Chapter

Agronomy-Food Security-Climate Change and the Sustainable Development Goals

Amanullah and Shah Khalid

Abstract

Climate change has negative effects on food security, water security, and energy security due to change in extreme events such as floods, droughts, and heat waves, and reduces agricultural productivity. Global demand for food is projected to double by 2050. The rapidly growing population and the increase in demand for food, feed, and fuel will require sustainable agronomic practices to increase crop productivity. To meet the challenge, many advanced agronomic practices have been developed. For example: (1) selection of suitable crops and their varieties that are resistant to biotic stresses, (2) selection of suitable crops and their varieties that are resistant to abiotic stresses (3) selection of suitable cropping system, sustainable intensification. Sustainable agronomic practices are important to improve food security in changing climates. SDG-2 focuses explicitly on food by seeking to "end hunger, achieve food security and promote sustainable agriculture". SDG-1 focuses on poverty reduction, where agriculture have a key role to play. SDG-13 specifically calls for "urgent actions to combat climate change and its impacts." About 45 of the 169 targets are related to SDG-13, which highlights the need to tackle climate change and avert its impacts, particularly on food security, water, energy, and economic development.

Keywords: agronomy, agriculture, sustainable development goals, SDGs, climate change, GHG gases, food security

1. Introduction

The main job of agronomists is introducing such sophisticated production system through which is made possible the best use of light, heat, water, and soil for the crop production. Haman intervention in production and consumption of food and feed for human and their animals is accountable in climate change, which gives rise to other environmental changes like change in biodiversity, carbon and nitrogen cycling, and fresh water supplies [1, 2]. Change in climate may bring positive effects in some part of the world, particularly above about 55° northern altitudes. Change in climate, will further complex to attain food security in developing countries because of the negative impacts of climate change on crop production especially in subtropical and tropical areas [3–7]. There are three major factors responsible for the climate change and their negative impacts. First, several developing countries are exposed to considerable change in rainfall and temperature; according to the IPCC [8] prediction, the tropical and subtropical areas can experience an increase in temperature of 2–5°C. An intensification in extreme events (droughts and floods) in terms of frequency and intensity is also expected [8, 9]. Second, most of the developing countries' economies are sensitive to the direct deleterious effect of climate change because of the major dependence of developing countries' economies on agriculture and due to the higher poverty level [6]. Third, in developing countries most of the people depend on agriculture directly for their food and livelihood and change in climate will have negative impacts on production of crop and food supply. It is clear that increase in production of crops will need to increase by 50% over next few decades to fulfill the expected demand [10] as the world population is expected to increase from 6 billion to 9 billion by 2050 [11]. The current demands of the people from the existing current production technology and cropping system may further raise environmental complexities [12, 13]; for example, increase in chemical fertilizers can increase GHG emission, which in turn can cause climate which is sometimes also called climate forcing and such changes can cause further decline in crop production. Agronomist have two major challenges. First is the production of food on sustainable basis with the changing climate along with reduction in climate forcing factors and secondly, efforts to more efficiently collaborate with other disciplines to enhance the supply of agronomic products both better integrated within the overall context of food security and better tuned to the needs of food security policy formulation.

2. Agronomy and its scope

Agronomy is a wide and dynamic discipline. Agronomy science becomes imperative in Agriculture in the following areas. Identification of proper season for cultivation of wide range of crops, proper sowing methods, weeds control through different techniques, use of chemical fertilizers and organic manures like poultry manure, farmyard manure, green manuring, brown manuring, compost formation, use of bioherbicides, different cropping techniques like intercropping, monocropping, extensive cropping, intensive cropping, storage techniques for different agricultural produces, water management, management of crop under changing climate and other farm management services broaden the scope of agronomy etc. Agronomy also has a strong relation with other agricultural sciences like agriculture chemistry, plant breading and genetics, plant ecology, crop physiology, economics, and biochemistry (**Figures 1** and **2**).

3. Agronomists and their role in agriculture

Like agronomy, an agronomist also has a vast responsibility. These scientists study various crop production problems and work for better soil and crop management to get higher yield; in a broader sense agronomists deal with production of food, feed, fiber for fulfillment of the needs of the growing population by recommending best crop variety, proper sowing time, sowing method, irrigation time and amount, weed control methods, and proper cropping techniques.

