Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

**E-ISSN:** 2278-4136
**P-ISSN:** 2349-8234
JPP 2019; 8(5): 124-127
Received: 01-07-2019
Accepted: 05-08-2019

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# Climate smart agriculture (CSA)-building resilience to climate change

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## Abstract
Climate change represents a significant threat to global biodiversity and ecosystem integrity. Climate-smart agriculture (CSA) is an approach that helps to guide actions needed to transform and reorient agricultural systems to effectively support development and ensure food security in a changing climate. CSA aims to tackle three main objectives: sustainably increasing agricultural productivity and incomes; adapting and building resilience to climate change; and reducing and/or removing greenhouse gas emissions, where possible and enhances achievement of national food security and development goals. It increase nutrient use efficiency, overall agricultural productivity and minimise use of synthetic agrochemicals, reduce environmental pollution by adopting site specific management, remote sensing, nanotechnology and digital agriculture for small as well as large holding farmers.

**Keywords:** Climate smart agriculture, climate change

## Introduction
The Food and Agriculture Organization (FAO) estimate that feeding the world population will require a 60 percent increase in total agricultural production. With many of the resources needed for sustainable food security already stretched, the food security challenges are huge. At the same time climate change is already negatively impacting agricultural production globally and locally. Climate risks to cropping, livestock and fisheries are expected to increase in coming decades, particularly in low-income countries where adaptive capacity is weaker (Gollier, 2002) [8]. Impacts on agriculture threaten both food security and agriculture's pivotal role in rural livelihoods and broad-based development. Also the agricultural sector, if emissions from land use change are also included, generates about one-quarter of global greenhouse gas emissions (GHG) (Dasgupta, 2006) [3]. Keller, *et al.*, (2007) [13] revealed that climate change involves not only global warming but also other physical changes such as precipitation, the intensity and frequency of storms and the occurrence of droughts and floods. As well, the widespread melting of the Greenland and West Antarctic ice sheets, which would imply a large sea level rise, and changes in the thermohaline circulation (THC) 3 - the global density-driven circulation of the oceans-which would amplify climate change, are considered as two of the main irreversible risks associated with climate change. Temperatures have already increased by an estimated 0.7 °C compared with pre-industrial levels. There is still some controversy on the contribution of anthropogenic GHG emissions to temperature increases. However, the last report of the Intergovernmental Panel on Climate Change (IPCC, 2007) [11], based on the most recent research in this area, attributes most of the observed increase in global average temperatures since the mid-20th century to anthropogenic causes with a probability of more than 90%. One of the most important impacts expected from climate change is to deteriorate health. Its size may be understated since estimates are largely incomplete. The number of additional deaths coming from an increase in temperatures has been estimated only for specific diseases (Malaria, heat- and cold-related cardiovascular mortality, heat-related respiratory mortality) (Ringius, 2002) [24]. Furthermore, the indirect consequences of climate change on health through food availability, water constraints, air quality or conflicts induced by climate change are mainly unknown. Climate change would also have a negative impact on biodiversity and the ecosystem (Klumper, *et al.*, 2014) [14]. Climate change can increase or decrease energy consumption and water resources and demand. The impact is expected to strongly depend on regions, with warm regions being more negatively affected than cooler ones. The movement proves great advantages for adopting climate smart agriculture for example; the use of Smart Farming techniques can optimize the yield of land, creating more output from the same amount of input. Towprayoon, *et al.*, (2008) [27] observed, not only does smart farming optimize, it also utilizes the knowledge of farming professionals by not replacing the traditional farmer but using their knowledge to support decisions and develop indigenous technological skill among farmers.

This optimization allows for less waste and maximum efficiency. And the use of sensor technology and real time data allows for unparalleled insight into the commodities market.

