



# Developing Sustainable Agriculture in Pakistan

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Iqrar Ahmad Khan  
Muhammad Sarwar Khan



CRC Press  
Taylor & Francis Group

# **Developing Sustainable Agriculture in Pakistan**



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Edited by  
**Iqrar Ahmad Khan**  
**Muhammad Sarwar Khan**



**CRC Press**

Taylor & Francis Group

Boca Raton London New York

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CRC Press  
Taylor & Francis Group  
6000 Broken Sound Parkway NW, Suite 300  
Boca Raton, FL 33487-2742

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Printed on acid-free paper

International Standard Book Number-13: 978-0-8153-6653-9 (Hardback)

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#### Library of Congress Cataloging-in-Publication Data

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Names: Khan, Iqrar A. (Iqrar Ahmad), author. | Khan, Muhammad Sarwar, author.  
Title: Developing sustainable agriculture in Pakistan / authors: Iqrar Ahmad Khan and Muhammad Sarwar Khan.  
Description: Boca Raton, FL : CRC Press, Taylor & Francis Group, 2018. | Includes bibliographical references and index.  
Identifiers: LCCN 2018001401 | ISBN 9780815366539 (hardback : alk. paper)  
Subjects: LCSH: Sustainable agriculture--Pakistan.  
Classification: LCC S471.P18 K436 2018 | DDC 338.1095491--dc23  
LC record available at <https://lcn.loc.gov/2018001401>

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<http://www.crcpress.com>

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# Preface

The history of agriculture is the history of humans breeding seeds and animals to produce traits they desire in their crops and livestock. Agriculture plays a pivotal role in the economy and development of Pakistan. It contributes to about 21% of the total GDP and employs nearly 46% of the labor force of Pakistan. However, agriculture production is compromised due to fixed cropping patterns, reliance on a few major crops, narrow genetic pools, and the changing climate. This demands a holistic approach to develop agriculture and to improve the livelihood of the rural populace. This book provides critical analyses of present trends, inadequacies in agriculture, strategic planning, and ways forward to improve programs and policies keeping in view the natural resources, agriculture (crops and animals) production technologies, input supplies, population planning, migration and poverty, and balanced policies on finance, credit, marketing, and trade.

*Developing Sustainable Agriculture in Pakistan* consists of 38 chapters subdivided into four sections. The flow of chapters in the book is strategically organized to allow for easy reading. It begins with [Chapter 1](#) “Planning for Sustainable Agriculture in Pakistan” in which Drs. Iqrar Ahmad Khan and Muhammad Sarwar Khan comprehensively provide an overview of the latest approaches which could be used to develop sustainable agriculture. Section I (Natural Resources and Input Supplies) begins with [Chapter 2](#), in which Drs. Tahir and Khaliq explain precisely how production factors can be exploited to improve agriculture. In [Chapters 3 and 4](#), Dr. Allah Bukhsh and his team stress upon the necessity of developing water reservoirs to meet ever-increasing requirements for irrigation while exploring the potential of renewable energy sources. In [Chapter 5](#), Drs. Rashid and Nasir discuss environmental degradation and its remedial measures. Dr. Zahir and his colleagues, in [Chapter 6](#), have proposed a number of remedies against factors which cause depletion of soil fertility and decrease productivity. In [Chapter 7](#), Drs. Arshad and Ahmad discuss facts concerning the irrigation system of Pakistan, whereas Dr. Cheema and colleagues, in [Chapter 8](#), describe ICT-based precision agriculture for increased farm productivity and decreased adverse environmental impacts. In [Chapters 9–12](#), Drs. Ali, Khan, Akhtar, Arif, and their colleagues describe the current status and provision of services to farmers for increasing agricultural productivity and improving their livelihood.

