Foreword

It is rather difficult to envision the expected needs, scientific developments, challenges and opportunities of the future. Nevertheless, one has to take up this task so as to plan for the same.

Looking back, Punjab has made unparalleled progress in agriculture. Having just 1.53% geographical area of India, it produces about 22% wheat, 11% rice and 10% cotton of the country. It generates second largest marketable surplus of rice and third of wheat in the world. Punjab Agricultural University (PAU), during 50 years of its service, has contributed immensely to this progress. In view of immense impact of new technologies during the 1960s and 70s on Punjab’s agriculture and the national food security, PAU can be rightly called the “Mother of Green Revolution” in India.

The University made landmark achievements in the development of improved crop varieties and their production-protection technology package, saline-alkaline soil reclamation technology, cropping-system and agro-ecologies based input application, etc. Besides crop science, PAU has remarkable contribution to its credit for cross-breeding of cattle, introduction of Italian honey bee and mushroom cultivation. These research achievements were coupled with innovative technology dissemination programmes, such as, interaction between scientists and farmers at Kisan Melas (started in 1967), Farmers Service Centre (1993) and distribution of seeds of new varieties in minikits. Over the years, PAU has produced large scientific human resource that has brought laurels in different spheres at the national and international levels. In recognition of its outstanding contributions to the nation, PAU was the first agricultural university to be conferred with the “Best Institution Award” by the Indian Council of Agricultural Research (1995) and also the first to get as large special grant as Rs. 100 crore from the Government of India (2007).
Punjab Agricultural University

Input intensive rice-wheat cropping system, that was followed in the state with a focus on assuring national food security, has led to stress on natural resource base, namely decline in water quality and quantity, soil health and biodiversity. On the top of this, the challenge of climate change, more specifically climate extremities, is looming large. The University has been continuously re-orienting its agenda. Conservation agriculture, integrated pest/nutrient management and integration of biotechnology with crop improvement have been focused in the recent past but re-prioritization is a continuous process. This is particularly true due to fast changing scenario and emergence of technologies, such as, information and communication technology, remote sensing and geographical positioning system. Further, farm mechanization is also undergoing rapid advances, the assimilation of which will promote precision agriculture. At the present high level of productivity (~ 113 q/ha) of paddy and wheat in Punjab, the focus has to be on secondary agriculture. Further, linkage of researcher-extension worker-farmer continuum needs to be extended to agro-industry. To execute the envisioned programmes, competent human resource needs to be developed for which global partnerships are needed. In ‘Vision 2040’, an effort has been made to visualize the likely challenges and opportunities in Punjab agriculture.

I appreciate the efforts of Drs S.S. Gosal, T.S. Thind, H.S. Sehgal, P.S. Chahal and all others who contributed to the preparation of this document. The document is expected to be helpful to the scientists, policy makers and other stakeholders in addressing the future needs for growth and development of agriculture in the state and sustaining national food security. However, in view of the rapid pace of scientific advances, we need to be aware of new developments and receptive to new ideas to efficiently serve the nation. For the scientists, the most important challenge is to think out of box and to be innovative.

October 10, 2012

(Baldev Singh Dhillon)
Vice Chancellor
Punjab Agricultural University
Preface

Punjab Agricultural University (PAU) is a widely acclaimed state agricultural university of India and has immensely contributed in meeting food requirements of the country. It pioneered the Green Revolution in India in 1960s and is considered as one of the best agricultural universities in Asia. The PAU has attained an international reputation for excellence in agriculture. The dedication and commitment of its scientific community in developing high yielding crop varieties along with matching production, protection and processing technologies and their rapid dissemination to the farmers has helped the country to achieve self-sufficiency in food production.

Punjab agriculture is currently passing through a difficult period. The agricultural growth has decelerated and the per capita income of farmers has declined during the last decade. The slow down in agricultural growth has become a major national concern. With continuing increase in population, there has been a further fragmentation of land into smaller holdings, making agriculture less profitable. Due to high cropping intensity, the soil health has deteriorated and the water level has gone down in most blocks of the State. Indiscriminate use of pesticides has led to contamination of the ground water, residues in food chain and environmental pollution.

New technologies that can help in enhancing production per unit of land and water, without adversely affecting the environment, are needed to overcome the prevailing technological fatigue. There is a need to develop appropriate technologies through basic, strategic and applied research to meet the demands for quality food. Special attention needs to be paid to develop affordable technologies that are better suited to the small and marginal farmers. Frontier technologies such as biotechnology, information and communication technology, renewable energy technologies, processing technologies and natural resources conservation technologies, are required to accelerate the agricultural growth. There is a need to
develop well trained human resource having national and international exposure to better understand the changing needs of agriculture. To give impetus to transfer of technology to the farming community, the role of modern communication methods can be of a great help.

The PAU has taken initiatives to address the current as well as emerging challenges of the Punjab’s agriculture. The Vision 2040 document has been prepared keeping in view the state and national needs and the future challenges such as food and nutritional security, rapidly degrading soil and water quality, scarcity of water resources, climate change, and new pests and diseases which are expected to affect agricultural productivity in the state. This document gives, in brief, the past achievements of the university and provides a framework for visualizing new priorities and developing new programmes and strategies to effectively address the emerging challenges. It outlines the agenda for research, teaching and extension programmes of the PAU for the next three decades.

I express my sincere gratitude to Dr. B.S. Dhillon, Vice Chancellor, for his invaluable guidance in preparing PAU Vision 2040. I am grateful to all the Deans, Directors, Registrar, Comptroller and Heads of Departments of PAU for providing relevant information for this document. My special thanks are due to Dr. T.S. Thind, former Additional Director of Research (Natural Resource and Plant Health Management), Dr. H.S. Sehgal, Liaison Officer and Professor of Zoology and Dr. P.S. Chahal, Associate Director of Research for their help and support in compiling this vision document.

