Proposed complexity mini-project
Supervisor – Yasmin Merali (Rosemary Collier and David Pink, HRI will be the "clients" for this project)

Supply of Lettuce to the UK pre-pack market.

The the food supply chain in the UK is complex involving a number of stakeholders/players and subject to a range of 'internal' and 'external' factors/parameters and influences which affect supply, demand and security of supply.   Some of these factors/parameters have predictable fluctuations, influences and impacts, others less so, and the complexity arises from the way in which they interact with each other and elements of the supply chain. The supply of perishable food with short shelf-life presents some interesting planning problems for producers and suppliers who want to have the capacity to deliver the right quantity of quality produce to meet market demands in a manner that is economically viable and environmentally responsible.

Producing a model of the supply chain would allow us to develop a better understanding of the systemic effects of fluctuations in the factors and parameters so that we could test the robustness of the supply chain under different scenarios. However, attempting to develop a model for the whole UK food supply chain would be very difficult. A more feasible approach would be to develop and test a model based upon an exemplar supply chain which exhibits a range of features associated with the supply of UK food in general.

The purpose of this project is to develop such a model for the supply of lettuce in the UK bagged salad market, based on research undertaken at HRI to look at the value system and supply chain for delivering lettuce to the UK pre-pack market. The project will entail a staged process, starting out with the development of a generic supply chain model using on data and relationships that we have already established (see below for examples). The model will then be incrementally enhanced to enable us to explore scenarios under different conditions in order to understand how growers and processing companies can address questions about how to balance patterns of growth and production to meet the possibly conflicting requirements for demand satisfaction, waste minimisation, reduction of the ecological footprint of the supply chain and reduction of exposure to risk form extreme events.

The researchers at HRI have collected a significant amount of data about the supply chain and demand fluctuations of a major UK supplier of pre-packed salad, and established a number of interesting parameters and relationships that would be useful to incorporate in the model. The next paragraphs provide a flavour of the problem domain and types of data/relationships we have to play with.

Lettuce like other fresh produce is currently marketed through a 'just in time' supply chain, and is vulnerable to potential disruption by a range of social, economic, environmental and factors (e.g. food scares, biological hazards (e.g. food poison microbes), energy issues, transport issues, pests and diseases, availability of labour, extreme weather events etc, etc.). Ready-to-eat bagged salads are high added value products, however, the value is not distributed evenly throughout the supply chain with most of the 'added value' being gained by the major retailers.   Salad bags are prepared in food factories belonging to companies such as Bakkavör: http://www.bakkavor.is/ Raw ingredients are supplied by companies growing crops in different geographical locations. The main UK growing season for lettuce is approximately April to October, but the start and end of production in the UK is heavily dependent on weather conditions. Outside of the UK growing season (and sometimes also within it), lettuce is sourced from locations with more favourable winter climates. In order to maintain continuity of supply some UK companies have farms in Spain, Portugal and Kenya and some are exploring growing in North Africa. These arrangements have environmental implications, as the lettuces are transported by lorry or airfreight (from Kenya, and in times of shortage from California).

Examples of data and relationships that we have established or can access :
- Effect of temperature on lettuce growth : the rate of lettuce growth is temperature dependent and we have got formula for predicting maturity dates
- Thresholds for reduced quality (yield) The weather can also impact adversely on quality and therefore, yield: we have got some thereshold data for this (e.g. for hail, frost, ..)
- Sets of weather data for different locations
- Demand fluctuations: The demand for salad depends on season, weather (temperature and rainfall) during seasons, social patterns (e.g. holidays, Christmas) and it may also depend on economic conditions – we have historical data for demand patterns
- Limits on capacity for harvesting (e.g. labour, vacuum cooling capacity in the field, refrigerated transport from field to factory) and processing (in the factories)
- Economics of production: cost of growing, options for harvesting & processing, waste (in the field, in transit, on shelves, in households and in the design of overlaps of production in the system for ensuring continuity of supply)
- Energy implications and ecological footprints

The problem domain is a complex one, and some of the balancing decisions depend on the values that may be attached to different ambitions (– e.g. cost reduction and the reduction of the ecological footprint).   The development and comparison of behaviours of the system under alternative scenarios will enable us to explore the trade-offs involved in various strategies for improving the economic and ecological performance of the supply chain, and the impact of these on the different stakeholders.