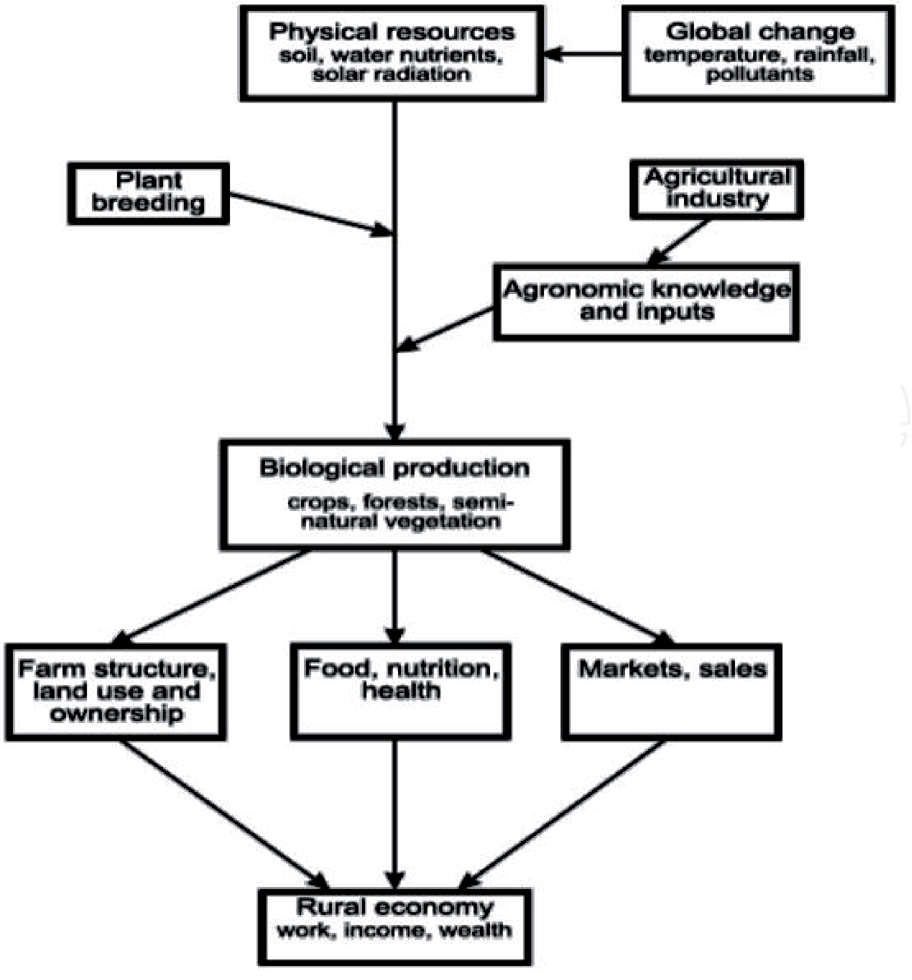

Figure 1.
Flow diagram of physical, biological, economic, and social dimensions of agronomy.

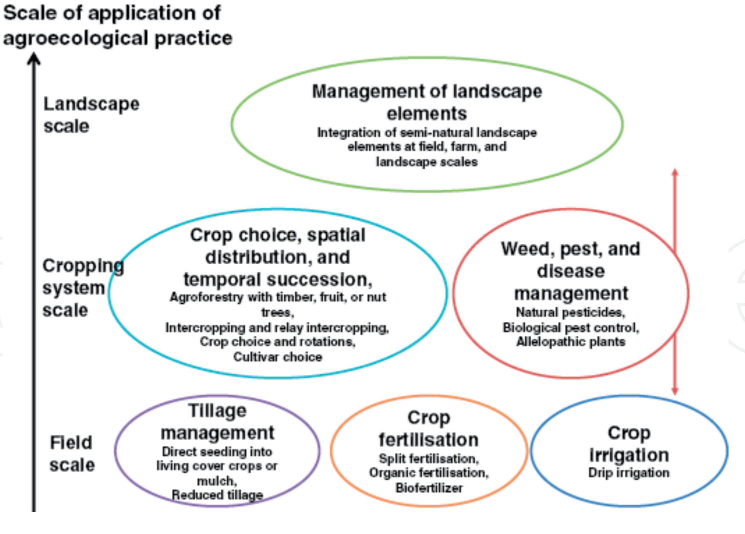

Figure 2.
Various classes of agroecological practices for increasing crop productivity at ranges from field scale to landscape scale.