October 8, 2012
(Satbir Singh Gosal)
Director of Research
Punjab Agricultural University
# Table of Contents

*Foreword*  
i  
*Preface*  
iii  

1. **Introduction**  
2. **Salient Achievements**  
3. **Emerging Challenges**  
4. **Vision and Focus**  
   - Crop Improvement and Biotechnology  
   - Natural Resource Management  
   - Mitigating Adverse Effects of Climate Change on Crop Production  
   - Horticulture  
   - Agro-Forestry  
   - Plant Health Management  
   - Farm Mechanization  
   - Bio-Energy  
   - Subsidiary Agriculture  
   - Institutional Mechanism and Policies  
   - Agri-Business and Public-Private Partnership  
   - Seed and Nursery Production  
   - Technology Transfer Mechanism  
   - Quality Human Resource Development  

5. **Strategies and Framework**  

*Epilogue*  
39
1. Introduction

Agricultural Scenario of Punjab

Punjab has played a leading role in ushering in the era of Green Revolution in the country. As a result of development of new technologies and their dissemination to the highly receptive peasantry and with the support of government policies, the food grain production increased from 3.2 million tonnes (mt) in 1960-61 to about 30.0 mt in 2011-12. The productivity of paddy increased from 1.5 ton/ha to 6.0 ton/ha and that of wheat from 1.2 ton/ha to 5.2 ton/ha during this period. Further, the jump in production was 47.1 and 10.3 times for rice and wheat, respectively. The State, with only 1.53% of the total geographical area of the country, produces 22% wheat, 11% rice, 10% cotton, 37% honey, and 40% mushrooms of the country. It has been contributing 7.4 - 48% of rice and 39 to 75% of wheat to the central grain pool during the period 1966-67 to 2011-12.

The predominant rice-wheat cropping system covering about 35.1 lac ha area in Punjab, though provided good returns to the farmers and contributed greatly towards food security of the country, has created a stress on water and land resources. It has become quite difficult to sustain current productivity levels of crops. The agricultural problems being faced in Punjab deserve immediate attention. Some of the major issues assailing Punjab agriculture are the alarming fall in ground water table, deteriorating soil health, emergence of new insect pests, diseases and weeds, crop residue management, toxic residues in agricultural commodities, shrinking land holdings, increasing labour shortage, lop-sided mechanization and inadequate processing and food engineering. Concerted efforts are required to meet the challenges being faced by the Punjab agriculture.
About PAU

Punjab Agricultural University (PAU) has attained a special status in the history of Indian agriculture for its pivotal role in ushering in Green Revolution in India. Contributions of PAU, in consonance with support of the State/Central governments as well as the efforts of the hard-working peasantry of the State, are well recognized in this regard. In recognition of its outstanding contributions in agricultural research, education and extension, The PAU was the first to be adjudged as the Best State Agricultural University by the Indian Council of Agricultural Research in the year 1995. A special grant of Rs. 100 crore was awarded to PAU by the Central Govt. in 2006 for its contributions to the Green Revolution its sustained efforts towards excellence.

The University was established in 1962 on the pattern of the U.S. Land Grant System. It has its origin in the Punjab Agriculture College and Research Institute, Lyallpur (now Faisalabad) in Pakistan, which was established in 1906. After partition of the country in 1947, the College was re-established in a building belonging to Khalsa College, Amritsar. The College was shifted to its present site in 1957 and upgraded as a university in 1962 through the Punjab Agricultural University Act passed by the Punjab Legislature on 17 October, 1961. Originally, the University had three campuses, one each at Ludhiana, Hisar and Palampur. The PAU was bifurcated by an Act of the Parliament on 2nd February, 1970 to establish PAU at Ludhiana and Haryana Agricultural University (now CCS Haryana Agricultural University) at Hisar. Palampur campus was separated and upgraded as Himachal Pradesh Krishi Vishva Vidyalaya (now CSK Himachal Pradesh Krishi Vishva Vidyalaya) in July, 1970. There were five constituent colleges of the PAU namely, College of Agriculture, College of Agricultural Engineering, College of Basic Sciences and Humanities, College of Veterinary Science and College of Home Science. In April 2006, the PAU was again bifurcated to establish Guru Angad Dev Veterinary and Animal Sciences University at Ludhiana and the College of Veterinary Science was merged with this university. There are now 30 departments, 4 schools and one institute of agriculture (Gurdaspur) in the 4 constituent colleges of the University as shown in Table 1.
Table 1. Departments/Schools under four constituent colleges of the University

<table>
<thead>
<tr>
<th>College</th>
<th>Departments/Schools/Institute</th>
</tr>
</thead>
<tbody>
<tr>
<td>College of Agriculture</td>
<td>Departments of Agricultural Meteorology, Agronomy, Entomology, Extension Education, Floriculture and Landscaping, Food Science and Technology, Forestry and Natural Resources, Fruit Science, Plant Breeding and Genetics, Plant Pathology, Soil Science, Vegetable Science, School of Agricultural Biotechnology, Institute of Agriculture at Gurdaspur</td>
</tr>
<tr>
<td>College of Agricultural Engineering and Technology</td>
<td>Departments of Civil Engineering, Farm Machinery and Power Engineering, Mechanical Engineering, Processing and Food Engineering, Soil and Water Engineering, School of Energy Studies for Agriculture, School of Electrical Engineering and Information Technology</td>
</tr>
<tr>
<td>College of Basic Sciences and Humanities</td>
<td>Departments of Agricultural Journalism, Languages and Culture, Biochemistry, Botany, Chemistry, Economics and Sociology, Mathematics, Statistics and Physics, Microbiology, Zoology, School of Business Studies</td>
</tr>
<tr>
<td>College of Home Science</td>
<td>Departments of Clothing and Textiles, Family Resource Management, Food and Nutrition, Home Science Extension &amp; Communication Management, Human Development</td>
</tr>
</tbody>
</table>

All the Departments/Schools/Institute are engaged in agricultural education, research and technology transfer activities.

