QUB-Mechanical and Aerospace Engineering PhD Project 2018-2019

Title: Renewable energy crops for reducing agricultural run-off and improving water quality

Project description:

Background

It is proposed that bioenergy crops, such as short rotation coppice (SRC) willow, could be used for the purpose of decreasing nutrient loading, thus fulfilling three roles: providing a renewable source of energy, reducing risks to water quality, and improving the sustainability of food production. With UK targets for 15% renewable energy by 2020 [1] and an 80% reduction in greenhouse gas emissions on 1990 levels by 2050 [2], there is a drive to expand bioenergy production. Although progress is being made regarding the proportion of energy being supplied from renewable sources within the Interreg VA area, this is predominantly in the power sector with the larger heat sector requirement being left far behind. It was estimated at the beginning of 2016 that approximately 6% [3] of N Ireland's heat requirement of 17.4 TWh per year [4] was being achieved against a backdrop of a 10% target by 2020. In the Republic of Ireland this figure was 6.8% of a 12% 2020 heat target [5] and in Scotland this figure was 4.8 to 5% of an 11% 2020 target [6]. Support for locally produced energy crops can help to address these shortcomings.

Ambitious targets for increased agricultural output, including a 60% rise in turnover by 2020, are also in place in N Ireland, and the 'Going for Growth' agri-food action plan has said that these increases should take place in an environmentally sustainable production model [7]. To date, however, energy, agricultural and environmental policies have generally been developed in isolation, and the interlinkages between food, energy and water have often been overlooked. Despite this, there is the potential for cross-sectoral measures to enable simultaneous progress towards multiple sustainability goals [8].

In N Ireland, 63% of water bodies are not achieving the 'Good or Better' status required by the Water Framework Directive, a performance well below the EU average (47%). This is caused by both wastewater treatment and agricultural pollution, where runoff from intensive slurry and dirty water land application, as well as legacy soil phosphorous (P), are major contributors. New management practices are being driven by the DAERA commissioned report, 'Delivering Our Future, Valuing Our Soils: A Sustainable Agricultural Land Management Strategy for Northern Ireland' (SALMS), which made recommendations for reducing risks to water quality; these recommendations include the targeted planting of woody crops/trees to intercept existing nutrient migration over land, through soils and into water resources [9].

Project aims

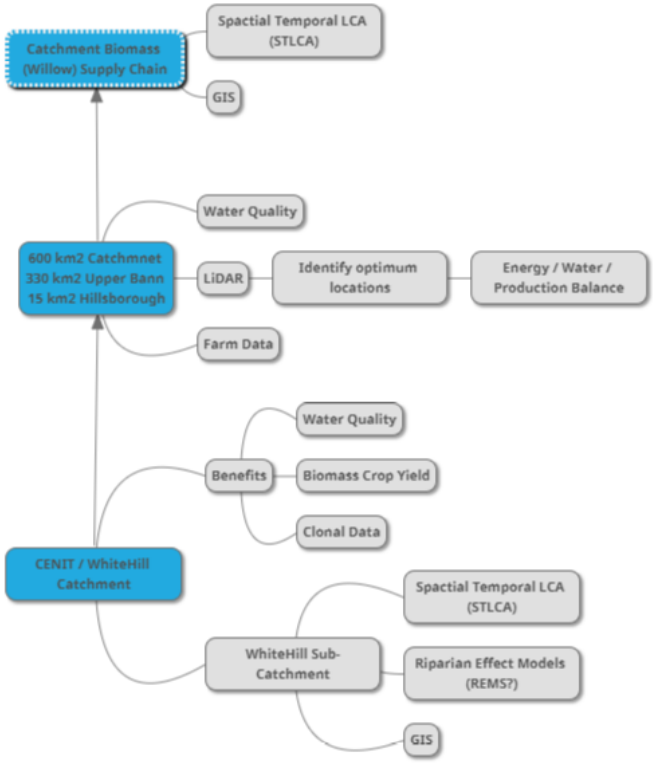
In order to achieve the changes in agricultural practice required for sustainable land management, the impacts of the proposed measures must first be thoroughly understood so that there is solid scientific evidence regarding the sustainability of agricultural outputs and that effective and straightforward recommendations can be issued to farmers [9]. There has been ongoing field research at AFBI since about 2000 investigating the efficacy, applicability and nutrient management potential of different site management techniques, with the more recent inclusion of strategically positioned SRC willow to protect against diffuse pollution into the environment. Following on from the field research, the aims of this project are (i) to utilise data from the field trials to investigate the effectiveness of renewable energy crops for reducing agricultural run-off and improving water quality, and (ii) to develop a model to analyse the impact of such systems on a wider scale and make recommendations for agri-environmental policy.