4. Agronomy and climate change

Enhancement in agronomy and plant breeding has enabled increase in yield of crops over last four decades or more. Yield of many crops, particularly cereal crops like wheat, rice, and maize, has steadily increased in last few decades; this increase is due to improvement in irrigation, fertilizer use, chemical herbicides for weed control and pesticides for pest and disease control, adaptation of new production technology, high-yield varieties, and improvements in crop phenotype from breeding, especially the widespread adoptions of semi-dwarfing genes in cereals [14] has resulted in yield per unit area increase. However, this increase was not similar throughout the world. Yield increase was observed in Europe, America, and Asia, but there was decline in African countries in crop yield due to the unavailability of inputs, credit, high-yielding varieties, and irrigation water and increase in temperature. Gregory et al. [15] concluded that an increase of 1°C in temperature above 32°C can decrease yield of rice by 5%. These temperature effects were the most deleterious for the major crops like wheat, rice, and maize [16–18]. Additionally, increase in temperature also affects the wheat protein contents [19, 20].

The effect of climate change on productivity of crop shows the major role of agronomists to develop such varieties and cropping system that are more resilient to the climate change with high production. Modification in the crop due to change in climate was not significant, its might be due to gradually increase in carbon di oxide and temperature rate that modified the time of sowing, veracity and crop production management practices will allow some adaptation in the crop production system. These include various adaptations like the selection of crops that have strong mechanisms and high resistance against disease, are more resilient to the abiotic stresses like heat and temperature, and have stronger genetic enhancement to compete with changing environment and the selection of cropping system according to the current climatic condition. According to Tubiello et al. [21], increase in CO_2 concentration and temperature can decrease the yield of existing varieties by 10–40%. The combination of early planting of summer and spring crops can sustain the present yield of the crops [21]. Change in climate may cause change in water regimes, which may increase water demand in temperate regions while in tropical and subtropical regions, this may lead to water scarcity [22]. Further studies are needed to discover the most adoptive form of cropping system for specific regions keeping in view the climate change scenarios and for that agronomists need to work closely in the water management department. Change in climate may bring new disease, pests, and weeds that may cause serious problems for the crops. Some of the pests and weeds which are under economic injury level become problem by exploiting the changing condition [23]. Again, agronomists will need to work with the help of integrated pest management and integrated weed management and other tactics to help control the problematic weeds, pests, and diseases.

The major role of agronomy is discovering new techniques for higher crop production without depleting natural resources and intensifying climate change. Choices for enhancing crop production safely involved extensification and intensification [13]. Extensification will help to raise the total quantity of production and contribute to increases in production, but increase through extensification is limited due the availability of limited new land [15].

According to Greenland et al. [24], more than 3 billion hectares of land is available for cultivation and can be used for good production and about 1.2–1.5 billion hectares of land is already cultivated. In general, further agriculture extensification will cause very limited increase in crop production. Typically, further extensification will contribute just 7.4% to cereal production while estimated extensification to crop production ranges from 18% in South Asia to 47% in sub-Saharan Africa by the year of 2020. To decrease the intensification of climate change and increase the extensification and intensification of farming practices in the subtropical and tropical areas should need to change with more resilience ones [15].

5. Agronomy and food security

To assess the impacts of climate change on crop productivity and food security, agronomic research has thus provided an admirable basis. According to global harvest initiatives (2010), the global agricultural productivity must be increased by 1.75% to double the agricultural productivity by 2050. The average annual TFP growth rate in low-income countries is in trouble. However, Sustainable Development Goal 2 (SDG-2) calls for doubling of crop productivity for small-scale farmers in the lowest-income countries. But the current annual rate of TFP growth in low-income countries is just 0.96%. If this decline sustains for longer period, people in low-income countries will increase the use of soil and water, which are already threatened by extreme weather and climate change (**Figures 3** and **4**). Implementation of some farming practices has a significant impact and ecofriendly consequences at the watershed level. For example, growing of fruit trees on contours or other non-timber trees for the compensation of decline in crop yield could have a significant saving effect on water conservation and water use efficiency. This will provide a new way of farming to the farmers for increasing their income and will help to stabilize their socioeconomic status. Agronomists are needed to design such a productive agricultural system that is more suitable and resilient to the socioeconomic needs of the farming communities like poverty and hunger alleviation, food security, climate change adaptation, and environmental protection.

Increase in crop productivity is important to reduce food security problem; therefore, agronomic research is related to food security. Food security can be ensured by an efficient system of food, food production, and new research in the area of crop production. Food system is a set of continuous interaction between and within humans and their biogeophysical environment and it includes food production, processing, and food allocation and food consumption [25], while agronomy has an important role in these activities like producing food, by modern scientific methods and practices, storage and processing of staple food, and production timing in relation to market and food diversity in terms of nutritional balance. To this end, agronomic research needs to be better linked to wide-ranging interdisciplinary sectors and across sectors of the food industry. This will facilitate the building of integrated socioeconomic-biophysical models that will enable analysis of adaptation

