Global Food Security MULTI-DISCIPLINARY PERSPECTIVES

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Abstracts

Ivan Reyna-Llorens, Department of Plant Sciences

Using evolution to improve crop productivity; the case of the C4 pathway

Plants use light energy to produce the chemical energy required to live and build biomass. At the same time, plants have evolved different ways to capture and fix carbon dioxide (CO2) from the atmosphere in the most efficient way. The C4 pathway is a carbon concentrating mechanism that evolved multiple times during plant evolution and gives the plant higher photosynthetic capacities than those possessing the ancestral C3 pathway. As a consequence C4 crops are the most productive of the planet. My project focuses on understanding the changes required to acquire the efficient C4 pathway. We use different plant models and a wide variety of molecular and computational tools to address this. In the long term we aim to contribute to improving crop productivity with this knowledge.

Natalia Przelomska, Department of Archaeology

Foxtail millet: could the sustenance of our ancestors become a health food and contribute to food diversity in the future?

With a steadily growing human population, food security is a world-wide priority. Both quantity and quality of food need to be considered. Millets are – at present – a group of cereals of low global economical significance, yet they play the role of staple crops for communities in parts of Asia and Africa.

Ecological and nutritional properties of millets render them noteworthy contenders for grains that will help sustain future generations. 97% of millet is produced in developing countries, where climate change is predicted to have the greatest effect and the human population is expanding most rapidly. One underlying reason is that millets are able to withstand periods of drought. Thanks to traditional farming methods and preservation of landrace collections in seed banks, genetic diversity is high in many of these crops, giving scope for adaptation to new climates.

In my PhD research I am studying foxtail millet (*Setaria italica*). This was one of the earliest domesticated crop species. The genus *Setaria* is being developed as a model species and is thus convenient for genetic research. I am looking into the genetic basis of variation in flowering time in over 300 accessions of Eurasian origins. Flowering time is an adaptive trait, allowing a crop to spread to new ecological zones and to complete its life cycle in unpredictable environments.

While my studies will give insight into the environmental adaptability of foxtail millet, an important avenue for research remains untrodden. Given the diversity retained amongst accessions of foxtail

millet, its nutritional properties require attention. Elevating the production and popularity of millets would diversify diets, with potential health benefits, such as meeting requirements for essential nutrients (particularly for people suffering from coeliac disease) and reducing the prevalence of Type 2 diabetes.

Penny Jones, McDonald Institute for Archaeological Research

Food security, climate change and the Indus Civilisation, 3000-1500 BC

This project investigates climate change and its impacts on food security in the Indus Civilisation, which flourished across the plains of north-western India and Pakistan between *ca* 3000-2000 BC. At its height, the Civilisation supported several cities, complex crafts and extensive trade networks, but from *ca* 2000 BC the cities declined and the Indus material culture disappeared.

The cause of the Indus decline remains controversial but a leading hypothesis attributes the Civilisation's decline to a climate change-induced food security crisis. There is mounting evidence for an abrupt reduction in monsoon rainfall *ca* 2200 BC, and it is frequently argued that placed wheat and barley supplies under drought stress and thus undermined urban food security to a critical degree. However, this hypothesis remains controversial and has not until now been effectively tested.

This research uses stable isotope analysis of faunal and crop remains from several Indus sites to directly test firstly how much monsoon rainfall actually declined on a local, site-specific basis, and secondly whether the staple crops at each site came under increasing water stress. Together, this tests whether climate change could have had a tangible, significant impact on food security, on a site-by-site basis.

This will not only make a significant contribution to our understanding of the role of climate change and food security in the Indus decline, but may offer constructive insights for meeting the region's future food security challenges. In particular, by testing for increasing water stress at several sites with very different crop assemblages, this project may offer insights into the relative resilience of various agricultural systems to shifts in monsoon rainfall. This is likely to be a key question for regional food security in coming decades, and with effective interdisciplinary collaboration, archaeological and palaeoclimatic research has the potential to provide a valuable contribution.