Project methods, novelty and impact

The impacts of nutrient runoff on the environment are affected by both spatial (e.g. characteristics of the receiving environment such as soil type) and temporal (e.g. weather conditions, time of year) issues. This type of variability cannot be comprehensively assessed using standard static life cycle analysis (LCA) techniques [10], and it is therefore proposed to use spatial-temporal LCA (STLCA) integrated with geographic information systems (GIS). STLCA combined with GIS is an area of research that is still under development, and the evaluation of STLCA for agriculture has been cited [11] as an area requiring attention. This project will contribute to developing the methodology. The environmental impacts investigated will be expanded beyond the standard indicators to include ecosystem services and non-market co-benefits (e.g. water quality, biodiversity, soil carbon sequestration and production from the point of view of biomaterials and the stabilisation/sustainability of an

agricultural production unit). The exclusion of these factors from existing LCAs has been cited as a limitation of the applicability of findings [10,12], and this project will address this gap in the literature. The inclusion of non-market co-benefits in the assessment will also assist in policy development. The SALMS report [9] highlighted the importance of environmentally positive farming being a profit rather than a cost centre; by including non-market co-benefits in the assessment, a more complete analysis of the 'cost' benefits of cross-sectoral measures in the food-water-energy nexus can be realised.

Current platform linkage



Activities ongoing at the CENIT/Whitehill Catchment will produce data on benefits. The use of modelling systems (e.g. REMS) will allow the effects of bioenergy crop diffuse pollution mitigation measures to be extrapolated to a larger catchment scale (15 km2, 300 km2 etc.) based on water quality, LiDAR and other farm data. This in turn will supply the relevant data for assessment of catchment-based biomass and the economics of an integrated approach for dealing with the agriculture/water quality/energy nexus.

The successful PhD candidate will be based between AFBI, Queen's University Belfast (QUB) and the University of the Highlands and Islands (UHI), but the majority of time will be spent on the AFBI site in Hillsborough.

Key skills required for the post:

- A minimum of a 2:1 or first degree in a relevant discipline/subject area (Agriculture, Chemistry, Biological/Environmental Science, or Civil/Environmental/Mechanical/Chemical Engineering) or
- A masters degree in a relevant subject area (Agriculture, Chemistry, Biological/Environmental Science, or Civil/Environmental/Mechanical/Chemical Engineering). The masters must have been attained with overall marks at merit level (60%). In addition, the dissertation or equivalent element in the masters must also have been attained with a mark at merit level (60%). Students with a postgraduate masters degree should preferably also hold a minimum of a 2:1 in their first degree.
- Experience or knowledge of bioenergy and agri-environmental issues is preferable.
- Analytical skills along with high self-motivation and preparation for laboratory/field work are required.
- Students should demonstrate the potential to engage in innovative research and to complete the PhD within a prescribed period of study.
- English language proficiency is essential (please refer to http://www.qub.ac.uk/International/International-students/Applying/English-language-requirements/).

Key transferable skills that will be developed during the PhD:
At the end of the doctorate the candidate is expected to have developed generic and transferable skills in time management, problem solving, report writing and oral presentations. The student is also expected to develop a considerable skillset in bioenergy and agri-environmental area. The project will also benefit from the collaborations with the project partners and the wider group within the Bryden Centre. Collaboration with industrial partners is also expected, and this should enhance both professional standing and competency.

The successful candidate will also have access to supplementary professional training, allowing him/her to develop skills in analytical and interdisciplinary thinking; improved oral and written communication skills through dissemination of research findings; contacts for future projects, employment and funding opportunities; and

project management skills in preparation for future challenges in both industrial and academic settings.	
AFBI supervisors **First/Lead academic supervisor**	Mr Chris Johnston/Dr Gary Lyons, Agri-Food and Biosciences Institute, Large Park, Hillsborough, chris.johnston@afbini.gov.uk, gary.lyons@afbini.gov.uk, +44 (0)28 9268 2484 Dr Beatrice Smyth, School of Mechanical & Aerospace Engineering, Queen's University Belfast, beatrice.smyth@qub.ac.uk, +44 (0)28 9097 4318
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Funding	Funding is for 39 months and covers full university tuition fees for UK/EU students and a stipend of £14,553 per annum. There is also the opportunity to undertake teaching and demonstration duties to earn a further £1,500 per annum. International students would be required to pay the balance in tuition fees, currently in the region of £15,500 per annum; details of international fees are available on the QUB website: http://www.qub.ac.uk/International/International-students/International-tuition-fees/
Project links	This project is part of the Bryden Centre, which has been funded under the European Union's INTERREG VA Programme. The Bryden Centre will create a 'virtual centre of competence' that will support industry-led applied/pre-commercial collaborative research on a cross-border, interregional basis that is focused on two specific forms of renewable energy: bioenergy and marine renewable energy. Please see the website for more information: https://www.brydencentre.com/

References

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