A low-cost weather station

A network of tens of thousands of low-budget weather stations will give people of Africa more certainty about weather and water. The project was launched this summer in Kenya.

Jos Wassink

On the afternoon of Friday 2 August, after a week of soldering, programming and building interfaces, the project was finally completed. More than twenty weather sensors came online simultaneously and sent their data to the internet.

Participants from all over Africa gathered at Nairobi’s iHub – Kenya’s equivalent of YesDelft – to build an experimental weather station, with the guidance of staff from TU Delft. The participants had been invited to take part on the basis of their original designs for weather sensors. In the space of a week, a total of 21 sensors (for rainfall, temperature, humidity, wind, etc.) were connected to each other and linked to the internet via a node. It was a small historic step when the system worked, and the first contours of a network of weather sensors created by and for Africa were visible.

The idea for a trans-African meteo-network was thought up at the beginning of the 1990s by three PhD students at Cornell University (USA). They knew that the density of weather stations in Africa was very low (as it was in South America), which meant that agricultural yields in the hostile African climate were not as high as they could be.

Food crisis

Today, twenty years later, their idea has even greater significance and urgency. Since that time, we have had a food crisis (2008) and food prices have peaked, plunging millions into poverty. The world population has increased to 7.1 billion and is set to reach 9.3 billion by 2050. The demand for food is increasing due to a combination of factors: population growth, the rising demand for biofuels, and shifting consumption patterns (more meat) in growing economies.

In a recent article at www.trust.org, Prof. Nick van de Giesen (Civil Engineering and Geosciences) wrote about the fact that food production will need to increase by 30 to 80 per cent to meet the growing demand for food. Van de Giesen, TU Delft’s Professor of Water Resources Management, was one of the trio of Cornell PhD students twenty years ago. The others are Professor John Selker, a hydrologist at Oregon State University, and Dr Marc Andreini, a researcher at the Water for Food Institute at the University of Nebraska. The report ‘Global Food Security’, published last June by Britain’s International Development Committee, speaks of a global food crisis – an outlook that Van de Giesen confirms. Unfortunately, it is usually the poor who are hit hardest and first by shortages and rising prices. But the food crisis is a security risk as well as a humanitarian disaster. Food riots in 2008 contributed to civil unrest in dozens of countries, including North Africa.

On the other hand, it is Africa that has the greatest potential in terms of producing more food. Furthermore, agriculture has been optimised to such an extent that there is little scope for further expansion. And growth in South America would be at the cost of the rainforests. The main problem in Africa is the unpredictable weather, and this would be easier to deal with if there was a denser network of local weather stations.

That is precisely what Van de Giesen, Selker and Andreini have in mind with the Trans-African Hydro-Meteorological Observatory (Tahmo).

Greater stability

The dream is to have thousands of weather stations up and running throughout Africa by 2018, mainly managed by schools. Local data on temperature, humidity and wind etc. will be combined with weather models and satellite data to provide more detailed information on heat and water fluxes in Africa.

Farmers will receive updates on weather and rainfall via smartphones or in spoken SMS messages. The forecasts should enable public authorities to take more effective decisions on water-management measures. Ultimately, this should boost not only food production, but also economic growth in Africa. This, in turn, could lead to greater stability, both within and outside Africa. That would be an enormous benefit. But how do you achieve that?

With modern micro-electronics. The fact is that, in the past few decades, there have been enormous advances in the capacity, price and format of electronics. Who would have thought that programmable microprocessors would one day be available for just a few tens of euros?

There are all manner of sensors for radiation, temperature, pH, rainfall, humidity, wind and much more.
and sound costing only a couple of euros or less. This ‘workshop’ of resources enables people to build their own weather sensors for next to nothing, or, in the words of ir.Rolf Hut (CEG) of the Tahmo project: ‘to use existing technology to measure climate variables in new ways.’ Hut himself - who is known for his ‘hands-on’ approach to science - set a good example a few years ago with his innovative rain sensor. Normally, this piece of equipment consists of a funnel above a readable reservoir. The disadvantage of this device is that it requires maintenance, otherwise it becomes blocked. It occurred to Hut that you don’t need to go outside your tent to find out how hard it’s raining. You can tell by ear from the amount and size of the raindrops as they fall on the tent. On that principle, together with final-year student Sjoerd de Jong, he built a low-budget, maintenance-free electronic rain gauge, or disdrometer. The piezo element, costing only 25 cents, converts the sound of the rain into an electrical signal, which is then electronically calculated as millimetres of rainfall. Total cost: approximately three hundred euros. Another example is a radiation meter, which costs five hundred dollars as a weather instrument, while an infrared sensor - as used in ear thermometers - can be bought for just ten dollars.