Erasmus zu Ermgassen, Department of Zoology

Land Use Savings from Recycling EU Food Wastes as Pig Feed

Livestock production occupies 45% of the planet's terrestrial land area, consumes 35% of the world's grain, and produces 14.5% of anthropogenic greenhouse gas emissions. With demand for meat and dairy products forecast to increase 50% by 2050, there is a pressing need to reduce the footprint of livestock. Food wastes are a potential source of environmentally benign animal feed, but their inclusion

in feed is currently banned in the EU because of disease control concerns. A number of South East Asian states have in the last 20 years, however, introduced a regulated, centralised system for safely recycling food wastes into animal feed. This study quantifies the land use savings that would result from including food waste in EU pig feed and discusses the barriers to implementation. We find that the application of existing technologies would reduce the land use footprint of EU pork (20% of world production) by 49.5% (29.1-70%), including more than 1.0 (0.8-1.3) million hectares of soybean production. This would reduce demand for 3-5% of the soybean harvest of Brazil, where 137 species are currently threatened by soybean expansion in the savannahs of the Cerrado.

Katya Yatskovskaya, IfM

Agri-Food Supply Chain Sustainability driven by water scarcity

Global population growth is causing increasing pressure on food production, food security, and the efficient use of natural resources.

The global population tripled during the twentieth century, when it reached six billion people, and was projected to increase to seven and a half billion by 2020, and to about nine billion by 2050 (Tilman et al., 2001). Due to this population growth there has been a high demand on food production, resulting in agricultural expansion. In the twentieth century there was an increase in the number of farmlands and a growth in the number of irrigation systems used to produce high yield crops. Consequently, the general trend in global food production was characterised by a change from food shortage to food surplus, resulting in food affluence and low prices (Spiertz et al., 2009)

Unfortunately, the excessive use of natural resources as a result of this growing population trend has caused a degradation of the land, shortages of water, and a negative impact on the ecosystem. Moreover, changing diet patterns of the global population and rapid urbanization have brought additional challenges for future food production. Increases in global income levels have influenced a shift towards a greater demand for more protein-rich products, such as meat. Meat production is a highly water consuming process and imposes additional pressure on the availability of finite water resources. Urbanisation also requires additional land and water, which often results in competition among different water-use sectors (Qadir et al., 2007).

All these factors can lead to less water being allocated to agriculture. As a result, poor quality water is often used in agriculture, leading to food security problems. Unsustainable farming is another factor behind increases in food insecurity. Today many of the main crops producers are located in developing countries, with inefficient irrigation systems and a lack of support from their governments. As such, in order to increase crops yields, farmers are likely to use fertilizers (pesticides, nitrogen, and phosphorus), which could have a negative impact on food security.

Global food demand has been projected to double in the twenty first century, further increasing the pressure on water demand. The lack of this resource could result in disastrous consequences for human

beings: water scarcity, hunger, poverty, and political instability. As a result, water security and availability will become an increasingly important topic in the twenty first century.

Noticeably, a number of solutions for alleviating water scarcity have already been discussed by water economists, ecologists, and operations management scholars. It has been argued that this problem can be addressed by use of a proper pricing mechanism, the relocation of supply channels, virtual water, and renewable water strategies.

Many leading food producing companies are also trying to minimise projected risks related to water scarcity and availability, investing more in sustainable manufacturing, distribution systems, and procurement systems based on more sustainable forms of agriculture. Some companies work directly with farmers, as immediate food suppliers, and others with multiple stakeholders. In order to mitigate water scarcity and security risks, some food businesses are trying to incorporate sustainable agriculture standards into supply contracts or to provide farmers with knowledge about sustainable agriculture and water saving equipment, whilst others try to increase collaboration among stakeholders within their supply chains.