Section II (Crop Production Technologies) consists of ten chapters (i.e., [Chapters 13 through 22](#)). In [Chapter 13](#), Drs. Ahmad and Husain provide a comprehensive account of climate change and its effects on agriculture. Dr. Murtaza and his colleagues discuss the treatment and management options of low quality waters in [Chapter 14](#), and suggest that changes be brought about in policies for significant improvement and sustainability of crop husbandry. In [Chapter 15](#), Dr. Khaliq and his colleagues discuss production trends, constraints in productivity, and have suggested a way forward for crops of economic significance. In [Chapter 16](#), Dr. Basra and his colleagues stress upon the use of crop rotation and diversification and also suggest introducing new crops in the cropping pattern. In [Chapter 17](#), Dr. Ahmad and his colleagues propose growing high-value horticultural plants including wild-type medicinal plants to improve the pharmaceutical industry. Dr. Siddiqui and his colleagues, in [Chapter 18](#), propose strategies to improve productivity on a sustainable basis while discussing forests and rangeland management issues. In [Chapter 19](#), Drs. Khan and Joyia elaborate on how biotechnology plays a pivotal role in developing GM plants, which are designed to address emerging problems of insects, pests, and diseases under changing climatic conditions. In [Chapters 20–22](#), three teams of authors discuss devastating diseases, insects, and the different uses of methods to combat them.

Section III (Animal Production and Health) is comprised of five chapters (i.e., [Chapters 23 through 27](#)). In [Chapter 23](#), Dr. Khan and his colleagues give an insight into problems and solutions related to livestock production, public and private ownership of commodities, and markets. In [Chapter 24](#), Dr. Akhtar and colleagues discuss problems related to the poultry industry. Drs. Javed and Abbas discuss in [Chapter 25](#) how capacity building and integration of new techniques are important for

sustainable aquaculture and fisheries in Pakistan. In [Chapter 26](#), Dr. Javed and his colleagues offer a lengthy discussion on the developments and issues related to the livestock and poultry industry and propose suggestions for improvement and value addition to the products of both industries. In [Chapter 27](#), Dr. Sharif and colleagues highlight the problems of malnutrition in children and—considering the severity of the issue—suggest various strategies to alleviate the problem such as school health, nutrition programs, diet diversification, targeted food fortification, nutrition education, and a “one health” approach.

Section IV (Agricultural Incentives for Farmers) consists of eleven chapters. [Chapter 28](#), by Dr. Anjum et al., illustrates the need for gender equality and women’s empowerment in different agricultural sectors and classifies the means for improving the economic impact of women’s work in agriculture, as well as for enhancing food security and sustenance. In [Chapter 29](#), Dr. Maan and colleagues give a SWOT analysis of the five years population plans and suggest improvements to the quality of schools—through improved curricula and staffing with competent teachers—to reduce the dropout rates of female students. In [Chapter 30](#), Dr. Akhtar and colleagues suggest that reducing the reliance upon foreign debts may result in poverty alleviation in Pakistan. Dr. Farah et al. examine in [Chapter 31](#) the rural–urban migration in Pakistan and suggest effective steps to manage and curb the increasing trend of internal migration. In [Chapter 32](#), Dr. Ali and his team present a critical review of various rural development programs carried out in Pakistan while discussing the highlights of the success story of rural development in South Korea. In [Chapter 33](#), Dr. Ahmad and colleagues describe various challenges confronting the outreach and agricultural extension system in Pakistan. They also refer to social mobilization while emphasizing various opportunities for improvements. In [Chapter 34](#), Dr. Sadaf and her colleagues discuss the future perspectives for Pakistani agricultural price policies in the light of regional and international policies, whereas Drs. Mushtaq and Bashir present the pros and cons of agricultural credit and agricultural cooperatives in [Chapter 35](#) and suggest changes for traditional cooperatives—keeping in view the global economic situation. In [Chapter 36](#), Dr. Ghafoor and colleagues suggest how different initiatives could improve the agricultural marketing system in Pakistan. In [Chapter 37](#), Dr. Ahmad and colleagues, while examining the bilateral trade relations of Pakistan in the region, comment on the fact that value addition in agricultural products is the limiting factor of trade with other countries. In the last chapter, Dr. Khan and colleagues stress upon the need for increasing the production of value-added products through improved supply-chain management, production of innovative nutrient dense foods, and improved storage conditions.

