National University of Ireland, Galway
Ollscoil na hÉireann, Gaillimh

SAMPLE 2

Department of Economics

MPhil/PhD Proposal Form

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Please enter full correspondence details for Institution Co-supervisors(s) who will act as co-supervisor(s) for the project:*

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Project Title	Development of a linked agri-environmental model

Where applicable some institutions such as Teagasc are involved in co-supervision

Research Centre Location for Project:	NUIG/RERC, Teagasc

Start Date: September 2008	**Finish Date:** August 2011

Is the project externally funded:	**Yes**	**No**
If yes please name the sponsor:		

Breakdown of Funding

	Year 1	**Year 2**	**Year 3**
Fellowship Stipend*	**€21,000**	**€21,000**	**€21,000**
Other Project funds			
Total	**€21,000**	**€21,000**	**€21,000**

***Currently €21,000 per annum**

1. PROJECT ABSTRACT
(300 words max.)

Because of current environmental legislation in European farming, there is a need to understand the potential economic impact on the agricultural sector. This requires the development of tools that can link both farm production with bio-environmental information. There is a growing interest in using linked agri-environmental models (or what are more commonly referred to as bio-economic models in the literature) as a tool for policy analysis to better understand pathways of development and to assess the impact of alternative agricultural and environmental policies on the soil, water and air (Okumu et al. 2002; Holden, Shiferaw and Pender 2004). One of the potential benefits of these models is that one can get a better and more comprehensive indication of the feedback effects between farming activity and natural resources. The purpose of a bio-economic model is to analyse the possible effects of technology change and policy interventions on farm household welfare and the quality of natural resources such as soil, water and biodiversity. Also, modern computer power permits development of complex models far beyond what was possible only a few years ago.

It has therefore become possible to make models that are theoretically more consistent and empirically more accurate. By linking the RERC Spatial Microsimulation Model of the Irish Local Economy (SMILE model) and the environmental models developed in Johnstown Castle, Teagasc (in collaboration with Rogier Schulte of Johnstown Castle we will link the NCYCLE and to SMILE) this project aims to develop on overall modelling tool that will facilitate the study of the impact of policy or farm input change on 1. the characteristics of the natural resource base, 2. the impact on the environment and 3. the impacts on the economic return of the farm operator. The model would be used to simulate and evaluate the potential impact of the water framework directive on the agricultural sector in Ireland.

2. PROJECT DESCRIPTION

2.1 Title: Development of a linked agri-environmental model

2.2 Justification (e.g. economic, gaps in existing knowledge, expected benefits) (400 words max.)

There are a number of reasons why the development of a bio-economic model would be a worthwhile research activity for the organisation:

- A modelling tool that would enable the study of the inter-temporal impact of key integrated agricultural management technologies (e.g., high yielding varieties, cropping systems, cereal-legume rotations, soil and water conservation structures, integrated nutrient and pest management) on the economic performance and welfare of farm households and on soil and water condition would be a valuable asset in terms of examining the future impacts of recent European legislation such as the Water Framework Directive, the Nitrates Directive, etc.
- A farm level bio-economic model would also allow for the identification and evaluation of appropriate technologies, economic policy instruments and the institutional needs for enhancing the effectiveness of the Irish Agri-environmental programmes such as the Rural Environmental protection Scheme (REPS).
- A farm level bio-economic model would also allow for the identification of the best land use strategy for the maximisation of farm incomes under alternative environmental legislative frameworks.
- A farm level bio-economic model would also allow for the assessment of the impact of flooding (or drought) under climate change scenarios on farm production, income and welfare.
- The linking of the Johnstown environmental models with the RERC SMILE population Model would also allow for the assessment of the impact of a switch to biofuel production, for example, in combination with population growth on water and soil quality, farm production, income and welfare
- The methodology used to build the model could also identify technologies and policy interventions necessary for the sustainable management of resources by the Irish farm community and contributes towards realization of Teagasc's vision for 2030 under the "Towards 2030" Foresight Report.