**How to make agriculture smarter?**

**By adopting Precision agriculture**

Soil characteristics including the amount of phosphorus, potassium, calcium, and magnesium often vary significantly from one area of a field to another. The practice of variable rate technologies (VRT) takes this variability into account to reduce inputs of water, seed, fertilizers, and fuel as well as to increase yields by dividing fields into sectors and prescribing rates for each one (Lipper, *et al.*, 2014) [17]. Precision agriculture is one of many modern farming practices that make production more efficient. A better name for precision agriculture might be "site-specific agriculture". Growers are able to take large fields and manage them as though they are a group of small fields (David, *et al.*, 2002) [4]. This reduces the misapplication of products and increases crop and farm efficiency. Precision agriculture practices allow applying nutrients, water, seed, and other agricultural inputs to grow more crops in a wide range of soil environments. FAO (2009) [6] reported that precision agriculture can help farmers know how much and when to apply these inputs. The primary aim of precision agriculture and precision agronomics is to ensure profitability, efficiency, and sustainability while protecting the environment. Precision water management system is a fully integrated water management system that provides a new set of tools to simplify and automate the management of moisture compensation. The system allows capturing sample moisture reading with the click of a button provides easy and accurate calibration process and has ability to measure simultaneously up to 12 probes (Neufeldt, *et al.*, 2013) [20]. Laser-assisted precision land levelling (PLL) is the foremost step in the judicious use of irrigation water and enhancing water productivity. It is a laser-guided (Light amplification by stimulated emission of radiation) precision levelling technique used for achieving very fine levelling with the desired grade on the field within ±2 cm of its average micro-elevation. The Trimble Green Seeker crops sensing system helps we effectively and precisely manage crop inputs on-the-go. With Green Seeker, we can address field variability by applying the right amount of fertilizer, in the right place, at the right time (4R's). It reduce nutrient input costs by eliminating excess application, eliminate the need for application maps or agronomist recommendations and operate night or day, and in fog or clouds (Scoones, 2009) [26].

**Fig 1:** A tractor towing a fertilizer sprayer using Trimble's Green Seeker system

**Remote sensing**

Ambrosi, *et al.*, (2003) [1] suggested the most common types of remote sensing used in agriculture can be spatial resolution, spectral resolution, radiometric resolution, and temporal resolution. In spatial resolution, information can be collected to identify physical traits in crops, such as size, relative distance and proximity patterns, height, width and diameter of plants, crop damage from pest infestation, weather, and more. Spectral resolution can collect information based on certain frequency ranges, including visible light, electromagnetic radiation, and non-visible light, such as infrared and near-infrared. It can be an invaluable tool when it comes to monitoring and managing land, water, and other resources. It can help determine everything from what factors may be stressing a crop at a specific point in time to estimating the amount of moisture in the soil (McCarl, *et al.*, 2001) [19].