Agriculture is an interdisciplinary endeavor; therefore, it is difficult to cover all aspects of this subject in a single book. The editors of this book are conscious of the fact that there is considerable scope for increasing agricultural productivity by incorporating modern technologies. This is only possible if the farmers have the means necessary and access to credit and free markets. The development of markets where farmers can sell their commodities will directly improve their lives. In this book, we have tried our best to provide a critical overview of the latest trends and future perspectives in agriculture. We hope this book will be a worthwhile resource of up-to-date information for different stakeholders, including policy makers. We also welcome your suggestions, which may help us improve the next edition.

**Iqrar Ahmad Khan, PhD**  
**Muhammad Sarwar Khan, PhD**

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# Editors



**Iqrar Ahmad Khan** has had a long career in education and agriculture and earned his PhD from the University of California, Riverside. He is currently serving as vice chancellor of the University of Agriculture, Faisalabad, Pakistan (since 2008). Dr. Khan has supervised more than 100 graduate students and researchers. Dr. Khan has established a center of agricultural biotechnology and has co-founded a DAAD-sponsored “International Center for Decent Work and Development” (ICDD). He has also helped in establishing a USAID-funded Center of Advanced Studies in Agriculture and Food Security, as well as a French Learning Center and the Chinese Confucius Institute. He has organized numerous international conferences and established academic linkages

across continents. Dr. Kahn has also released a potato variety (PARS-70), pioneered research on breeding seedless Kinnow, and discovered new botanical varieties of wheat. Dr. Khan has initiated an internationally acclaimed program to solve the devastating problem of Witches’ Broom Disease of lime in Oman. He is currently leading international projects to combat citrus greening disease and mango sudden death. He has published more than 270 articles, five books, and several book chapters.

Dr. Khan has the diplomatic skills to attract international partnerships and establish academic linkages in such countries as Afghanistan, Australia, South Korea, China, Germany, France, Malaysia, Indonesia, Turkey, Iran, India, Oman, Canada, the United Kingdom, and the United States. He has managed collaborative research projects sponsored by national and international agencies. Dr. Khan is a fellow of the Pakistan Academy of Sciences and a member of several professional societies and associations. He has been the recipient of a civil award, *Sitara-e-Imtiaz*, from the government of Pakistan in recognition for his outstanding contributions to the areas of agriculture and food security. Recently, he has also been awarded the *Ordre des Palmes Académiques* (with the grade of Officer) by the French government for his exceptional role as educator.



**Muhammad Sarwar Khan** has a vibrant career in agriculture, education, and biotechnology and has earned his PhD from the University of Cambridge, UK. The Rockefeller Foundation awarded him a prestigious fellowship under the Rice Biotechnology Program for Developing Countries to carry out research at the Waksman Institute of Microbiology, Rutgers, at the State University of New Jersey. His findings—a research of first-of-its-kind—was published in *Nature Biotechnology*. Dr. Khan was appointed as national coordinator to train “A” and “FSc” level students by holding training camps across Pakistan to compete for medals in the International Biology Olympiads. He served as the founding head of Biotech Interdisciplinary Division

at NIBGE, and is currently serving as the director of the Center of Agricultural Biochemistry and Biotechnology (CABB), University of Agriculture, Faisalabad, Pakistan.

Dr. Khan has supervised more than 100 PhD candidates, MPhil students, and researchers who are now serving at national and international levels in various research institutes and universities. He has vastly published in high impact journals, including *Nature* and *Nature Biotechnology*, and is the author of a number of book chapters and books. Dr. Khan has made significant contributions in the field of agricultural biotechnology. He has developed transgenic sugarcane resistant to top borers and tolerant to herbicides, which was approved by the National Biosafety Committee (NBC) for field trials in 2006–2007. This was the first proposal of endogenously developed GM plants

approved by the NBC in Pakistan. Dr. Khan has also pioneered plastid transformation in rice and sugarcane, recalcitrant plant species. He has also knocked out a number of genes from the chloroplast genome of higher plants to assign functions. His current research interests include development of edible-marker-carrying transgenics and cost-effective therapeutics and edible vaccines for animals. Dr. Khan has received prestigious awards, including the President's Medal for Technology, a Gold Medal in Agriculture from the Pakistan Academy of Sciences, a Performance Gold Medal by NIBGE, the Biotechnologist of the Year Award by the National Commission of Biotechnology, and the Best University Teacher Award by the Higher Education Commission of Pakistan. He is also a fellow of the Cambridge Commonwealth society, the Cambridge Philosophical Society, the Rockefeller Foundation, the Pakistan Botanical Society, and the International Association for Plant Biotechnology.