2.3 Methodology and other details: (Please ensure that sufficient details are provided to enable the reviewers to establish: hypotheses, the relevant/appropriateness of methodologies being proposed.) (1,500 words max.)

The conceptual framework of a bio-economic farm model illustrates the interaction of various exogenous factors with farm household decisions (production and consumption) and the condition of the natural resource base. The farm level decisions on land use, livestock mix, adoption of soil and water conservation technologies, new crop varieties and fertilizer use jointly determine the rate of land degradation, water quality, productivity and income. Bio-economic models can be classified into different categories based on different criteria such as a) emphasis on biophysical component or economic component, b) time scale, c) level of aggregation. Bio-economic models vary in terms of their emphasis on the economic or biophysical components in the model.

Brown (2000) identifies the following categories: i) biophysical processes models to which an economic analysis component is added; ii) economic optimization models that include a biophysical component; iii) integrated bio-economic models.

Biophysical models are primarily designed to simulate agro-ecological processes involved in various systems such as crop production, livestock, agri-forestry and soil and nutrient. Such models may be a detailed description of a single component or model the major inter-linked components of a particular ecosystem. Most biophysical models also incorporate some socio-economic issues and accounting equations that enable to calculate the benefits and costs of alternative scenarios.

Economic optimization models on the other hand involve decisions related to production and resource use cover a wide range of models that differ on the way the biophysical components are included in the model. Some economic optimization models take a simplistic approach in which the model basically optimises farm income but includes some biological equations that measure the sustainability of the system being modelled. Others are more complex in that they attempt to account for the possibility of multiple objectives (economic and sustainability) by taking into account the dynamic relationships through the use of multi-period modelling approach. Barbier and Carpentier (2000) distinguish two ways in which environmental problems are included in bio-economic models. The most common way is to simulate the effects of economic decisions on the environment without taking into account the feedback effect of the change in the condition of the environment on the production function of the model. The second and more difficult way is to model the feed back of natural resource degradation on agricultural production. Integrated bio-economic models refer to the later type of models in which the economic features of economic optimization models and the biophysical processes are adequately taken into account. The strength of the bio-economic modelling approach lies in the close integration of important biophysical information and ecological processes with economic decision behaviour.

In this project we aim to develop the second type of model described above by integrating a spatial microsimulation farm model with environmental models for soil and water quality. Habitat data will also be incorporated using a GIS framework. The economic model to be used is as previously mentioned, the RERC SMILE Model (See Hynes et al, forthcoming). To enrich our knowledge of farming activity at a more regional level in Ireland the RERC SMILE Model combines the National Farm Survey and the Census of Agriculture to create an attribute rich synthetic farm dataset with information on every farm in Ireland at the Electoral Division (ED) level. The RERC SMILE farm level model is basically a spatial microsimulating tool used to build this synthetic dataset of the Irish farm population. This data has also been linked to household information from the Living in Ireland Survey, so that the model contains not only farms, but farm household non-farm incomes and in addition all non-farm households, containing both the location of their economic activity and where they reside.

As with most microsimulation models the first step is to generate a population microdata, which comprise lists of individuals along with an associated set of individual characteristics (Williamson et al, 1998; Williamson, 2002). The chief task in microsimulation is to select individuals from a microdata set to fill census areas. In the context of the research presented here we generated synthetic farm population microdata sets at the Electoral Division (ED) level for Ireland with the use of a Simulated Annealing (SA) based reweighting programme. SA is a generic probabilistic meta-algorithm for the global optimization problem, namely locating a good approximation to the global optimum of a given function in a large search space. The SA algorithm was implemented in Java, an object-oriented programming language, which has been accepted as the most suitable type of programming language for spatial microsimulation modelling (Ballas and Clarke, 2000; Ballas et al, 2005). The programme aims at implementing a combinatorial optimisation approach to generating spatially disaggregated population microdata sets at the small area level (in our case, EDs). Object-orientated modelling has, amongst other benefits, the added advantage of platform-independence.