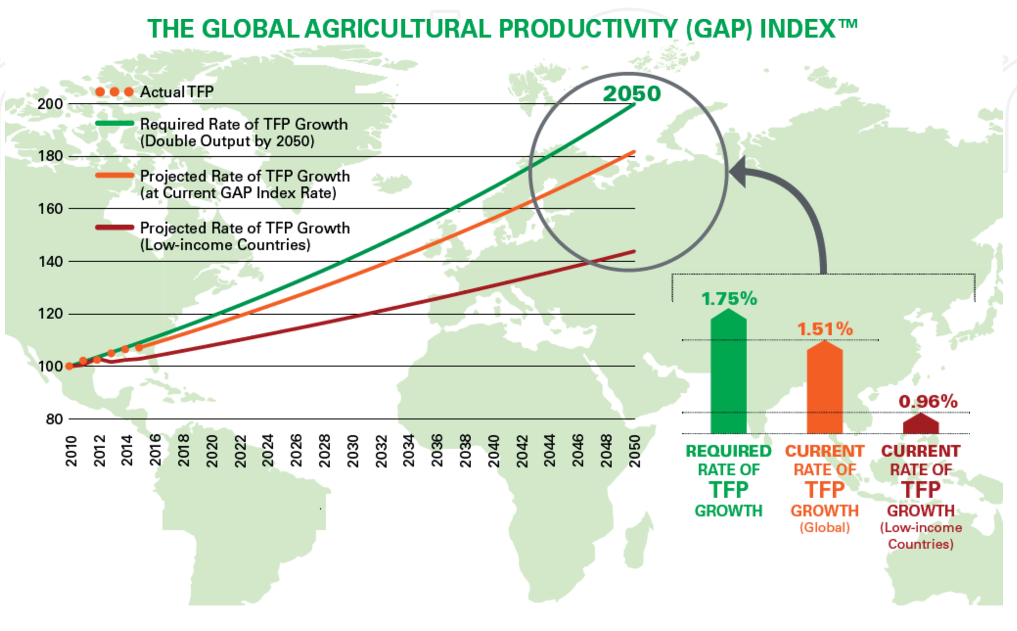

Figure 3.
Agricultural output from TFP growth.

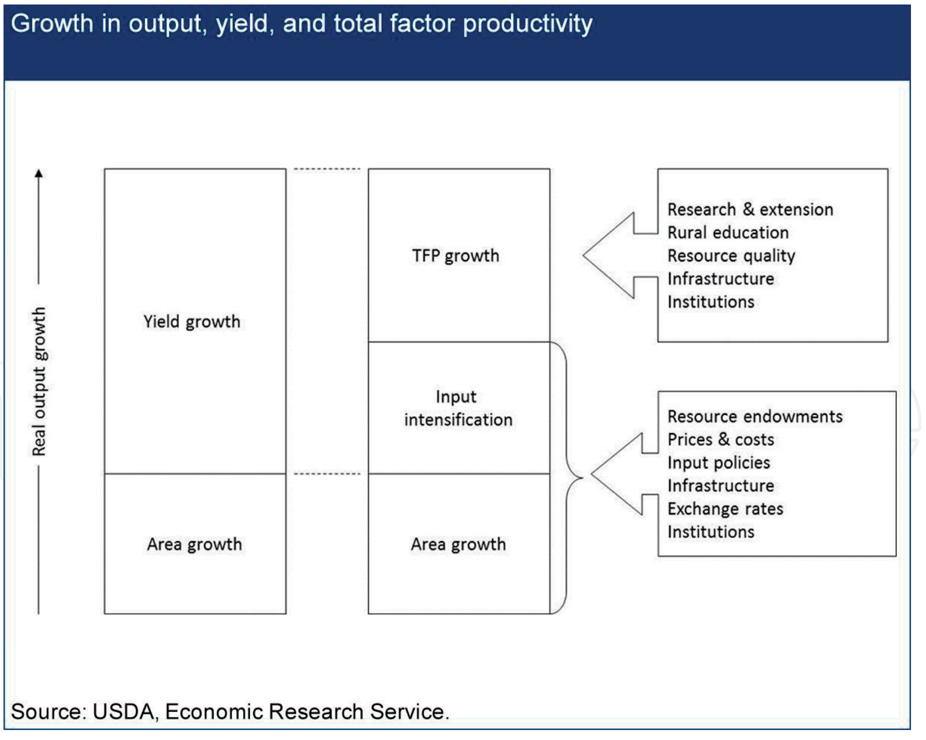

Figure 4.
Economic survey of USDA.

options to food systems, thereby underpinning policy formulation for improved food security and nutrition. The SDGs emphasize the importance of agriculture and the need to reinvigorate farming worldwide by supporting farmers, increasing investments in research, technology and market infrastructure, and extending knowledge sharing. This will catalyze innovation and empower farmers.

