Title: Low-Cost sensing for 3rd world precision agriculture

Academic team leader(s): To be confirmed

Challenge:
Climate Change is widely agreed to be already a reality [1]. The extreme weather in recent years [2][3], provides visible proof of the changes in our global climate and the need to mitigate the consequences. Countries in the developed world, such as the Netherlands and the UK are preparing themselves for increased risk of flooding from ocean and rivers [4], by rapidly increasing the available budgets for Flood Control.
In the developing world however, most severe impact is expected in food security and access to clean drinking water [1]. In many countries in Africa, Asia and Latin America, where agriculture is the major source of income –e.g. 60-70% of the population in Africa relies on agriculture for their income- the impact of Climate Change is expected to be potentially disastrous [5], strengthened by the fact that the low access to technology in the developing world makes the agricultural systems less resistant to the effects of Climate Change [1].
Even more stress is expected on global agriculture, through rising population and increasing welfare in many parts of the world, changing both the amount of food necessary, as well as the types of food demanded. In a recent review paper, Lal [5] concludes:

(1) To accommodate the increasing world population, combined with the growing preference for animal based diets, global food production needs to increase substantially, and
(2) Global soil and water resources are limited, vulnerable and coupled with the very processes that govern climate change.

Currently, many regions in the world are already seeing the effects of the continuously increasing demand. A prominent example is Central Asia, as observed by Sorg et al. [6]

"Water shortages in summer will place the entire region's agricultural system under pressure, thus fuelling tensions that have existed since the collapse of the Soviet Union in the early 1990s. The high water demand for irrigation has already transformed downstream sections of powerful rivers such as the Syr Darya, Amu Darya and Ili into small rivulets, thus exacerbating the drying-out of the Aral Sea and Lake Balkash."

Research and policy have traditionally observed shortages in water as national or regional problems. Hoekstra and Mekonnen [7] observe that governments have traditionally matched national water demand to national water supply, studied at local, national or river-basin level, thereby ignoring the global dimension of water demand patterns.
However, given the active global trade in water-intensive commodities, such as cotton or bovine meat, they propose to measure the Water Footprint of a nation, rather than its national water use. Figure 1 depicts the Virtual Water balance of nations, showing in red the countries which are high importers of fresh water and in green the countries which export fresh water. By using this definition, Chapagain et al. [8] conclude that EU25 consumers are 20% responsible for the decline of the Aral Sea in Central Asia, the most famous example of the effects of water extraction for irrigation.
All in all, mitigation of the global water shortage should aim at 2 core elements:

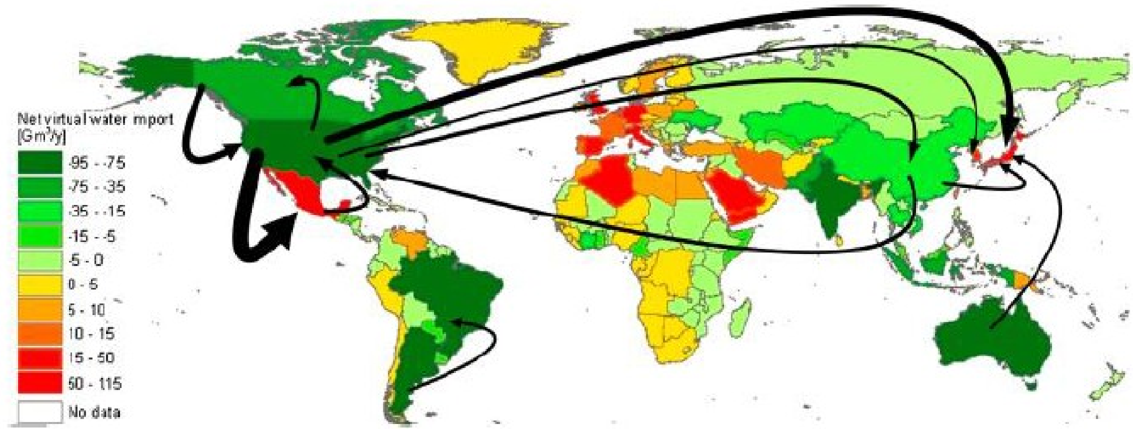

Figure 1. Virtual water balance per country and direction of gross virtual water flows related to trade in agricultural and industrial products over the period 1996–2005. Only the biggest gross flows (>15 Gm3/y) are shown. [6]

(1) Increasing the resistance of third-world agriculture towards the effects of climate change and
(2) Increasing awareness about the global dimension of water shortage.

In this paper, we describe the Poseidon Project, aimed at using recent technological advances to tackle the first of these.

INCREASING RESISTANCE: PRECISION IRRIGATION

Precision irrigation is defined as "site-specific irrigation management that relies on variable application of water". It is emerging as a potential solution to increase the productivity and reduce the environmental impact of irrigated agriculture [5]. Studies have demonstrated that using precision irrigation, water-use by crop-agriculture can be reduced by up to 20% in Australia [12], helping tremendously in lowering agricultural footprint.

The situation is even more striking in the arid regions of Central Asia, where excessive, non-beneficial water use as deep percolation and an inadequate use of the available soil water and groundwater contribution is commonly practiced. Simulations [14] have demonstrated that water usage could be easily reduced by 25%, through implementation of mild deficit irrigation. It may be expected that more advanced models and realtime, in situ monitoring could bring even more reduction in water usage [15].

However, despite the promise of lowering water usage and the obvious need for water-usage reduction in many parts of the world, precision irrigation has not found global uptake as of today. For instance, Roth et al. observe that in the Australian Cotton Industry, one of the most advanced agricultural industries in terms of irrigation-scheduling tools only ~40% of production is aided by Soil-Moisture probes [13].

Vellidis et al. [15] observe 3 core reasons for a low uptake of precision agriculture, current systems are either (1) too expensive, (2) too unreliable or (3) too complicated for uptake in a farm environment. (2) and (3) were confirmed in en experiment in the Netherlands [16], in which Langendoen et al. demonstrated the practical difficulties of deploying a sensor-network in a real-life potato farm.

We believe that recent developments in Computer Science can bring solutions to all of these blockades, enabling a leap-frog in adaption of precision agriculture.

Fighting drought and lowering Water Footprint is a global challenge and we'd like to fight it at the source. The challenge for the ICT with Industry workshop is:

"How can we use technology for cost-efficient monitoring of the parameters needed for agricultural decision making?"