The spatial microsimulation process is complete when the selection of farms from the NFS can reproduce the SAPs tables for the number of farms by size and system and soil type contained in the Census of Agriculture with less than 5% of a difference between the original SAPS tables and those generated from the NFS selection. Once this point is reached the programme stores the set of farms for that ED and repeats the process to find the set of NFS farms that best fits the Census SAP tables for the next ED and so on. Matching the NFS and the SAPS data creates synthetic demographic, socio-economic and farm level variables, such as martial status, age, fertiliser usage, livestock units per farm, etc and most importantly from our research perspective an indicator value for each farmer in the population indicating whether or not he or she is participating in the REPS programme. The simulating annealing process conduced for this research produces 145,000 individual farm records.

The RERC SMILE microsimulation model therefore contains a database of farms containing all the data from the National Farm Survey and non-farm households containing data from the Living in Ireland Survey at the Electoral district.

The objective of the analysis is to be able to simulate the impact of economic activity (both agricultural and non-agricultural) on water quality and other environmental issues. In order to do this, we require better spatial information about this economic activity than the electoral district location. A technique has been developed by an existing Walsh Fellow John Cullinan at RERC, to use GIS to assign households to actual spatial points derived from addresses in the geo-directory. This method will be used to locate farms synthetically to spatial points provided by the DAFF.

In the development of the bio-economic model it is intended to incorporate, in collaboration with Rogier Schulte of Johnstown Castle, a number the centres NCYCLE environmental model into the SMILE framework. NCYCLE is a mass balance empirical model that was developed in the UK for grassland and calculates the annual N transformations, fluxes and losses for cut and grazed grassland at the field scale, according to inputs specifying climatic zone, soil texture and drainage class, sward management and age and fertilizer input. The annual leachable NO_3 load is predicted on a per hectare basis. The model also enables the overall efficiency of N use to be calculated, so that the feasible trade-offs between production and environmental impact can be identified. Gaseous N losses from ammonia (NH_3) volatilization and denitrification are also calculated and account for possible N pollution swapping to be identified.

The NCYCLE model is different from other empirical approaches because it employs submodels that allow a high degree of application in relation to climate zone, soil conditions and land management so has the potential to be developed for many temperate grassland sites. The general principles for the reformulation of NCYCLE for application to N cycling in other temperate grasslands with specific reference to Ireland were as follows (del Prado et al., 2006):

1. Identification of grassland agroclimatic areas.

2. Consideration of the case for the inclusion of a range of fertilizer types (e.g. urea or ammonium nitrate.

3. Development of a new mineralization submodel according to climatic zone and plant residue quality.

4. Addition of an Irish map in which different values of atmospheric N from deposition at field scale are associated to different areas of Ireland.

5. Modification of N uptake and partitioning in the plant.

6. Refinement of harvesting of herbage by cattle, N capture by the rumen and partitioning into product and excreta according to feed characteristics and animal type.

7. Simulation of partition of excreta into N in urine and dung according to feed characteristics.

8. Modified NH3 production from urine and dung according to climatic zone and feed quality.

9. Derivation of the denitrification and leaching submodel according to climatic zone.

Overlaying spatial environmental information such as soil type, slope, water conditions and other variables required by the NCYCLE model, allow us then to model agricultural activity within the environmental context, while NCYCLE will allow for local environmental indicators to be simulated.

Each farm in the model therefore will contain both agricultural activity and all the variables required by NCYCLE to model the impact on localised water quality. To consider wider Water-Framework Directive Analyses will however require us to understand the hydrology of the water catchment and the relationship between economic activity (agricultural and non-agricultural) on water quality in rivers, lakes and estuaries. This is clearly beyond a single PhD fellowship, although the project will benefit from research developed as part of the min-catchment programme. An intermediate solution that will be used will be to calibrate the model results using EPA water quality information. Understanding the spatialised local water quality, the environment (slopes, water, water flow, soils) in a catchment and the economic activity (farm and non-farm) will allow us using spatial regression techniques to relate the spatial pattern of local water quality to catchment and downstream water quality indicators.