The focus of my research will be on examining how firms and their extended supply chains are responding to the challenge of water scarcity in terms of product and supply network design, water conservation strategies, sustainability metrics and reporting. Further, a classification of agri-food supply chain water strategies and practices, emerging product-process archetypes, and reporting will be developed according to relevant situational factors (e.g. location, projected water stress levels).

James Addicott, Department of Sociology

Precision agriculture in England

The topic of my research is 'precision agriculture' in England. This is the incorporation of satellite and information communication technologies (ICT) into agricultural practices. It has been proposed by the UK Government that precision agriculture is one solution to tackling environmental issues, while 'sustainable intensification' of agricultural production will help to feed a growing world population. My research is critically engaged with precision agriculture and focuses on human wellbeing in the computerisation of agriculture.

Regina Hansda, Department of Human Geography

Alternative Agriculture and Food Security: Understanding the Shifting Dynamics of Gender and Labour within System of Rice Intensification (SRI) in Eastern India

My research looks at an emerging and alternative rice growing technique called the System of Rice Intensification (SRI) employing a gender lens. This research is important for two reasons; first, it examines an alternative/sustainable agriculture practice of rice cultivation, which even though contested hold significant potential for addressing food security challenges in regions which are food

insecure and for categories of farmers who are usually left neglected in policy planning i.e. small and marginal farmers; and second, it goes beyond the current productionist focus of SRI debate which are mostly centred around the contested claims on yield, productivity and scale of adoption. In this research I focus on the intensive aspect of this modified practice, which has significant gender and labour connotations. This is largely so because women are key to rice cultivation in any country and so is the case in India. But so far, very little attention has been paid to this aspect. Based on an extended ethnographic field work in Gaya district in Bihar in the Eastern part of India, I argue that gender and labour dynamics is witnessing a shift and that certain sections of women tend to bear the social costs of this agrarian transition without being acknowledged or attended to adequately.

Lana Whittaker, Department of Geography

Realising food security using government-led food distribution: What might we learn from India?
Following the recent food and financial crises, food-based safety nets have been increasingly used as part of efforts to realise food security. In particular, school feeding programmes have gained new prominence. However, insufficient research has been conducted on the relationship between government-led food distribution and the goal of food security. It is thus often unclear how food distribution can deliver safe and nutritious food in line with preference and what the most appropriate delivery mechanisms are in different contexts. This presentation will explore these issues for the largest school-feeding programme in the world, India's Midday Meal Scheme. Following India's 2013 National Food Security Act, this scheme has become central to efforts to achieve food security in India. This presentation will reflect on the challenges and debates surrounding the scheme and will outline my proposed PhD research which seeks to examine the outcomes of the scheme on food security.

Jonathan Kennedy, Department of Sociology

The political economy of farmers' suicide in India
National-level suicide rates are among the highest in the world, but suicide rates vary sharply between states and the causes of these differences are disputed. We test whether differences in the structure of agricultural production explain inter-state variation in suicides rates. This hypothesis is supported by a large number of qualitative studies, which argue that the liberalization of the agricultural sector in the early-1990s led to an agrarian crisis and that consequently farmers with certain socioeconomic characteristics–cash crops cultivators, with marginal landholdings, and debts–are at particular risk of committing suicide. We report scatter diagrams and linear regression models that combine the new state-level suicide rate estimates and the proportion of marginal farmers, cash crop cultivation, and indebted farmers. When we include all variables in the regression equation there is a significant positive relationship between the percentage of marginal farmers, cash crop production, and indebted farmers, and suicide rates. This model accounts for almost 75% of inter-state variation in suicide rates. If the proportion of marginal farmers, cash crops, or indebted farmers were reduced by 1%, the suicide rate – suicides per 100,000 per year–would fall by 0•437, 0•518 or 0•549 respectively, when all other

variables are held constant. Thus, even if the Indian state is unable to enact land reforms due to the power of local elites, interventions to stabilize the price of cash crops and relieve indebted farmers may be effective at reducing suicide rates.