**Mandate**

- To impart education in agriculture, agricultural engineering, allied basic sciences, and home science for developing quality human resource
- To conduct research for seeking solutions to the emerging problems in agriculture and allied fields
- To disseminate agricultural technologies to the farmers through various extension programmes.

**Mission**

To serve the farming community through generation and dissemination of knowledge for sustainable agricultural production.
Financial Growth

There has been a considerable increase in the budgetary outlay of the grants received by the University from 1962-63 to 2011-12, as shown in Fig. 1.

![Budget of the University from 1962-63 to 2011-12](image1)

Fig. 1. Budget of the University from 1962-63 to 2011-12

Faculty Growth

The PAU had a good faculty strength uptill 2005-06 that started to decline thereafter, as shown in Fig. 2.

![Faculty strength from 1985-86 to 2011-12](image2)

Fig. 2. Faculty strength from 1985-86 to 2011-12
2. Salient Achievements

A. Teaching

The PAU has been a preferred destination for world-class agricultural education. Consequently, the enrollment of students and the number of the teaching programmes have increased over the years. The University, since its inception, has produced more than 27000 students in different streams of agriculture and allied sciences.

At present, a total of 84 teaching programmes are offered by the University (11 Under Graduate, 44 Masters, 29 Doctoral, one Certificate course and one Diploma course). There are nearly 2,800 students on the rolls of the University, of which more than 50% are postgraduate students. Enrollment of rural students in B.Sc. Agri. (Hons.) programme appreciably increased after the introduction of 6 year B.Sc. Agri. Programme after 10th class in the academic session 2008-09. New/revised UG and PG course curricula have been implemented with special emphasis on Experiential Learning in Commercial Apiculture, Mass Production of Bio-agents, Protected Cultivation of Vegetables, Mushroom Production, Entrepreneurship in Bakery and Confectionary Products, Child Care Providers’ Training, Apparel Manufacturing, Training Unit in Artistic Creations, Hands on Training in Production of Agricultural Machinery and Hands on Training in Drip, Sprinkler & Poly-houses. New courses have been initiated in the frontier areas of Biotechnology, Bioinformatics, Conservation Agriculture, ICT-based Agriculture, Agribusiness, Intellectual Property Management, Bio-diversity & Biosafety, Environmental Science and Nanotechnology as well as professional courses such as Nutrition and Dietetics and Fashion Designing.

The University library provides latest information to its faculty and students through a rich collection of books (2.42 lac), e-books (51), CDs (2144) and subscribes to a large number of Indian and foreign journals.
both in print (222) and online (43). Keeping pace with the digital technology, library facilities have been updated to provide free internet access to 8 online databases and 2 CD-ROM databases. To strengthen the research system of PAU, an campus wide access to 31,518 online journals is provided through CeRA and J-Gate. There is also a provision of Library Online Public Access catalogue for efficient retrieval of information.

As a measure to check in-breeding, PAU has signed various MoUs/Agreements with reputed national/international institutions for the exchange of faculty and students. This has provided opportunity for several PG students to conduct research in world class foreign universities. The students also avail other opportunities such as under the Beachell-Borlaug Fellowship, Dr Hargobind Fellowship, Sandwich Degree Programme under Agriculture Knowledge Initiative, and Fulbright Fellowship for doing a part of their research work in reputed foreign laboratories. Another such measure is sending the Ph. D. students to other reputed universities in India for one semester for taking courses. To encourage the Ph. D. students to publish their research, from the session 2012-13, Ph.D. theses will be submitted in a new format containing research papers instead of Results and Discussion chapter. The university has decided to impart six months Induction Training to the newly recruited faculty members, one month each at its outstations at Ballowal Saunkhari, Gurdaspur, Faridkot, Bathinda and the University Seed farms after initial placement for one month at Ludhiana campus.

B. Research

Crop Improvement

The Punjab Agricultural University has developed/recommended 707 varieties/hybrids of different crops including 359 varieties of field crops. Out of these, more than 117 varieties/hybrids have been released at the national level. Some of the varieties developed by the PAU such as WL 711 (wheat), PR 106 (rice), Vijay (maize) and C 235 (gram) have also been adopted in other countries. Economic returns from some of the varieties such as wheat variety PBW 343 have been phenomenal on account of the large acreage (about 7 million ha. during peak cultivation) and the long duration of cultivation at the farmers’ fields. PAU has released 56 varieties of wheat for cultivation in the Punjab state and out of these
32 varieties have been released at the national level. Likewise, 36 varieties of rice and 32 varieties of maize have been developed. Several landmarks were achieved in this research area while continuously maintaining the varietal pipeline over the last 50 years. The PAU was the first institute to release grain pearl millet hybrid (HB-1) in the world. It has the distinction of releasing the first single cross maize hybrid (Paras), first gobhi sarson hybrid (PGSH 51), first canola type varieties of gobhi sarson (GSC 5 and GSC 6), first multiline variety of wheat (KSML 3 in India. The PAU also has the distinction of developing the first short-duration (65 days) variety of mungbean (G 65) in 1971 and later, another short duration variety SML 668 (60 days) having synchronous maturity in 2002. The PAU is also the first in the country to develop maize variety (J-1006) especially for fodder purpose. Improved varieties of barseem viz BL-10 and BL-42 have been released which yield good quality green fodder till end June. BL-10 has the highest breeder seed indent from the last many years that reflects its popularity at national level. The first cotton leaf curl disease resistant cotton hybrid (LHH144) in the country and the first desi cotton hybrid (LDH 11) in North India were developed at this University. The cultivation of the new crops like menthe, turmeric and celery has been promoted in the State with the adoption of production technology developed by the university. Development of improved varieties and matching crop production and protection technologies have brought a remarkable increase in the productivity of wheat, rice, cotton and maize, and their adoption over large areas has led to a significant improvement in production and farm economics.

