Impact case study template (REF3b)

Title of case study: The Past and Future Roles of Asian Millets

1. Summary of the impact

Hardy, small-grained cereals have received less scientific attention than their high-yielding, large-grained counterparts, in particular, wheat, rice and maize. The research of Jones' group at Cambridge into one of the hardiest of these, broomcorn or proso millet, has raised awareness of their past, present and future utility among environmental planners and bioscience research industries. It has influenced international policy advisers (via the *Chevening Economics of Climate Change Programme*, UK Foreign and Commonwealth Office), commercial decisions regarding research and development investment (by Unilever) and recognition of a new *Globally Important Agricultural Heritage Systems* site in the region of Aohan, Inner Mongolia (by the United Nation's *Food and Agriculture Organization*).

2. Underpinning research

Martin Jones has been George Pitt-Rivers Professor of Archaeological Science since 1990. In 2004, Jones' seminal article on the prehistory of millet cultivation was published (Jones 2004). Also in that year a major consortium research project, '*The Domestication of Europe'*, was funded by NERC with Jones as Co PI, to bring together three HE institutions (Cambridge, Manchester and Sheffield) with one of the leading crop-breeding centres, the National Institute of Agricultural Botany (NIAB). The aim of this project was to explore the potential of the newly emerging 'archaeogenetics' (a term coined by Colin Renfrew in the context of research initiated at the McDonald Institute) to issues of crop-plant origins and spread. From the following year, 2005, Cambridge's focus was expanded to include the millet crops, research that has successively been funded by the Wellcome Trust, the Leverhulme Trust, the European Research Council and other bodies.

Jones' research on millets as globally expansive crops (Jones 2004) was consolidated geographically by Hunt *et al.* (2008), and topographically by Liu *et al.* (2009). These three papers recorded the spatial extent, the presumed chronology, and the ecological mode of Asian millets, demonstrating that, in circumstances that prevailed in prehistory, an adaptive potential of Asian millets was clearly recognized by early farmers. Jones and Liu (2009) and Jones *et al.* (2011) placed those findings in the context of the global history of major and minor crops, drawing attention to a significant episode of food globalization in prehistory, with implications regarding the flexible and innovative uses of minor crops now disappearing from the landscape. A series of archaeogenetic publications culminating in Hunt *et al.* (2012), provide compelling evidence for a domestication of all the world's *Panicum miliaceum* strains in North China, emphasizing the significant expansiveness in the past of this now-declining cereal. That expansiveness in turn derives from a suite of adaptive features, most notably an exceptionally economic use of water and resistance to micro- and macro-predator attack.

In sum, the research reported in references 1–6 in Section 3, and in other publications from Jones' group, has established that *Panicum miliaceum*, today a minor cereal in decline, hitherto attracting little scientific attention, was once among the most expansive in geographical terms, with a centre of origin in northern China, but spreading to India and Europe in prehistory. The regions into which it spread in many cases already had a millennial record of cultivation of more locally derived cereals, indicating that it was the specific qualities of millet, rather than the lack of a cereal resource, that stimulated its expansion. These specific qualities include extreme economy of water use, increasingly advantageous in relation to on-

going climate change, rapid growth and short season, valuable for the emerging multicropping systems of south and west Asia, as well as predator resistance and a very favourable nutritional balance.

3. References to the research (in alphabetical/chronological order)

Key Research Outputs:

1. Hunt, H.V., Vander Linden, M., Liu, X., Motuzaite-Matuzeviciute, G., Colledge, S. and Jones, M.K. 2008. Millets across Eurasia: Chronology and context of early records of the genera *Panicum* and *Setaria* from archaeological sites in the Old World. *Vegetation History and Archaeobotany* 17 (Suppl. 1): S5–S18. INT1* category peer-reviewed publication on the European Reference Index for the Humanities. DOI: 10.1007/s00334-008-0187-1

