long-term studies on the transition from grassland to biomass crops, and back again, funded by NERC [3.8], Energy Technologies Institute [3.7], EPSRC [3.9; 3.11] and BBSRC [3.10], which produced a substantial number of research publications. This led to several significant reviews, including: the measured and modelled impacts of land use change to perennial biomass crops [3.2]; evaluating the costs and benefits of land use transition to Miscanthus [3.3]; the evidence for and against six consensus statements summarising the effects of land-use change to perennial bioenergy crops [3.4]; the development of seed-based hybrids in Miscanthus for upscaling the area planted and needed for the deployment of BECCS [3.5]; the state of the art for the plant breeding of the major perennial biomass crops, for mass-scale deployment, in Europe, north America and Asia [3.6].Three of these reviews [3.2; 3.3; 3.4] were cited in the CCC Report [5.1]. These studies addressed significant knowledge gaps on the transition to biomass crops including the emissions of CO_2 and N_2O during the period of establishment; transitions from grassland to biomass crops; the impact on soil carbon sequestration; how to upscale Miscanthus and the readiness of deployment. Our studies have been particularly valuable in providing measurements during the period of transition (rather than just measurements on established crops), for providing long term datasets in mature crops, and in the Maglue project [3.9], the impact of the reversion from biomass crops back to grassland agriculture. This has significantly improved UK relevant information on perennial biomass crops available for policymakers and also for those creating models to inform policy.

3. References to the research (indicative maximum of six references)

3.1 Hastings, A., **Clifton-Brown, J.**, Wattenbach, M., Mitchell, P. & Smith, P., (2009) *The Development of MISCANFOR, a New Miscanthus Crop Growth Model: Towards more Robust Yield Predictions under Different Climatic and Soil Conditions*. GCB Bioenergy 1: 154-170. DOI: 10.1111/j.1757-1707.2009.01007.x

3.2 Harris, Z., McNamara, N., Rowe, R., Dondini, M., Finch, J., Perks, M., Morison, J., **Donnison, I. S.**, **Farrar, K.**, Sohi, S., Ineson, P., Oxley, J. C., Smith, P. & Taylor, G., (2014) Research Spotlight: The ELUM project: *Ecosystem Land-Use Modelling and Soil Carbon GHG Flux Trial*. Biofuels, 5: 111-116; DOI: 10.4155/bfs.13.79

3.3 McCalmont, J., Hastings, A., McNamara, N., Richter, G. M., **Robson, P.**, **Donnison, I.** & **Clifton-Brown, J.,** (2017) *Environmental costs and benefits of growing Miscanthus for bioenergy in the UK*. GCB Bioenergy 9: 489-507. DOI: 10.1111/gcbb.12294

3.4 Whitaker, J., Field, J. L., Bernacchi, C. J., Cerri, C. E. P., Ceulemans, R., Davies, C. A., DeLucia, E. H., **Donnison, I.,** McCalmont, J., Paustian, K., Rowe, R. L., Smith, P., Thornley, P. & McNamara, N. P., (2018) *Consensus, uncertainties and challenges for perennial bioenergy crops and land use*. GCB Bioenergy, 10: 150- 164. DOI: 10.1111/gcbb.12488

3.5 Clifton-Brown, J., Hastings, A., Mos, M., McCalmont, J.P., Ashman, C., Awty-Carroll, D., Cerazy, J., Chiang, Y-C., Cosentino, S., Cracroft-Eley, W., Scurlock, J., **Donnison, I.S.**, Glover, C., Gołąb, I., Greef, J.M., Gwyn, J., Harding, G., Hayes, C., Helios, W., Hsu, T-W., Huang, L.S., Jeżowski, S., Kim, D-S., Kiesel, A., Kotecki, A., Krzyzak, J., Lewandowski, I., Lim, S.H., Liu, J., Loosely, M., Meyer, H., Murphy-Bokern, D., Nelson, W., Pogrzeba, M.,

Robinson, G., **Robson, P.**, Rogers, C., Scalici, G., Schuele, H., Shafiei, R., Shevchuk, O., Schwarz, K-U., Squance, M., Swaller, T., Thornton, J., Truckses, T., Botnari, V., Vizi, I., Wagner, M., Warren, R., Webster, R., Yamada, T., Youell, S., Xi, Q., Zong, J. & Flavell R. *Progress in upscaling Miscanthus biomass production with seed based hybrids*. GCB Bioenergy 9: 6-17. (2017). DOI: 10.1111/gcbb.12357