Besides crop varieties, the University has also contributed towards refining the breeding methodology. For instance, new methods of recurrent selection have been developed in cross pollinated crops. Efficient screening techniques for evaluating germplasm for resistance against diseases such as Karnal bunt and loose smut of wheat, bacterial blight and sheath blight of rice, Ascochyta blight of chickpea, etc. have been developed/refined at PAU.

Crop management technologies such as optimum sowing schedules, seed quantity, tillage requirements, weed management, crop geometry, and irrigation needs have also been developed to increase the productivity of different crops. As a result of availability of appropriate varieties
suitable for different agro-climatic conditions and cropping sequences, complemented by farm mechanisation, the cropping intensity in the State has increased from 126% in 1960-61 to 190% at present.

Horticulture

The PAU has made significant contributions towards improvement of horticultural crops since its inception. It has released 145 varieties of vegetable crops, 132 of fruit crops and 30 of floricultural crops. Some of
the varieties/hybrids of vegetables such as Hara Madhu, Punjab Sunehri and Punjab Hybrid (muskmelon), CH-1 and CH-3 (chilli), Mattar Ageta 6 and Punjab 89 (pea) and Punjab Chhuhara (tomato) have been widely adopted by farmers in Punjab and other states in India.

The University introduced Kinnow cultivation in the country, which now covers about 41 thousand ha (56% of the total area under fruit crops) in the State with productivity of 20 t/ha. High tech nursery production technology for mass production of disease free nursery plants, drip irrigation and integrated management of insect pests and diseases have helped in area expansion under its cultivation. Research efforts of the PAU through recommendation of prominent guava varieties Allahabad Safeda and Sardar (L-49) also resulted into expansion of area under guava cultivation from 4015 ha in 1990-91 to 7840 ha in 2010-11. Dusehri and Langra varieties of mango have been recommended after evaluation for general cultivation in the State. Low chill pear (Patharnakh), peach (Shani-Punjab) and plum (Satluj Purple) varieties introduced and released by the PAU have been widely adopted in the State. The quality improvement technology in grapes (var. Perlette) comprising of flower bud thinning, girdling and GA$_3$ dip as well as fruit thinning in peach have been widely adopted.

The PAU has developed and recommended 136 improved varieties and 9 F1 hybrids of different vegetable crops. Among these, 29 varieties/hybrids have been identified at the national level. Punjab Hybrid of muskmelon developed by the University was the first F1 hybrid of the public sector in India. Punjab Chhuhara of tomato and Punjab Sunehri of muskmelon have been listed in the international seed catalogues for better shelf life. CH-1, the first hybrid of chilli in India developed by exploiting GMS system, has revolutionized chilli cultivation in North-Western parts of India. The PAU is a pioneer in recommending net-house cultivation of vegetables (sweet pepper, tomato and brinjal) that has helped in early and better quality harvest with reduced use of pesticides. A seed to seed method for completing seed cycle in one year in onion has been developed for the first time.

To promote floriculture in the State, 17 varieties of chrysanthemum and 13 of gladiolus including four hybrids, have been recommended. Ratlam
Selection of chrysanthemum and Sylvia of gladiolus have become very popular among the farmers. The later, being tolerant to high temperature, is also cultivated for off-season production of cut spikes during April and May.

**Agricultural Biotechnology**

Significant contributions have been made in the areas of micropropagation, wide hybridization, genetic transformation, gene tagging and marker assisted selection and genome sequencing. The PAU has developed and popularized tissue culture micro propagation technology for 17 crops including sugarcane, potato, mentha, and banana. Methods for doubled haploid production in rice and wheat have been developed. Protoplast to plant system has been standardized in basmati rice. Genetic transformation systems have been developed for rice, sugarcane and maize. Wild wheat germplasm, consisting of more than 1,000 accessions, has been evaluated for traits of economic importance and disease resistance. Rust resistance genes *viz. Lr 57, Lr 58 and Yr 40* are being mobilized from wild species to elite wheat background through marker-assisted selection (MAS). High grain protein gene *Gpc B1* and high grain Fe and Zn QTL have been transferred to durum and bread wheat lines. Likewise, drought and heat tolerance factors are in the process of being tagged with molecular markers. Wild rice germplasm (about 1800 accessions) for biotic stresses and for productivity traits. Four novel bacterial blight resistance genes have been transferred from wild species to cultivated rice and one new gene designated as *Xa38* has been identified in *Oryza nivara*. Bacterial blight resistant, dwarf types of Basmati 370 and 386 have been developed using MAS and these are under field evaluation. Wide hybridization has been used in *Brassica* for incorporation of alien sterilizing cytoplasm, sclerotinia stem rot and mustard aphid. Derived and synthetic amphiploids of *B.juncea* and other genomic resources have also been developed. Resistance to Ascochyta Blight and Botrytis Grey mould from the wild sources has been transferred to relevant cultivated chickpea genotypes. Chitinase and glucanase genes from *Trichoderma viride* have been cloned for introduction into crop plants for disease resistance.