2. Hunt, H.V., Moots, H.M., Graybosch, R.A., Jones, H., Parker, M., Romanova, O., Jones, M.K., Howe, C.J. and Trafford, K. 2012. Waxy phenotype evolution in the allotetraploid cereal broomcorn millet: Mutations at the *GBSSI* locus in their functional and phylogenetic context. *Molecular Biology and Evolution* 30 (1): 109–122. International peer-reviewed publication with an H Index of 145 according to the SCImago Journal and Country Rank. DOI: 10.1093/molbev/mss209

3. Jones, M.K. 2004. Between fertile crescents: Minor grain crops and agricultural origins. In Jones, M. (ed.), *Traces of Ancestry: Studies in Honour of Colin Renfrew*. Cambridge: McDonald Institute for Archaeological Research, 127–135. ISBN: 9781902937250

4. Jones, M.K. and Liu, X.H. 2009. Origins of agriculture in East Asia. *Science* 324: 730–731. International peer-reviewed publication with an H Index of 739 according to the SCImago Journal and Country Rank. DOI: 10.1126/science.1172082

5. Jones, M.K., Hunt, H.V., Lightfoot, E., Lister, D.L., Liu, X. and Motuzaite-Matuzeviciute, G. 2011. Food globalization in prehistory. *World Archaeology* 43(4): 665–675. INT1* category peer-reviewed publication on the European Reference Index for the Humanities. DOI: 10.1080/00438243.2011.624764

6. Liu, X., Hunt, H. and Jones, M.K. 2009. River valleys and foothills: Changing archaeological perceptions of North China's earliest farms. *Antiquity* 83: 82–95. INT1* category peer-reviewed publication on the European Reference Index for the Humanities. ISSN: 0003-598X

Research Grants:

1. Jones, M.K. *et al., The Domestication of Europe,* NERC, 2004–2007, £240,171.

2. Jones, M.K., '*Modelling Agricultural Origins',* Wellcome Trust, 2006–2010, £237,115.

3. Jones, M.K., '*Pioneers of Pan-Asian Contact'*, Leverhulme Trust, 2010–2013, £229,754.

4. Jones, M.K., '*Food Globalisation in Prehistory',* ERC, 2010–2015; £1,735,966.

*INT1 – International publication with high visibility and influence among researchers in the

various research domains in different countries, regularly cited all over the world.

4. Details of the impact

While the impact described here arises from the publications above, awareness of those publications beyond Jones' immediate research community has been facilitated (as acknowledged in testimonials by Contacts 1 and 2) by Jones' additional publication of accessible books on food and archaeogenetics, primarily *Feast: Why Humans Share Food*, awarded 'Food Book of the Year' by the Guild of Food Writers and in 2009 placed on the list of 'Outstanding Academic Titles' by the American Library Association.

As a consequence of the widespread awareness of one or more of Jones' books, and of various references in Section 3, he was invited to participate in meetings from which impact arose. The first was in February 2009, when Jones was invited to lead a session with 12 early-career policy makers from many parts of the world who had been awarded Chevening Fellowships through the British Council as part of *The Chevening Economics of Climate Change Programme* run by the UK Foreign and Commonwealth Office. Drawing on the relevance of his research for food futures, Jones delivered tailored seminars for the Fellows at the University of Cambridge within a session entitled *Climate Risks and Food*.

The Director of the Chevening Programme (Contact 1) draws attention to the benefit and impact of Jones' contribution, which can be followed through to policy advice within the Asian agricultural sector, for example through the *Observer Research Foundation* and *One World South Asia*. The *Observer Research Foundation* is an independent think tank that provides informed and viable inputs for policy- and decision-makers in the Indian Government and to the political and business leadership of India. *One World South Asia* disseminates topical information to audiences worldwide on development issues, makes technology work for people at the grassroots and conducts research on best practices in governance.