3.6 Clifton-Brown, J., Harfouche, A., Casler, M.D., Jones, H.D., MacAlpine, W.J., Murphy-Bokern D., Smart, L.B., Adler, A., Ashman, C., Awty-Carroll, D., Bastien, C., Bopper, S., Botnari, V., Brancourt-Hulmel, M., Chen, Z., Clark, L.V., Cosentino, S., Dalton, S., Davey, C., Dolstra, O., **Donnison, I.**, Flavell, R., Greef, J., Hanley, S., Hastings, A., Hertzberg, M., Hsu, T-W., Huang, L.S., Lurato, A., Jensen, E., Jin, X., Jørgensen, U., Kiesel, A., Kim, D-S., Liu, J., McCalmont, J.P., McMahon, B.G., Mos, M., **Robson, P.,** Sacks, E.J., Sandu, A., Scalici, G., Schwarz, K., Scordia, D., Shafiei, R., Shield, I., Slavov, G., Stanton, B.J., Swaminathan, K., Taylor, G., Torres, A.F., Trindade, L.M., Tschaplinski, T., Tuskan, G.A., Yamada, T., Yu, C.Y., Zalesny, R.S. Jr., Zong, J. & Lewandowski I. *Breeding progress and preparedness for mass-scale deployment of perennial lignocellulosic biomass crops switchgrass, miscanthus, willow, and poplar.* GCB Bioenergy 11: 118-151. (2019). DOI: 10.1111/gcbb.12566 .

Research grants

3.7 Donnison, I.; Ecosystem land-use modelling and soil carbon GHG flux field trial (ELUM); Technology Institute (ETI); 09/05/2011 to 08/05/2014; GBP112,134.95

3.8 Donnison, I.; Understanding processes determining soil carbon balances under perennial bioenergy crops CARBO-BIOCROP; Natural Environment Research Council.;01/06/2010 to 31/12/2014; GPB80,261.67

3.9 Donnison, I.; Measurement and analysis of bioenergy greenhouse gases: Integrating GHGs into LCAs and the UK Biomass Value Chain Modelling Environment (MAGLUE;Engineering & Physical Sciences Research Council; 01/01/2015 to 31/08/2018; GBP181,716.30

3.10 Donnison, I.; BBSRC Core Strategic Programme in Resilient Crops: Miscanthus; Biotechnology and Biological Sciences Research Council. 01/04/2017 to 31/03/2022; GBP1,484,303.00

3.11 Donnison, I.; Supergen Bioenergy Hub; Engineering & Physical Sciences Research Council; 01/11/2018 to 31/10/2022; GBP488,710.00

4. Details of the impact (indicative maximum 750 words)

Impact on UK Government policy making, and legislation, to meet international targets on climate change

Aberystwyth researchers have influenced UK Government policymaking on biomass crops, climate change and land use to achieve net zero targets, through their working with the UK Climate Change Committee (CCC) and UK Government departments. For example:

i) Donnison was a member of the expert advisory group for the report on Biomass in a Low Carbon Economy (2018) [5.1] which recommended the use of greenhouse gas removals and BECCS to achieve net zero;

ii) Clifton-Brown and Donnison were part of a stakeholder group at a workshop on “Steps to scaling up UK sustainable bioenergy supply” which is highlighted within and informed the CCC Biomass report [5.1];

iii) three papers [3.3; 3.4; 3.5] authored by AU researchers, on the implications of land use transitions to perennial biomass crops, were cited in the CCC Biomass report [5.1];

iv) Donnison was a member of the expert advisory group for the CCC report on *Land use: Policies for a Net Zero UK (2020)* [5.3]. This review followed up on the CCC’s Net Zero Report (2019) and evaluates the opportunities for farmers and landowners to enable the UK to achieve its net zero target.; and

v) Donnison engaged with UK Government departments (BEIS, Defra and Department for Transport (DfT)) on future biomass availability, becoming an author of the *Supergen Scoping Report* that assessed the current state of knowledge around UK biomass resource availability for the bioenergy sector and Biomass Availability Modelling for DfT [5.8], which cites and describes the MISCANFOR model developed by Clifton-Brown and collaborators based on his earlier MISCANMOD model [3.1].

The CCC Report on *Biomass in a Low Carbon Economy* informed, and enabled recommendations on the role of greenhouse gas removals and BECCS to be incorporated into the CCC *Net Zero Report (2019)* [5.2 – pp. 26, 53, 98, 137, 142-144, 146, 148, 151-152, 156, 160, 172]. The CCC *Net Zero Report* advised the UK Government to be more ambitious in relation to tackling climate change, including by setting a course for the UK to become net zero through the use of greenhouse gas removals. UK Government accepted the recommendation of the CCC on the net zero target [5.7] and subsequently introduced legislation (Climate Change Act 2008 (2050 Target Amendment) Order 2019)) [5.6] for the UK to become net zero by 2050. As a result, the UK was the first major economy to pass a net zero emissions target into law. Both CCC reports that AU researchers have contributed to, are cited in the CCC's 6th carbon budget [5.4], which not just sets the targets but also describes the pathways to achieve them. This aligns with UK Government's initiatives on building back greener, the ten-point plan for the green industrial revolution, and hosting of the upcoming 26th Conference of the Parties (COP26) in Glasgow, November 2021.