**Natural Resource Management**

Intensive cultivation during the past four decades has resulted in
depletion of sub-soil water and poor soil health in the State. To check the erosion of natural resource base, the PAU has developed several resource conservation technologies such as laser land leveler, tensiometer, zero tillage, bed planting, mulching, green manuring, direct seeding of rice, leaf colour chart, net-house cultivation, micro-irrigation and fertigation. The relevant farm machinery such as zero till drill, strip till drill and happy seeder have been designed and recommended for bringing in precision and timeliness in farm operations and for saving irrigation water. The area under zero/ minimum tillage in Punjab has increased to 6.0 lakh ha in 2011-12. Transplantation of paddy after 10th of June led to saving of irrigation water without causing any yield loss. Straw mulching with crop residues resulted in water saving of 70-300 mm and enhanced yield in sugarcane, maize, soybean, sunflower, potato and tomato. An economical technology was developed for reclaiming salt affected soils that helped to reclaim 5.5 lakh ha in mid 1970s. Alternating irrigation of saline ground water with surface water has given better crop yields in the south-western region. The PAU has developed and recommended remunerative cropping systems such as maize-potato-sunflower/summer moong, basmati rice-wheat/berseem, soyabean-wheat, and cotton-wheat/mustard which help in saving water as compared to the rice-wheat cropping system. Rice/maize-potato-summer moong and wheat-dhaincha/sunhemp-rice cropping systems have been developed for saving fertilizers and maintaining soil fertility.

The use of laser land leveler has resulted in saving of the ground water and also the electricity. The technology of happy seeder, developed by the PAU, reduces 50% cost of sowing and saves ground water. Crop-Weather calendars for major crops of the State have been developed and are being used in agro-advisory service for judicious use of natural resources. Water harvesting technologies have been developed for storing water in Kandi water shed.

The protected cultivation (under poly net-house) recommended for the production of vegetables has resulted in enhanced productivity and judicious use of water and other inputs. Use of *Rhizobium* in berseem and other leguminous crops has resulted in improved soil health, crop growth and yields. A consortium of microbes has been developed and recommended for use in sugarcane for improving soil and plant health.
The University has developed and recommended economical and efficient technologies for the management of insect pests, diseases and weeds in different crops. Supervised pest control modules, based on economic threshold values, have been developed and recommended against a large number of insect pests of cotton, rice, rapeseed-mustard, gram, okra, cauliflower, radish, tomato and berseem. The implementation of IPM technology, developed by the PAU, has led to a decreased dependence on pesticides and has resulted in an economical pest management in cotton, rice and maize in the State. The IPM technology for the control of cotton pests led to reduction of pesticide applications by 30–40% and helped in managing the problem of insecticide resistance. Integrated management strategies have also been developed for the control of plant diseases such as foot rot in basmati rice, yellow rust of wheat, late blight of potato, foot rot and gummosis in citrus. The technologies developed for the management of important insect pests, diseases and weed problems in field, fruit, vegetable and floriculture crops have brought in economic gains to farmers.
To reduce dependence on chemical pesticides, PAU has developed biological control of insect pests such as shoot borer and top borer in sugarcane using Trichogramma releases. Sugar mills in Punjab are now using this technology. Trichogramma has also been found effective for the control of stalk borer in maize and stem borer in basmati rice. Biological control of foot rot in basmati rice and black scurf of potato by using talc-based formulation of *Trichoderma* has been developed for eco-friendly management of these diseases. Based on soil solarization, a package recommendation has been given to the farmers for managing soil-borne pathogens including nematodes in net-house grown vegetables. The University has developed web-based Decision Support Systems for monitoring and management of potato late blight and for integrated management of insect pests in cotton. It has proved useful in timely management of these problems and in saving on the pesticide applications.

Integrated weed management technologies through cultural methods and judicious use of herbicides have been developed for rice, wheat and several other crops including vegetable and fruit crops. These have helped to avoid build up of resistance to herbicides and also gave higher yield returns. Based on the behaviour of birds, the University has developed and recommended efficient technologies based on the use of reflective ribbons and distress calls for scaring away harmful birds. This has helped to avoid damage to the standing crops significantly. Similarly, chemical baits have been recommended to avoid damage due to field rats. Improved multicatch traps have been devised for the control of rats under different habitats.

**Agro-Forestry**

The University has developed and recommended nine Poplar clones out of which PL-5 and PL-3 have been widely adopted for cultivation in the central plain region and the semi-arid region of the State, respectively. Among six *Eucalyptus* clones evaluated, C-413 has been found promising for wider adoption in Punjab. Wheat variety PBW 502 has been recommended for sowing under poplar block plantations. It is also recommended to plant poplar at a spacing of 8 x 2.5 m with tree rows in north–south direction. Poplar based agroforestry system is economically viable in comparison to sole cropping system (rice-wheat). Application
of zinc sulphate has been recommended in poplar block plantations to ameliorate zinc deficiency. Bio-ecology parameters and management strategy against poplar leaf defoliators have been established. Site-index curves have been developed for *Eucalyptus* to measure its productivity level. Likewise, local and standard timber volume and weight tables for *Eucalyptus, Dalbergia, Acacia* and Poplar have been developed. These weight tables are useful to the farmers for determining the tentative weight and value of timber standing on their farms. The University is mass multiplying genetically improved clones of poplar for supplying to the farmers. For rainfed forestry in Kandi area, *Leucaena* and *Acacia* have been identified as suitable species and the former, being nutritionally rich, has been recommended as a fodder.

**Agro-Processing**

A new post-harvest technology of waxing of Kinnow, developed by the PAU for increasing its shelf life, has become popular among the fruit growers. The University has developed technologies for low-calorie, high-protein, high-fibre multi-grain and gluten free bakery products. Methods for extruded products such as high-protein pasta, barley noodles and heat and eat pastas have been standardized. Low cost and nutritious snacks using cereal blends with potato, brown rice, legume flours and multi-grains have been prepared. Blends of multi-fruit juices and concentrates, both carbonated and non-carbonated, from Kinnow, grape, pear, guava and mango and other products from fruits like candies, jams and marmalades have been developed. High protein bread formulations having dietary fibre have been developed using sunflower kernels and linseed. Protein rich cookies have been developed from a composite flour of wheat, green gram and black gram. A technology has been developed for the production of good quality baked products from sprout damaged wheat. For profitable utilization of dairy by-products, vegetable impregnated *paneer*, fruit yoghurts and whey-based fruit beverages have been developed. Machines have been developed for cleaning of grains, washing of fruits and vegetables and extraction, heating and filtration of honey. Agro-processing complexes have been established in rural areas for enhancing farm income.
Seed and Nursery Production

The PAU has a well established programme for production of seeds of improved varieties at its five seed farms that has been strengthened over the years. Due to their excellent quality, the University seeds attract the farmers from all over the State and also from the adjoining states. The total seed production of different crops including wheat, barley, raya, gram, oats, rice, mungbean, maize, cotton and soybean during 2001-02 was 46,020 quintals which increased to 64,140 quintals during 2011-12. The farmers evince a keen interest in buying seeds of crop varieties recommended by the PAU. The University also produces disease free nursery plants of fruit crops like Kinnow and supplies these to farmers for raising healthy orchards.