In addition to contributing to innovations in the field of agricultural science, Dr. Khan has served in different senior positions of the Social Safety Net Program of the Government of Pakistan—supported by international donors, including the World Bank—to contribute towards poverty alleviation. During his service there, a number of social protection special initiatives were undertaken to help underprivileged people in Pakistan, especially women for their empowerment.

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price/public procurement and subsidies lies in increasing efficiency and precision to reduce the unit cost of production. Livestock breeding and health initiatives must be made into commercially viable propositions to attract the private sector into the business of service providers.

*Priority 3:* Climate change has provoked new challenges to sustain agricultural productivity. There has to be an elaborate plan to mitigate and adapt to these. The immediate option is to redefine crop zones on the basis of long-term climate trends, soil and water analyses, available technologies, available skills, and current markets and industrial demands. The country could be divided into more than 30 different crop zones and subzones, which would allow a precise decision mechanism for technology transfer and incentive packages.

*Priority 4:* There should be an emergency plan to curtail postharvest losses by half. This will require an investment in the training programs promoting value addition through product development and for market preparations along the value chain. Home science groups should be incorporated in rural development and extension programs. Investments are also required for transportation and storage infrastructures. The marketing system needs a long-term improvement plan for new markets, legislation, and governance reforms. The Punjab rural roads program must be amplified and the example of cattle markets should be replicated to create a new structure of grain and produce markets. CPEC routes should be marked for the establishment of new agro-processing zones and markets for exports to regional markets. The French government has introduced a new law to mandate the distribution of unsold produce and food at the retail level and in the restaurants for the needy; otherwise, it requires the return of such items to farmers for use as bioenergy or organic matter in soil.

## 1.6 LONG TERM STRATEGIES

If implemented, the short-term strategies can raise the agriculture sector growth above 4% for the near future. However, for long-term sustainability of the system, as well as agricultural growth and poverty alleviation, the following sections detail the proposed areas of public policy interventions.

### 1.6.1 FOOD SECURITY, NUTRITION, AND HUNGER

The food security paradigm must shift from a supply side excess of staple items to an integrated nutritional package where diversified dietary needs are met (zero hunger of SDGs). Food safety issues like pesticide and antibiotic residues in food, mycotoxins, and malpractices associated with food handling must be addressed. All food secure countries in the world have less emphasis on wheat and rice and more on corn, potato, soybean, vegetables, fruits, dates, dairy, and poultry. We need to work on diversification of food supply and consumer habits.

It is pertinent to include food and nutrition subjects in school curricula, coupled with media awareness campaigns and counseling. Legislation for mandatory wheat flour fortification with iron should be introduced/implemented. Breeding programs for genetic fortification of food crops for nutritional enrichment and fertilizer use efficiency are long-term solutions. The greater good could only come from a social and behavioral change towards food through participatory actions. Rural poverty alleviation programs must be focused on the landless and women's enterprises.

### 1.6.2 LEGAL FRAMEWORK AND INSTITUTIONAL REFORMS

Performance of agriculture is linked with the performance of many public and private sector institutions. This requires legislative and administrative measures, political will, and social movements. There are federal and provincial legal frameworks. With the 18th amendment of Pakistan's constitution, much confusion has arisen which have diminished the role of already underperforming federal institutions. The Irrigation Act, Seed Act, the Plant Breeders Act, the Pesticide Act, the Fertilizer Order, the Cooperatives Act, the Market Act, the Food Act, National Biosafety Committee, and so on are obsolete instruments. The Punjab Government has an Agriculture Commission, which has embarked upon the review of laws and policies impacting

agriculture. Similar actions are required to be taken on by the other provincial governments. The Council of Common Interest (CCI) should have an agenda to provide a fresh look at federal laws and policies affecting agriculture and rural development. The CCI could also ask for uniformity among the provinces and all federating units.