Impact on industry take up and its communication

AU research is also helping to de-risk investment by industry. The Energy Technologies Institute (ETI) have estimated that the costs of the UK energy system would be up to GBP44,000,000,000 higher per year by 2050 without bioenergy. In other words, without negative emission technologies such as BECCS, the cost to energy consumers in the UK is likely to make industry uncompetitive and increase fuel poverty. Our engagement with industry through the NFU (Donnison is a member of the NFU Net Zero Science Advisory Panel), and with other biomass supply chain actors, is helping to create an environment in which agriculture can become net zero by 2040 [5.5]. Farmers and landowners are already reporting progress and making pledges of changes to practice via the NFU website. The net zero commitments of the UK and NFU are in turn referenced within the Agriculture Bill 2019-2021.

AU researchers have also communicated with the media to engage more widely. Donnison was asked to comment on the report ahead of publication by the UK Science Media Centre and was interviewed live following the 5pm news on Radio Wales (Good Evening Wales) on 02/05/2019 (approximately 17,000 listeners [5.9]) - the day of the publication of the CCC Net Zero Report- to discuss and describe what net zero meant for farmers and consumers. In addition, AU researchers wrote an article for *The Conversation* [5.10] on the challenge and opportunity of net zero targets for farming in Wales, following publication of CCC *Net Zero Report*, read 6,968 times with 23 comments. There were also a number of articles in the Welsh print media including in relation to the different range of targets within England, Scotland and Wales that make up the overall UK 2050 net zero target. Donnison was invited by BEIS and the Energy Systems Catapult as a technology expert to participate in a workshop in June 2018 to propose levels of ambition for the levers associated with the land use, biofuels and greenhouse gas reduction sector for the MacKay Carbon calculator [5.11]. The MacKay calculator provides a means to create pathways to net zero by 2050 and beyond; to help everyone engage in the debate and allows government to explore how its plans support the path to net zero.

5. Sources to corroborate the impact (indicative maximum of 10 references)

5.1 Climate Change Committee Report on Biomass in a low carbon economy. 2018. www.theccc.org.uk/wp-content/uploads/2018/11/Biomass-in-a-low-carbon-economy-CCC-2018.pdf.

5.2 Committee on Climate Change Report: Net Zero The UK's contribution to stopping global warming. May 2019. www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-The-UKs-contribution-to-stopping-global-warming.pdf

5.3 Climate Change Committee Report on Land Use: Policies for a Net Zero UK. 2020. www.theccc.org.uk/wp-content/uploads/2020/01/Land-use-Policies-for-a-Net-Zero-UK.pdf

5.4 Climate Change Committee, 6th Carbon Budget. www.theccc.org.uk/wp-content/uploads/2020/12/The-Sixth-Carbon-Budget-The-UKs-path-to-Net-Zero.pdf

5.5 National Farmers Union (NFU) Achieving net zero. 2020. www.nfuonline.com/nfu-online/business/regulation/achieving-net-zero-farmings-2040-goal/
and
gtr.ukri.org/resources/outcome.html#?type=policyinfluence&outcomeId=5e661a5e294f59.87979064&grantRef=EP%2FS000771%2F1

5.6 Climate Change debate, Hansard Volume 662, on 24 June 2019. Passage of law for net zero emissions, making the UK the first major economy in the world to commit to net zero. hansard.parliament.uk/Commons/2019-06-24/debates/28C238E5-2CA0-421C-AE98-B2588C102CB0/ClimateChange

5.7 Statement on the proposed Net Zero legislation statement to the House of Commons by Secretary of State for Business, Energy and Industrial Strategy (BEIS), Greg Clark, on 12 June 2019. hansard.parliament.uk/Commons/2019-06-12/debates/A348AE4C-8957-42C8-8180-0F59E597E3EA/NetZeroEmissionsTarget

5.8 Supergen Bioenergy Hub UK Biomass Availability Modelling Scoping Report. www.supergen-bioenergy.net/wp-content/uploads/2020/10/Supergen-Bioenergy-Hub-UK-Biomass-Availability-Modelling-Scoping-Report-Published-Final.pdf

5.9. Estimated audience figures for Good Evening Wales programme on Radio Wales business.senedd.wales/documents/s63445/NJW02%20BBC%20Wales.pdf

5.10 *The Conversation* article following the CCC Report on Net Zero (2019): Wales past was in coal but its future is in carbon farming. theconversation.com/waless-past-was-in-coal-but-its-future-is-in-carbon-farming-116706

5.11 The MacKay Carbon Calculator model of the UK energy system to explore pathways to decarbonisation, including net zero by 2050. www.gov.uk/guidance/carbon-calculator#the-levels-of-ambition