Farm Machinery

Punjab has been the front runner in the development and use of farm machinery in India which has played an important role in achieving higher crop yields. The University has developed various types of machinery for farm-related operations. Several useful machines such as potato digger, Happy seeder, sunflower thresher, reapers, oilseed drill, straw combine, etc. have been designed, developed and tested at PAU. Other important ones include no-till drill, strip till drill, straw chopper, paddy transplanter, sugarcane trencher, tractor-operated sprayer, self-propelled boom sprayer, axial flow paddy thresher, maize dehusker-cum-sheller etc. are also developed by the University. Manually operated tools like seed drill, multi-crop planter, power weeder, and seed extracting machine have also been developed. Apart from designing and development, testing of farm equipments has been an important activity of the University. The Farm Machinery Testing Center of PAU has tested more than 500 commercially available agricultural machines. As a result, the University has established an active liaison with the private industry in research and development. This has helped the manufacturers and farmers in extensive propagation and adoption of better quality farm equipment. Mechanization of farm operations has helped in drastically reducing the labour requirement, drudgery and cost of cultivation and saving farmers from vagaries of weather. It has also led to an increase in cropping intensity.
Subsidiary Agriculture

Beekeeping

The PAU has done pioneering work in introduction and establishment of Italian honey bee (*Apis mellifera*) in India during 1962-1964. It has developed technologies for the bee management, prevention or control of bee diseases and enemies, mass queen bee rearing and bee breeding. Technologies have also been developed for production of various bee products like bee pollen, bee propolis, bee wax and royal jelly. With the consistent efforts of the PAU, Punjab has emerged as the leading state in bee keeping and is producing about 14 thousand tonnes of honey (more than 37% of the national apiary honey) of which more than 90% is being exported. It also supplies colonies and apicultural equipment to other states.

Mushroom Cultivation

The PAU has developed and popularized mushroom cultivation technology in Punjab. Five varieties of mushrooms namely, white button mushroom (September-March), dhingri (October-April), paddy straw mushroom (April-August), milky mushroom (April-September) and shiitake mushroom- a medically important edible variety (October-March) have been recommended for cultivation in the State. Thus, mushroom cultivation is being done round the year. The current annual mushroom production in the State is 48 thousand tonnes annually (40% of the national produce) and about 80 % of this is exported to other countries.

C. Transfer of Technology

The University has a strong linkage with the line departments and has contributed significantly in efficient transfer of new farm technologies to the farmers by organizing various activities such as Kisan Melas (Farmers’ Fairs), training programmes, method demonstrations, frontline demonstrations, campaigns, exhibitions, field days, group discussions, on-the-spot guidance, plant health clinic services, on-farm trials, adaptive research trials and advisory services enabling the farmers to enhance productivity and profitability. The Kisan Melas are organized at Ludhiana, Rauni (Patiala), Faridkot, Ballowal Saunkhri (Shaheed Bhagat Singh Nagar), Bathinda, Amritsar and Gurdaspur during the months of March
and September every year before the start of Kharif and Rabi crop seasons. Farmers participate in large numbers in these to get seeds of new varieties and learn know-how about latest farm technologies.

The PAU was the first in the country to establish a Plant Disease Clinic in 1978 for diagnosing disease problems in crop plants and providing their solutions. It was later changed to a broad-based Plant Clinic in 1993. The single window system for dissemination of knowledge through subject matter specialists, diagnosis of plant disorders, availability of seed, *Rhizobium* and *Trichoderma* culture, mushroom spawn, honey, fruit saplings, literature, *etc.* in PAU is a unique model for transfer of technology to the farmers.

The Krishi Vigyan Kendras (KVKs), one each in 17 districts of the State, impart vocational training for entrepreneurship skills, short-duration trainings for farmers to increase productivity and refresher trainings for the extension functionaries to upgrade their knowledge regarding the latest developments in agricultural sciences and technology. The subject matter specialists stationed at the 12 district headquarters advise the farmers about rational use of natural resources and promote the adoption of integrated nutrient management (INM), integrated pest management (IPM), protected cultivation, conservation agriculture, precision in input use, organic farming, adoption of improved methods of irrigation, crop diversification as well as integrated farming system. Such knowledge is transferred through literature, TV and Radio talks, internet connectivity and mobile advisory service.

At each KVK special programmes are organized for empowerment of rural women through various vocational trainings. Amongst more than 33,000 bee-keepers in the State, there is a good number of women bee-keepers. Similarly, the involvement of farm women in dairying, poultry, mushroom cultivation, and vegetable production is noticeable and increasing day by day. PAU has also formed Self Help Groups in different districts which have enhanced income of small and marginal farmers.
D. Awards/ Recognitions

- The first to get Best State Agricultural University Award of the Indian Council of Agricultural Research, Govt. of India in the year 1995.
- Agricultural University of the Year Award 2011 (Krishi Shiksha Samman) by Mahindra & Mahindra.
- The first International Potash Institute (Switzerland) and Fertilizer Association of India (IPI-FAI) Award for transfer of technology in balanced use of fertilizers in the year 2010.
- The first to get Special Grant of Rs. 100 Crore by the Govt. of India, in recognition of promoting excellence in basic and strategic research and making remarkable contributions towards Green Revolution.