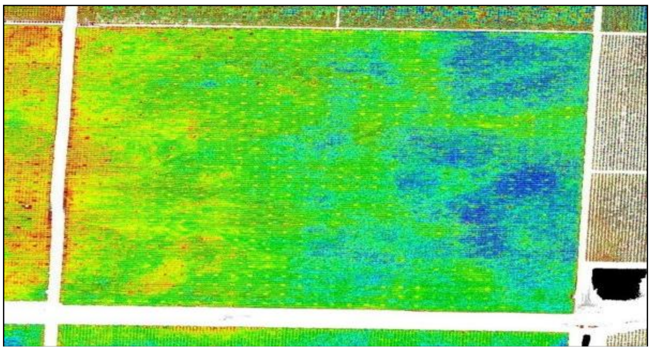

**Fig 2:** Field prescription map showing normalized difference vegetation index (NDVI) data at 30 centimetre resolution

**Nanotechnology**

The application of nanomaterials in agriculture aims in particular to reduce applications of plant protection products, minimize nutrient losses in fertilization, and increase yields through optimized nutrient management (Barrows, *et al.*, 2014) [2]. These agricultural systems can make excellent use of nanotech-enabled "smart" devices that can perform a dual role of being a preventive and early warning system (Gao, *et al.*, 2006) [7]. These devices can identify plant related health issues even before they become visible to the farmers and simultaneously provide remedial measures. These nanotech systems can also be used to monitor the delivery of chemicals. User-friendly and eco-friendly nano delivery systems for nutrients and pesticides have started to find their place in the market. These can allow the use of pesticides with the absolute minimum risk of environmental damage. Companies have implemented nanoemulsions in commercial pesticide products (Jain, *et al.*, 2008) [12]. Nanomaterials and nanostructures with unique chemical, physical, and mechanical properties-e.g. electrochemically active carbon nanotubes, nanofibers and fullerenes-have been recently developed and applied for highly sensitive bio-chemical sensors (Lu, *et al.*, 2002) [18]. These nanosensors have also relevant implications for application in agriculture, in particular for soil analysis, easy bio-chemical sensing and control, water management and delivery, pesticide and nutrient delivery.

In recent years, agricultural waste products have attracted attention as source of renewable raw materials to be processed in substitution of fossil resources for several different applications as well as a raw material for nanomaterial production (see for instance: "New synthesis method for graphene using agricultural waste") (Ryan, 2009) [25]. Nanocomposites based on biomaterials have beneficial properties compared to traditional micro and macro composite materials and, additionally, their production is more sustainable (Zhang, 2003) [28]. Many production processes are being developed nowadays to obtain useful nanocomposites from traditionally harvested materials.

**Digital agriculture**

Most of today's farmers make decision such as how much fertilizer to apply based on a combination of rough measurement, experience and recommendations. Once a course of action is decided, it is implemented but the results are not normally seen until harvest time. Fankhauser, *et al.*, (2005) [5] focused on a digital agriculture system that gathers data more frequently and accurately, often combined with external sources (Weather information). The resulting combined data is analysed and interpreted so the farmer can make more informed and appropriate decision. These decisions can then be quickly implemented with greater accuracy through robotics and advanced machinery and farmers can get real time feedback on the impact their actions. Farmers can adopt artificial intelligence optimize the use of water and fertilizer (IAASTD) 2009 [10]. Sensors can measure moisture content and soil fertility in real time. Those readings signal the farmer to optimize the timing of amount of inputs to the crops. Along with soil sensors, and communication networks, digital agriculture uses advanced imaging to look at temperature gradients, fertility gradients, moisture gradients, and anomalies in a field. Imaging features have low financial and ecological cost, and high spatio-temporal resolution (Paustian, *et al.*, 2004) [21].

**Is it relevant to adopt climate smart agriculture by small and marginal farmers?**


Huang, *et al.*, (2012) [9] reported that the options tested as part of the climate smart village research agenda for dealing with climate change and variability include: weather-smart activities (Weather forecasts, climate informed agro-advisories, weather insurance, climate analogues as a tool for forward planning, strategies to avoid maladaptation), water-smart practices (Aquifer recharge, rainwater harvesting, community management of water, laser-land levelling, microirrigation, raised-bed planting, solar pumps), seed/ breed smart (Adapted varieties and breeds, seed banks including community-based activities), carbon/ nutrient-smart practices (Agroforestry, minimum tillage, land use systems, livestock management, integrated nutrient management, biofuels) (Lal, 2004) [15] and institutional/market smart activities (cross-sectoral linkages; local institutions including learning platforms or farmer-to-farmer learning and capacity development) (Leach, and Scoones, 2015) [15], contingency planning, financial services, market information (Scoones, 2009) [26], gender equitable approaches, and off-farm risk management strategies (Pingali, 2012) [22]. Use of green seeker, leaf colour chart, SPAD chlorophyll meter and remote sensing are the cost effective tools of climate smart agriculture that make more profitability and sustainability among ecosystem and create farmer smarter and intelligent (Post, *et al.*, 2001) [23].

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