The second invitation was from *Unilever Bioscience* to a meeting organized by them in February 2010 at their Unilever Discover offices at Colworth Science Park. Its purpose was to explore "Man's evolutionary adaptation to his current diet, his diet in the past and lessons that can be learned from this with respect to diet and the food industry". As a result of that meeting, and Jones' contribution to it, Unilever has developed an interest in research into millet and decided to commit some of its own resources to collaborative research on the crop. This commitment has included joint support of graduate research and an international workshop, held in July 2013, entitled *Millets: A Past, Present and Future Solution to Food Security Challenges*. The latter, co-hosted with NIAB Innovation Farm and Cambridge, enjoyed participation from both universities and industry, and drew contributors from Europe, America, Russia and China.

Unilever see the collaborative research they are doing with Cambridge on millet as contributing to the implementation of their *Sustainability Living Plan* (Contact 2), particularly in the context of reducing water use in agriculture. They also "envisage the research may further contribute to other elements of that plan: the improvement of nutrition (we are interested in the nutritional advantages of millet), and 'better livelihoods' and the wellbeing of the smallholders with whom we engage worldwide" (Contact 2).

By demonstrating the global context of the North Chinese centre of origin of Asian millets, Jones' research has also led to the significance of the region of Aohan, Inner Mongolia, being

recognized by policy makers concerned with conservation of agrarian, social and biological resources. In particular, the *Food and Agriculture Organization* (FAO) has recognized (in September 2012) the Aohan Dryland Farming System as a new *Globally Important Agricultural Heritage Systems* (GIAHS) site. GIAHS is a United Nations initiative whose goal is to identify and safeguard Globally Important Agricultural Heritage Systems and their associated landscapes, agricultural biodiversity and knowledge systems. Its methods are to catalyse and establish long-term programmes to support such systems – and to enhance global, national and local benefits derived through their dynamic conservation, sustainable management and enhanced viability. In this context, the Director for the China Office for FAO/GIAHS has specifically emphasized the role of research by Jones' group in prompting greater attention to the place of minor cereals in future human ecological strategies and eco-agricultural developments (Contact 3). In August 2013 a meeting was held in Aohan to celebrate the FAO decision, with Jones' contribution to both the conference and the history of millet publicized in the Chinese press (e.g. *China Daily, People China*).

5. Sources to corroborate the impact (in alphabetical/chronological order)

1. American Library Association. n.d. *Outstanding academic titles* [online]. Available at: <http://www.ala.org/awardsgrants/awards/370/all_years> [Accessed 26 September 2013].

2. Food Globalisation in Prehistory. 2013. *Millets: A past, present and future solution to food security challenges* [online]. Available at: <http://www.foglip.mcdonald.cam.ac.uk/workshop.html> [Accessed 26 September 2013].

3. Fu, L. 2013.专家证明：内蒙古赤峰市敖汉旗是世界小米的发源地. 'Experts establish that Chifeng City, Inner Aohanqi, is birthplace of millet'. *People China* [online] 8 August. Available at: <http://nm.people.com.cn/n/2013/0808/c196667-19264527.html> [Accessed 28 September 2013].

4. Globally Important Agricultural Heritage Systems. n.d. *Aohan Dryland Farming System, China* [online]. Available at: <http://www.giahs.org/giahs-sites/south-east-asia/aohan-dryland-farming-system-china/en/> [Accessed 26 September 2013].

5. The Guild of Food Writers. n.d. *Past recipients – Awards* [online]. Available at: <http://www.gfw.co.uk/past-recipients.cfm#Guild_of_Food_Writers_Awards_Winners_2008> [Accessed 26 September 2013].

6. Kaihao, W. 2013. **敖**汉旱作农业遗产 **延**续八千年的耕作传奇. 'Globally important agricultural heritage systems in Aohan: Eight thousand years of agricultural practice'. *China Daily* [online] 28 August. Available at: <http://www.chinadaily.com.cn/dfpd/2013-08/28/content_16927084.htm> [Accessed 28 September 2013].

Testimonials:

1. Contact 1: Director, Global Sustainability Institute, Anglia Ruskin University, Cambridge.

2. Contact 2: Scientist, Unilever, Colworth Science Park, Sharnbrook.

3. Contact 3: Director of China Office, Globally Important Agricultural Heritage Systems, Food and Agriculture Organization, Beijing (China).