A modelling approach, such as that outlined above, that combines a farm microsimulation model of economic behaviour with biophysical models of plant growth, chemical absorption and the condition of the soil would allow for the identification of the best land use strategy for the maximisation of farm incomes under alternative environmental legislative frameworks.

The final part of the PhD will focus on assessing the relationship between economic (agricultural and non-agricultural) activity on water quality and to simulate alternative options required to meet water quality targets. The economic cost of potential agricultural responses will be considered and will be linked to non-market valuations of the benefits of better water quality as part of Mavre Stithou's Walsh Fellowship research at RERC to understand the cost and benefits of meeting the WFD targets.

References

Ballas, D., Clarke G.P. (2000), 'GIS and microsimulation for local labour market analysis', *Computers, Environment and Urban Systems*: 24: 305-33

Ballas, D., Clarke G.P., Dorling D., *et al* (2005), *'SimBritain: A spatial microsimulation approach to population dynamics'*, Rowntree, York.

del Prado, A., Brown, L., Schulte, R., Ryan, M. and Scholefield, D. 2006. "Principles of development of a mass balance N cycle model for temperate grasslands: an Irish case study" *Nutrient Cycling in Agroecosystems*, 74:115–131.

Barbier, B. and Carpentier, C. 2000, The conditions for sustainability of tropical agriculture: Bio-economic models applied to five contrasting farming systems, Paper presented for a symposium on modelling at the International Association of Agricultural Economists conference, Berlin.

Brown, R. D. (2000), A review of bio-economic models, paper prepared for the Cornell African Food Security and Natural Resource Management program.

Holden, S. and B. Shiferaw (2004), "Land degradation, drought and food security in a less-favoured areas in the Ethiopian highlands: a bioeconomic model with market imperfections", *Agricultural Economics*, 30-31- 49.

Hynes, S., Morrissey, K., O'Donoghue, C. and Clarke, G, (forthcoming) 'Building a Static Farm Level Spatial Microsimulation Model for Rural Development and Agricultural Policy Analysis in Ireland', *International Journal of Environmental Technology and Management*.

Okumu, B., M.A. Jabbar, D. Colman, D. Russell, M.A. Mohamed Saleem and J. Pender, 2000, Technology and policy impacts on economic performance, nutrient flows and soil erosion at watershed level: the case of Ginchi in Ethiopia, Global Development Network (GDN).

Williamson, P. 2002, 'Synthetic Microdata' in *The Census Data System*, (eds.) P. Rees, D. Martin, and P. Williamson, Wiley, Chichester

Williamson, P., Birkin, M. and Rees, P.H. 1998, 'The estimation of population microdata by using data from small area statistics and samples of anonymised records', Environment and planning A, 30, 785-816allas, D., Clarke G.P., Dorling D., et al (2005), '*SimBritain: A spatial microsimulation approach to population dynamics'*, Rowntree, York.

2.4 Workplan and Timescale: (The objective here is to clearly demonstrate that thought has been given the major components of the workplan rather than being overly prescriptive).

Task	**Title**	**Timescale**	**Any other relevant information**
No.	**Text (500 characters)**	**No. of Months**	**Text (750 characters)**
1	Recruit fellow	2	Completed by end of September 08
2	First Supervisory team meeting	1	Teagasc supervisor, university supervisor and student meeting (held monthly thereafter)
3	Literature review of previous work conducted on bio-economic modelling approached in Europe and the USA.	3	
4	Assemble models and relevant existing land use and habitat data for relevant years for analysis.	2	This phase will involve the Spatial Analysis team in RERC and Rogier Schulte in Johnstown Castle who will assist in combining the geo references information and the environmental models into the SMILE model.
5	Develop methodology to link the models and other related data within a GIS framework.	8	
6	Use the bio-economic model to analysis the appropriateness of technologies, economic policy instruments and the institutional needs for enhancing the effectiveness of Irish Agri-environmental programmes	6	
7	Develop a calibration mechanism using Teagasc and EPA data	6	
8	Using the combined models and habitat land cover data to examine interactions between aspects of biodiversity, chemical leaching, water quality and farming activity.	5	
9	Editing and write-up of thesis	5	It is assumed that individual sections will be written up throughout the course of the project