The PAU has the distinction of producing eminent scientists including those who have been awarded Padma Bhushan (7), Padma Shri (8), World Food Prize (1), Rafi Ahmed Kidwai Award (23), Shanti Swarup Bhatnagar Prize (2) and bestowed with other coveted honours such as Fellows of Indian National Science Academy (15) and National Academy of Agricultural Sciences (67). Besides, the University has the distinction of producing Director General of ICAR (1), Chairman of Agricultural Scientists Recruitment Board (1), Chairman of Commission for Agricultural Costs and Prices (2), Chancellor (1), Vice Chancellors (35), several administrators, defense personnel, litterateurs, and luminaries as a result of its excellent education and skill-imparting capacity.
3. Emerging Challenges

The agriculture in Punjab is facing deceleration in growth due to stagnation in productivity of its major crops, overexploitation of natural resources, changing climate, new pests and diseases, high input costs etc. Some of the challenges the Punjab’s agriculture is facing today are mentioned below:

1. Increasing crop productivity from decreasing cultivable area to meet the food needs of a burgeoning population.

2. Diversification of mono-cropping of wheat and rice to other crops for conserving water and soil resources and for sustainability of agriculture.

3. Managing depleting water resources in the central region and poor-quality groundwater in the south-west region.

4. Managing emergence of multi-nutrient deficiencies in soils due to over-mining of inherent nutrient reserves and decreasing fertilizer use efficiency.

5. Mitigating the adverse effects of changing climate on crop productivity.

6. Managing crop residues as about 20 million tonnes of paddy straw and a sizeable portion of wheat straw are burnt resulting in the micronutrient deficiency and environmental pollution.

7. Managing the build-up of pesticide residues in crops due to indiscriminate use of pesticides, increasing amounts of heavy metals in agricultural soils due to dumping of municipal and industrial wastes and the emission of greenhouse gases.

8. Controlling new insect pests, pathogens and weeds which have emerged due to changes in cropping pattern and climate and adoption of new varieties that otherwise have an outstanding performance.
9. Managing rodent pest problems emerged due to changing agronomic practices and resetting of priorities for bird management in the wake of changed climate and reduced habitat for birds.

10. Refining the precision agriculture technologies for conservation of natural resources.

11. Developing and refining the agro-processing technologies for value-addition and developing functional foods to control life style diseases.

12. Developing clones of fast growing, high-biomass trees like *Eucalyptus* and *Salix* having tolerance to salinity and water-logging.

13. Reducing the cost of production and increasing farmer’s profitability from squeezing and fragmented land holdings. About 65% farmers have less than 4 ha of cultivated land due to which the resource endowed technology is not being adopted.


15. Ensuring nutrition and livelihood security of rural women, children and vulnerable groups.

16. Narrowing down the time gap between technology development and technology transfer and building the capacity of farmers in understanding and using modern scientific methods of farming.

17. Developing globally competitive human resource in agriculture.

18. Commercializing technologies through public-private partnerships.
4. Vision and Focus

The PAU envisions accelerating growth and achieving adequate, nutritious, healthy, safe food and livelihood security through sustainable agriculture. The vision of PAU will be accomplished by focusing scientific pursuits on the following priority areas:

1. Crop Improvement and Biotechnology

The productivity levels in most of the crops have nearly stagnated after reaching very high levels. There is a need to lay emphasis on introgression of important genes from wild species for genetic enhancement under pre-breeding programmes. In view of these considerations, the crop breeding programmes in the conventional mode have to be augmented with molecular techniques. This calls for integrating research in plant breeding and biotechnology to quicken the pace of crop improvement, make the process more precise and overcome sexual barriers to gene transfer. Climate change is now a reality demanding an urgent reorientation of crop breeding programmes in terms of genetic and genomics as well as trait profile. The main thrust will be on breeding including genetic modification of crop varieties with better quality and tolerance to biotic and abiotic stresses. More emphasis will be given to breed varieties to fit in major cropping systems, having high biomass and calorific value, suitable for mechanized harvesting (e.g. of cotton, sugarcane, pea) and having better nutrient and water use efficiency. The use of biotechnology (MAS and GM technology) shall be the hallmark of future breeding programme. Emphasis will be given on identification and pyramiding of desirable alleles of major QTL governing important agronomic traits using high throughput facilities. The germplasm base in major crops such as wheat, rice, maize, pulses, brassicas, cotton, sugarcane, vegetables and fruits will be broadened. The focus will be on exploitation of wild germplasm, particularly in wheat, rice and brassicas through introgression. Doubled haploid technology in wheat, rice, maize and brassicas needs to be refined and employed to
replace conventional selfing. Cytoplasmic-genetic male sterility systems in cotton will be developed to facilitate hybrid seed production. More focus will also be given to breed better, nutritive varieties of fodder crops.

Use of marker-aided selection will also get greater emphasis in perennial crops, particularly fruit plants and forestry trees. Emphasis needs to be given on bio-fortification of crop varieties for nutritional security. Keeping in view the fast pace of developments in understanding the molecular basis of desired traits in crop plants, crop improvement would integrate biotechnological approaches in a major way. Cloning of abiotic stress tolerance genes from wild relatives of crops and non-crop sources will be an integral component of future crop improvement programme.

2. Natural Resource Management

Higher productivity and intensive cropping systems, particularly in rice and wheat, have caused over-mining of nutrient reserves leading to depletion of soil fertility, decline in groundwater table, emergence of multi-nutrient deficiencies and lowering of fertilizer use efficiency. Depleting water resources in the central region and the poor quality groundwater table in the south-western region imply that the future agriculture will be water-limited. Indiscriminate use of fertilizers, dumping of municipal and industrial wastes containing heavy metals in soils and emission of greenhouse gases in agricultural system are emerging as major environmental threats. Keeping into view the natural resources degradation due to intensive agriculture, emphasis will be given to develop new technologies and refine the existing ones for their need-based use and to conserve these for sustaining agricultural growth.