### 1.6.3 RESEARCH SYSTEM AND BUDGETS

The national agricultural research system (NARS) and international agricultural research system (IARS) must compliment each other for a better agriculture (crops, livestock, irrigation, forest, and fisheries). Unfortunately, our NARS is underperforming, full of overlaps, and segmented (research, education, and extension). There are federal institutions, provincial institutions, and universities that have huge investment and strengths. The outcome has been very impressive over a long period of time, however, the current stagnation reflects serious recent malfunctions. There are institutions that have lost their relevance after 18th amendment which include the Pakistan Forest College in Peshawar, the FSC&RD, and to some extent the PARC. Mechanisms are needed for funding research well above the current level of 0.18% of agricultural share in the GDP. Autonomous commodity boards are an option to levy a research tax on value-added agricultural products.

A worldwide recognized system of integrated research, teaching, and extension is that of the United States, called as land grant colleges. It is a tripartite arrangement created through a series of enactments by the U.S. congress (Figure 1.8). However, we have not following this model and have kept research, education, and extension in different domains without any practicable mechanism for integrated effort for agricultural growth. This needs to be aligned to successful land grants college models to improve the efficiency of our public agriculture services.

We also need to create mechanisms to prioritize agricultural research and introduce funding of commissioned research programs. The research should be internationally compatible (scholarship) on the one end, and farmer focused on the other end, with innovations a high priority. At present, investment in commissioned research in the following priority areas is considered essential:

- a. Seed production and technology
- b. Development of stress-tolerant germplasm for crops and livestock genetics
- c. Promotion of new and nontraditional crops
- d. Special programs on dates, rangelands, and orchards

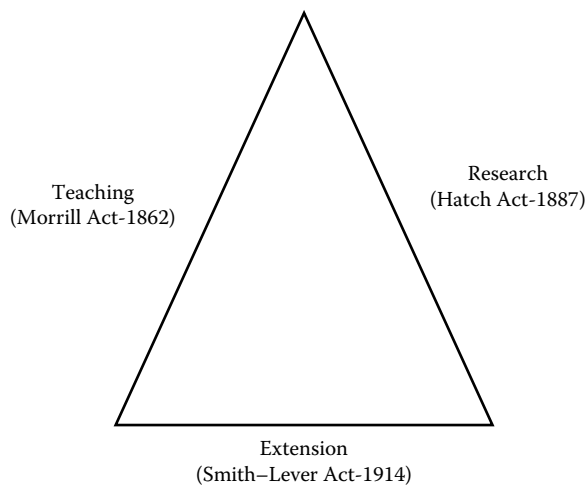


FIGURE 1.8 The structure of land grant university: A success model.

- e. Pest management strategies for fruit flies, ticks, pink boll worm, white fly, and vector borne diseases
- f. Control of tree dieback (mango and sheeshamin in particular) and citrus greening
- g. Ensuring and improving the health and nutritional value of food
- h. Mechanization of farm operations (land development to postharvest) including technological adaptation to the Pakistan farm setting and precision farming
- i. Increasing viability of horticulture enterprises through zoning and cool chains owned by the marketing cooperatives
- j. Use of Information and Communication Technology (ICT) in the transfer of agriculture and food systems knowledge and technology (Smart Agriculture)
- k. Policy research and commodity analyses as a regular feature.