2.5 Expected outcomes: (e.g. deliverables) (400 words max.)

1. Literature review of previous work conducted on bio-economic modelling approached in Europe and the USA.
2. A paper outlining the development of the linked bio-economic model.
3. A number of papers that evaluate of appropriateness of technologies, economic policy instruments and the institutional needs for enhancing the effectiveness of Irish Agri-environmental programmes.
4. A PhD thesis awarded by the National University of Ireland.

3.1 AFFIRMATION

Signature of applicant (student): ______________________________ **Date:** ____________________

(Attach list of any relevant publications or reports if applicable for the applicant)

3.2 AFFIRMATION

Signature of primary NUIG supervisor: ___________________________ **Date:** ______________

(Attach list of 5 most recent peer-reviewed scientific publications for main college applicant)

Hynes S., N. Hanley, C. O'Donoghue, forthcoming, "Using Spatial Microsimulation Techniques in the Aggregation of Environmental Benefit Values: An Application to Corncrake Conservation on Irish Farmland", *Land Economics*.

Hynes S., K. Morrissey, C. O'Donoghue, G. Clarke, *forthcoming*, "A Spatial Microsimulation Analysis of Methane Emissions from Irish Agriculture", *Ecological Complexity*.

Hynes, S., N. Hanley and C. O'Donoghue, *2009* "Measuring the opportunity cost of time in recreation demand modelling: an application to a random utility model of whitewater kayaking in Ireland", *Journal of Environmental Management*.

Hynes S., K. Morrissey, C. O'Donoghue and G. Clarke, *2008* "Building a Static Farm Level Spatial Microsimulation Model for Rural Development and Agricultural Policy Analysis in Ireland", *International Journal of Environmental Technology and Management*.

Hynes, S., N. Farrelly, E. Murphy and C. O'Donoghue, *2008* "Modelling Habitat Conservation and Participation in Agri-Environmental Schemes: A Spatial Microsimulation Approach", *Ecological Economics*.

Signature of Institution (Co-supervisor): ______________________________ **Date:** __________________

(Attach list of 5 most recent peer-reviewed scientific publications for Institution Co-supervisor)

Hynes, S. and Cahill, B. 2007. "Valuing the benefits to the local community of supplying recreational facilities in community owned forests: an application of the contingent behaviour method" *Small-scale Forestry*, 6:219–231

Christie, M., Hanley, N. and Hynes, S. 2007. "Valuing Enhancements to Forest Recreation using Choice Experiments and Contingent Behaviour Methods" *Journal of Forest Economics*, Volume 13, Issues 2, P 75-102

Hynes, S., Buckley, B and van Rensburg, T. 2007. "Recreational Pursuits on Marginal Farm Land: A Discrete-Choice Model of Irish Farm Commonage Recreation". *The Economic and Social Review*, Vol. 38, No. 1: 63 – 84.

Shrestha, S., Hennessy, T. and Hynes, S. 2007. "The Effect of Decoupling on Farming in Ireland: A Regional Analysis" *Irish Journal of Agricultural & Food Research*, 46: 1.

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Mill, G., van Rensburg, T., Hynes, S. and Dooley, C. 2007. "Valuing Preferences for Multiple Use Forest Management in Ireland: Citizen and Consumer Perspectives" *Ecological Economics* 60: (3) 642-653.

Hynes, S. and Hanley, N., 2006. "Preservation versus Development on Irish Rivers: Whitewater Kayaking and Hydro Power in Ireland". *Land Use Policy*, vol. 23, p170 - 180.