Amateur inventors

Cheap sensors, in conjunction with the wish to build more weather stations in Africa, led to the Tahmo Sensor Design Competition. In this competition studies, researchers and amateurs were challenged to develop a weather sensor using elements from alarm systems, telephones and the hardware store.

In the first round, 21 designs were selected. These were submitted by thirteen teams, who now received a ‘Maker Package’ and could start to work with the following an Arduino microprocessor, sensors, pliers, wires, a glue gun, soldering set and, of course, duct tape. When the participants flew to Nairobi a few months later, they brought their prototypes with them. The next step - and the purpose of the workshop - was to connect the individual sensors to each other to create an experimental weather station. A Raspberry Pi computer was to enable the core of the network. The next task was to work out which wires from which Arduino to attach to where on the connection board, and how to program the computer for the communication protocol. The Delft team was assisted in this by Adam Gleave, a student from Cambridge and a trainer at the Raspberry Pi Foundation.

By the last afternoon of the week, the working prototypes had been set up on a long table. Here and there, various labels were to be seen, indicating the function of the sensor: ‘psychrometer’ and ‘radiation meter.’ Coloured wires and leads run in all directions, and somewhere in the middle of all this is the microprocessor that reads the sensors and publishes the results on the internet. ‘Look - no wires,’ says Rolf Hut triumphantly as the data appear on his laptop. Is this the beginning of an African weather network? In one sense it is not, because the weather station was dismantled after its premiere; and its builders left again, heading for all four corners of the vast continent.

But they left, Hut and Van de Giesen firmly believe, as ambassadors for Tahmo. They extended not only their knowledge but also their network of contacts. Although the ultimate aim is a network of weather stations, it begins with a network of people.

More information:
www.tahmo.org

From the selection for Nairobi:

Rainfall gauge

The Nigerian team (Ladippe Kehinde Ogunleye, Mr A. Okunola and Dr Ahmed Balogun) made it through the selection round with seven designs. One of the designs is for an automated rain gauge with a tipping bucket. Rain falls through a funnel into a suspended asymmetrically hinged bucket. When the water reaches a certain level, the bucket tips, the water is emptied out and the process begins again. An electronic counter keeps tally of how often the bucket is emptied. So it does involve some electronics.

Temperature

A double thermometer that calculates humidity (a psychrometer). The design consists of an aluminium housing containing two identical temperature sensors. One of the sensors is dry, and the other is wet and ventilated. The greater the difference between the wet and dry temperatures, the drier the air. N.B. A red light indicates the battery has power, a green light indicates a low battery.

Relative humidity

Abdulfah Akekule Oluwole and friends from Nigeria came up with an original plan for measuring relative humidity, using the silicone gel normally found in camera bags. Silicone gel absorbs moisture from the air, and thus becomes heavier. Take at least 100 grams of Silicone gel, measure the changing mass with a pressure sensor, calibrate the system, and you have a humidity sensor.

Air pressure

Dr Carelse and colleagues from the University of Zimbabwe designed an electronic barometer based on an aneroid capsule. They use an evacuated metal box from a standard barometer (with a membrane that bulges when air pressure is low) and measure the displacement of the membrane with a Hall sensor in the magnetic field of a coil around the box. Estimated cost: 25 dollars or less.

Wind speed and direction

A team from theHigher Technical School of Agricultural Engineering of Madrid submitted an elegant design for a wind meter without moving parts. It resembles a vertical antenna with a sphere on top. As the wind blows and moves the antenna, strain gauges indicate not only the force but also the direction of the wind.

Radiation sensor

The sensor designed by George Sserwadda of Uganda detects visible light and incoming and outgoing heat radiation. This is done with a phototransistor (light), an upward-facing infrared sensor (incoming heat radiation) and a downward-facing temperature-sensitive resistor (outgoing heat radiation). These are all connected to analog-to-digital converters, through which the data are sent to an Arduino microcontroller for processing and storage. The unit has a display and USB port for external connections.

View the presentation of the Nairobi workshop at: youtube.be/zJD1VP6F83k
www.facebook.com/tahmo.initiative