#### **1.6.4 FISCAL POLICY**

The taxation of the agricultural sector and the overall growth rate of the economy are strongly correlated (Krueger et al., 1988; Schiff and Valdés, 1992). The economic growth of a country is strongly linked with growth in its agriculture sector (Johnston and Mellor, 1961) as its growth generates a large multiplier effect (Block and Timmer, 1994). Despite empirical evidence, the agriculture sector has remained subject to heavy taxes (implicit). It is assumed that the agricultural exports earn high profits due to country quota and should be taxed. An explanation for agricultural taxation is given by the fact that the sector is not making proportionate contributions in tax revenue compared to its share in national GDP. Such arguments fail to consider the fact that the agricultural sector provides raw materials and markets which helps the growth of other sectors. Some of the key devices proposed for agriculture taxation include selective commodities taxation, export quota taxation, agricultural income tax, and general sales tax on inputs. It is important to compute all implicit taxes if the goal of the government is to generate tax revenues from agriculture sector, which are commensurate to its share in the GDP. The selective commodity taxation cannot be recommended as it alters resource allocation (the taxed commodity gives incentive to shift to a different commodity). The risk of intersectoral resource allocation can make matters worse for an already dwindling agriculture sector.

Fiscal policies and taxation regimes are important determinants of regional trade and commerce. With the passage of time, support prices of various commodities have been withdrawn except for wheat. Higher general sales tax rates on fertilizer and petroleum products and other taxes on inputs contribute to the escalating costs of production. In order to improve the profitability of various commodities, there is a need to move back to the support price system (selectively) and the provision of inputs at subsidized rates (targeted). The ultimate aim should be progressive liberalization and deregulation to let the market forces work. A rational fiscal policy proposition would be to first provide enabling conditions for agriculture growth and then impose taxes once it progresses at a decent pace.

#### **1.6.5 CREDIT AND COOPERATIVES**

Agriculture is a business and every business requires investment. The farmer is always cash strapped and at the mercy of “rent seekers.” He needs credit. Looking at agriculture’s share in GDP and corresponding formal credit availability, it is evident that there is a situation of huge underinvestment. The rural areas remain deprived of vast coverage of financial services mainly due to remoteness, high transaction costs, lack of traditional collateral, low literacy to understand procedures, and perverted instruments. The issue is aggravated due to inflexibility on the part of lending agencies. The formal credit services can be made sustainable in rural areas through innovative policies to screen reliable borrowers, monitoring techniques for effective use of loans, and erecting a regulatory environment to encourage sustainable rural financial services (Norton, 2004).



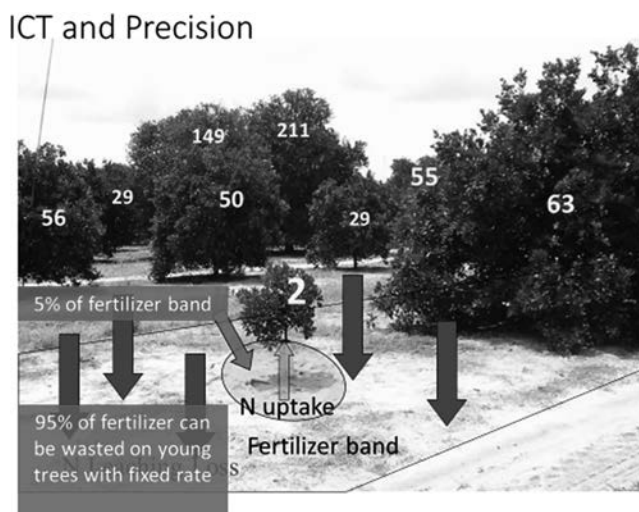
The formal/institutional credit for agriculture is an insignificant component in the entire investment portfolio of agriculture. The vacuum created by the lack of a formal financial stream is being filled by the nonformal sector at exorbitant costs to the farmer. Cooperatives used to play a significant role in the supply of credit and services. In Punjab, there are 136 branches of the Punjab Cooperative Bank, which is dysfunctional. We need to create Marketing and Services Cooperatives (default corporatization) to revive the supply of credit through these branches. This will require market reforms, investment in the improvement of supply chains, promotion of clusters, and enablement for value addition. Revival of cooperatives can boost the productivity of small farmers in many ways. The development of CPEC offers an opportunity of SEZs (Special Economic Zones), which could be agro-focused centers for value addition. This can support credit for entrepreneurship, SMEs, and local employment opportunities. A credit task force of composed of bankers should be constituted to look after these needs.