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References

[1] Vitousek PM, Mooney HA, Lubchenco J, Melillo J. Human domination of earth's ecosystems. Science. 1997;**277**:494-499

[2] Steffen W, Tyson P. Global Change and the Earth System: A Planet under Pressure. Stockholm: International Geosphere—Biosphere Programme (IGBP); 2004

[3] Fischer G, Shah M, van Velthuizen H, Nachtergaele FO. Global Agro-Ecological Assessment for Agriculture in the 21st Century. Laxenburg, Austria: International Institute for Applied Systems Analysis; 2001

[4] Rosegrant MW, Cline SA. Global food security: Challenges and policy. Science. 2003;**302**:1917-1919

[5] Parry M, Rosenzweig C, Inglesias A, Livermore M, Gischer G. Effects of climate change on global food production under SRES emissions and socio-economic scenarios. Global Environmental Change. 2004;**14**:53-67

[6] Stern N. Review on the Economics of Climate Change. London: HM Treasury; 2006

[7] Hadley-Centre. Effects of Climate Change in the Developing Countries. UK: Met Office; 2006

[8] IPCC. Africa. In: McCarthy JJ, Canziani O, Leary NA, Dokken DJ, White KS, editors. Climate Change 2001: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Third. 2001

[9] Tyson P, Odada E, Schulze R, Vogel CI. Regional–global change linkages: Southern Africa. In: Tyson P, Fuchs R, Fu C, Lebel L, Mitra AP, Odada E, Perry J, Steffen W, Virji H, editors. Global—Regional Linkages in the Earth System. Berlin, London: START/IHDP/IGBP/WCRP. Springer; 2002

[10] Doos BR. The problem of predicting global food production. Ambio. 2002;**31**:417-424

[11] UN-DESA. World population prospects: The 2004 revision report, chapter 1. United Nations Department of Economic and Social Affairs/Population Division; 2004

[12] Tilman D, Cassman KG, Matson PA, Naylor R, Polasky S. Agricultural sustainability and intensive production practices. Nature. 2002;**418**:671-677

[13] Bruinsma J. World Agriculture: Towards 2015/2030. An FAO Perspective. London: Earthscan Publications Ltd; 2003

[14] Evans LT. Feeding the Ten Billion. Cambridge: Cambridge University Press; 1998

[15] Gregory PJ, Ingram JSI, Andersson R, Betts RA, Vrovkin V, Chase TN, et al. Environmental consequences of alternative practices for intensifying crop production. Agriculture, Ecosystems and Environment. 2002;**88**:279-290

[16] Jones PG, Thornton PK. The potential impacts of climate change on maize production in Africa and Latin America in 2055. Global Environmental Change. 2003;**13**:51-59

[17] Stige LC, Stave J, Chan KS, Ciannelli L, Pettorelli N, Glantz M, et al. The effect of climate variation on agro-pastoral production in Africa. Proceedings of the National Academy of Sciences. 2006;**103**:3049-3053

[18] Kurukulasuriya PR, Mendelsohn R, Hassan R, Benhin J, Deressa T, Diop M,

et al. Will Africa survive climate change? World Bank Economic Review; 2006

[19] Kettlewell PS, Sothern RB, Loukkari WL. UK wheat quality and economic value are dependant on the North Atlantic oscillation. Journal of Cereal Science. 1999;**29**:205-209

[20] Slingo JA, Challinor AJ, Hoskins GJ, Wheeler TR. Food crops in a changing climate. Philosophical Transactions of the Royal Society B. 2005;**360**:1983-1989

[21] Tubiello FN, Donatelli M, Rosenzweig C, Stockle CO. Effects of climate change and elevated CO_2 on cropping systems: Model predictions at two Italian locations. European Journal of Agronomy. 2000;**13**:179-189

[22] UNDP. The 2006 Human Development Report—Beyond Scarcity: Power, Poverty and the Global Water Crisis. New York. USA: United Nations Development Programme; 2006

[23] Sutherst R, Baker RHA, Coakley SM, Harrington R, Kriticos DJ, Scherm H. Pests under global change—Meeting your future landlords? In: Candell JG, editor. Terrestrial Ecosystems in a Changing World. Springer; 2007. p. 336

[24] Greenland DG, Gregory PJ, Nye PH. Land resources and constraints to crop production. In: Waterlow JC, Armstrong DG, Fowden L, Riley R, editors. Feeding a World Population of More than Eight. 1998

[25] Ericksen PJ. Conceptualizing food systems for global environmental change research. Global Environmental Change. 2008;**18**:234-245