**1.6.6 INPUT SUPPLY**

Seed, fertilizer, agrochemicals, and energy/machinery are the major inputs. The farmers who can better manage these elements are called progressive and can usually harvest optimal yields. The progressive farmers are not necessarily the large owners. They can be landless contractors or small farmers. Generally, large farming operations end up with a better mix of input supplies, and hence produce better yields. The state has a role to play in ensuring timely supply and accessibility of inputs (unadulterated) to the farmers regardless of their ability to pay up front. Now, with ICTs becoming easily accessible, the state must enable the farmer with a “decision support strategy.” Use of ICTs for research and development, dissemination of knowledge, and crop/commodity advisories must be fully capitalized. Credit delivery and monitoring should be linked with the ICT services. Precision agriculture has emerged as a tool for efficiency. The ICT strengths in Punjab are enough to take advantage of precision agriculture technologies (Figure 1.9).

**1.6.7 SERVICE PROVIDER**

Agriculture has now become a high-tech sector in developed countries and the role of agricultural technology is rapidly increasing. In order to remain in the business and be competitive in the world



**FIGURE 1.9** A definition of precision in terms of site/size specific application. This citrus grove has trees with canopy volumes ranging from 2 cubic meters to 211 cubic meters. A uniform application could be wasteful or insufficient.

at large, technological adoption is an essential condition. There are always risks involved with new technologies but it is proven that the restrictive approach of trade in technology is riskier than the liberal policy of importing technologies (Gisselquist and Grether, 2000). The service providers can be a useful conduct to transform the agriculture sector into a high-tech sector. This is an option to narrow the technology gap and for the small holders to achieve significant savings. This model has been successful in different parts of the world. The idea is to create a range of crop-specific or region-specific entrepreneurial setups with farm machinery and input supplies. These could be matched with credit availability when required. Incentivized farmer's cooperatives could be another option. Entrepreneurs are given loans and incentives to start their businesses (corporatization). The goal should be to elevate the productivity of underperforming small farms and to improve the gains of progressive farmers. Use of agricultural drones is a hot topic of research. Crop monitoring, yield mapping, and agrochemical spraying can be performed by manned and unmanned aerial vehicles.

### **1.6.8 RURAL DEVELOPMENT**

Agriculture and rural development go together. Rural infrastructure development (roads, school, health) and skill development need massive investments. There is room for social mobilization for collective action and dispute resolutions through community-based organizations. Population welfare, gender mainstreaming, and youth programs must be targeted for rural communities to raise their aspiration and increase their love for agriculture. The agriculture and veterinary universities should be mandated to prefer students' intake from the rural schools. These universities should be mandated to create pre-agriculture programs to promote the attendance of rural youth. Rural poverty needs multidimensional strategies of enablement and job creation along with alternate income generation activities.

### **1.6.9 WAY FORWARD/STRATEGIC PLANNING**

In the short term, sustainability planning should include education and dissemination of knowledge and skill for enhancing the participation of farming/rural communities. In the medium and long term, the role and effectiveness and relevance of agricultural research and extension, credit services, and marketing are needed to build resilience. Investment in decision support systems would be critical:

1. Analyze public investment and subsidies in the agriculture sector, particularly after the 18th amendment and institutionalize public investment priorities in agricultural infrastructure and marketing with a clear commitment of finances perpetually.
2. Irrigation systems needs improvements from the dam up to the farm level. Real time discharge data should be made public. The tail end farmers must be looked after. Groundwater pumping should be regulated and water should be priced. Promote low delta crops and ban rice cultivation before the onset of rains.
3. Revamp the marketing system on the along the lines of cattle markets to get rid of "Market Administrators" and cartels. That should be aimed at creating a transparent (market information and intelligence), competitive, and efficient marketing structure.
4. Phase out of public procurement of wheat by creating a PPP model for storage (buffer) and distribution. Incentivize warehousing of major commodities and create a commodity exchange. Minimize postharvest losses: Fix targets for reducing overall postharvest losses to the level of 25% for fresh produce and 8% for grains (a half of the present).
5. Incentivize crop diversification by providing a better marketing option or support price for the minor crops/oilseeds/pulses and nontraditional crops. Launch special programs for periurban agriculture to avoid contaminated produce.

6. Create a regional trade policy forum like NAFTA, EU, APAP with a special focus on CPEC. A CPEC think tank on agriculture must work on developing long-term strategies.
7. Seed sector reforms include facilitation for the private sector in seed multiplication and trade. Enforcement of biosafety rules is required to pave the way for the introduction of GM crops. The universities must launch seed science and technology programs. A liberal regime for international partnerships is needed.
8. Balanced use of fertilizer is an utmost need to improve the productivity and to protect our environments. That will also reduce the cost of production. The urea economy of fertilizer industry must be revisited. The attention on P and K has already proved to be a wise step. The crop residue management and micronutrient would be other essential items. Soluble fertilizer formulations are now demanded to promote fertigation.
9. Mechanization and reverse engineering of farm machinery is an opportunity for the small and medium sized enterprises (SME) sector. This includes all tractor mounted equipment from ploughing to postharvest handling and processing. Establishment of service centers/ Rural Business Hubs (RBH) is an option for small rural towns where mechanization and input needs could be met under one roof.
10. Climate change adaptations and mitigation framework needs to be formalized as an essential part of Smart Agriculture; it can be called Climate Smart Agriculture.
11. Invest in skills for value addition and for promotion of SMEs. The rural youth needs to be trained for SME and service delivery options to create alternate income streams for their families (rural nonfarm sector). Value addition training is the low hanging fruit to promote aspirations and create opportunities. Link microfinance and youth loans with skills and entrepreneurship.
12. Gender mainstreaming by extending benefits of women development programs to the rural areas will address inequality by developing women markets and investment in startups. Promotion of bikes for rural girls after matriculation and nutrition awareness of girls are needed. Skill development for women labor forces and awareness about their rights are also important. Future mothers and school lunch programs and curricula are needed. Targeted food fortification and blending options deserve to be tried.
13. Extension and outreach should promote entrepreneurship and aspirations in the agriculture sector. Venture capital and training for future farmers in high-value crops, fruits, and commodities should work. Launch residue management programs and educate farmers on the responsible use of chemicals. Launch crop packages for diversification (alfalfa, oilseeds, pulses, soybean, sorghum, millet, and vegetables) on the basis of agro-ecological zones. ICT enabled centers with the provision of extension and training of farmers (particularly women and youth) are currently being tried. Special programs for lead farmers and theme leaders (champions of change) should be created.
14. Investments should be made in skill development to reduce postharvest losses and to add value. The quality standards and WTO requirements as well as regional opportunities offered by the CPEC must be addressed to become globally competitive. Comprehensive market reforms program are needed.
15. The investment in research and development should be linked with institutional reforms for the integration of education, research, and extension. Commodity research boards should be institutionalized. Long-term research experiments should be launched to model sustainability of cropping systems.
16. Rural development must include infrastructures for farm to markets at a much larger scale than presently available. Rural life must be made attractive to reduce migration by introducing women and youth development programs along with alternate income propositions (at Markaz level or the small town centers/the new Mandi Towns).

## 1.7 CONCLUSION

This book is a farmer centric document to be treated as a baseline to establish a continuous review for policies and planning processes. There should be a 1–3 years plan written as a departmental operations manual, which includes investment strategies and implementation targets. Food security must include nutritional security. The political economy of food security must not compromise the profitability of the farmer and transfer resources from rural to urban economies (terms of trade). The immediate targets should be addressing the small farmers' productivity challenges by ensuring quality seed (plant population), machinery, balanced fertilizer, insect pest management (IPM), and weed management. The public procurement of wheat should be phased out and available resources should be used to incentivize crop diversification. The HEIS must be evaluated and redesigned. Medium to long-term plans should be devised for land and water resource management (fragmentation, on-farm water storage, rain water harvesting, water pricing). Grain and produce markets are insufficient and imperfect. Infrastructure and legal frameworks are needed to enhance capacity and to promote the transparency and competitiveness of business systems, which should be free of exploitation by middlemen.

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