Integrated nutrient management systems will be developed and promoted under different cropping systems to improve nutrient use efficiency and maintain good soil health. Research on conservation agriculture will be strengthened to optimize crop yields and profits, simultaneously taking care of the soil and agro-ecosystem resources to achieve a balance of agricultural, economic and environmental benefits. GIS-based maps will be developed for soil health status of different regions of the State. Promoting research on bio-fertilizers such as Rhizobium, Azotobacter and phosphate solubilizers and their mass production will
reduce dependence on chemical fertilizers. Refinement and promotion of crop residue based mulches will be taken up to enhance water use efficiency and weed management. Efficient technologies need to be developed for utilizing crop residues for bioenergy production. Research efforts will be focused on developing suitable technologies for management of declining underground water in the central districts. Technologies for conjunctive use of brackish and good quality waters as well as management of brackish water in South-Western Punjab will be further refined and rice genotypes having tolerance to salinity will be identified. Bio-drainage technology using fast growing tree species and salt tolerant crop varieties such as that of rice will be developed for water-logged areas. Work will be taken up for conserving useful, farmer friendly bird species.

3. Mitigating Adverse Effects of Climate Change on Crop Production

The changing climate is adversely affecting the productivity of crops. An increase in temperature can reduce crop duration, affect chilling requirements of horticultural crops such as pear and stone fruits, enhance evapo-transpiration rate, alter photosynthate partitioning between source and sink, affect the survival and distribution of existing pest and pathogen populations and the emergence of new insect pests and pathogens, hasten nutrient mineralization in soils and decrease fertilizer use efficiency. Thus, it is extremely important to draw our focus on development of adaptation technologies to mitigate the adverse effects of climate change on crop production.

Special efforts will be made to develop suitable technology for prediction of extreme weather events such as hailstorm, cloud bursts, excessively hot weather and frost for giving timely advice to the farmers and minimize losses. Crop genotypes having tolerance to multiple stresses will be identified. As an example, wheat genotypes shall be tested under high stress conditions for developing varieties having terminal heat tolerance. Wild relatives of important crops will be evaluated for identification of genes for hardy traits. Multiple-cropping systems shall be developed as adaptive measures to changing climate. Use of remote sensing technology for assessment of crop losses due to biotic and abiotic stresses will be taken up.
4. Horticulture

Horticulture can play an important role in crop diversification and augmenting farm income. Some of these crops have a good export potential also. There is a need to bring diversification in horticulture crops as well. More emphasis will be given to develop varieties of fruit crops suitable for processing e.g. seedless Kinnow for better juice quality. Daisy tangerine, due to its early maturity as compared to Kinnow, has been identified and will be promoted to replace some area under Kinnow in the State. Efforts will be made to develop technologies for development of horticulture in the Kandi area for fruits like amla, galgal, ber, and guava. Emphasis shall be laid to develop varieties of fruits such as pear, peach and plum that have low chilling requirement. Availability of disease free planting material will be ensured by strengthening the plant nurseries. Work on root stocks of different fruits for tolerance to biotic and abiotic stresses will be strengthened. For producing Kinnow plants resistant to Phytophthora foot rot, the use of Citrus volkamariiana root stock will be promoted.

Protected cultivation of vegetables under low cost poly-net house is helpful in advancing maturity and increasing the fruiting span. It is an alternative for better quality, pesticide free vegetable production and for efficient use of land and other resources as well. In view of the ample scope of protected cultivation of vegetables, thrust will be on developing such technologies that not only help to produce quality vegetables but also enhance the income of farmers. Refinement of poly-net house and poly-tunnel technologies for vegetable and flower cultivation, particularly with respect to drip irrigation and fertigation, will be strengthened. More emphasis will be given to breed vegetable crop varieties suitable for growing in net houses. Pollination systems will be developed for cross pollinated vegetable crops grown in net-houses. Research will be initiated to identify elite root stocks for grafting in vegetables like tomato, cucumber, chilli, brinjal etc. for protection against soil-borne pathogens. Production technologies based on bio-intensive INM will be strengthened for various vegetables grown in protected structures and in the open. The net-house technology will be further improved and extended on a large scale.

Flower varieties having more demand in cities will be developed and promoted in the peri-urban areas. More flower varieties need to be developed for cultivation during summer season. Emphasis will be given
to develop technology for production of high value cut flowers in high-tech green houses using solar energy for export purpose.

**Agro-Forestry**

Agro-forestry can play an important role in crop diversification, maintain ecological balance and provide resilience against climatic aberrations. Evaluation of potential fast growing species such as poplar, eucalyptus, dek, mulberry, willow, Subabul and Ghmari (Gmelina arborea), in association with different crops under varied agro-climatic zones of Punjab, will be taken up. Technology for intercropping of wheat in forest tree plantations such as poplar, for tolerance to terminal heat but protection against yellow rust, will be fine-tuned and promoted. Strategies for conservation, regeneration and sustainable forest management will be developed and propagated. Genetically improved plant stock of higher biomass trees for use in bio-energy production will be developed and made available for cultivation. Research on carbon sequestration through agroforestry system will be strengthened. Emphasis will be given to mass multiply the elite clones for supplying to the farmers.

**5. Plant Health Management**

Due to increasing intensity of cultivation, continuous change in cropping patterns, excessive use of nitrogenous fertilizers, changing climate and sowing of un-recommended varieties/hybrids, emergence of new and less known insect-pest species, diseases and weeds has become a major challenge. There is thus a need to generate basic and applied information for developing sustainable pest management programmes. Emphasis will be laid on developing a holistic approach for managing plant health that would combine concerns for both biotic and abiotic stresses.

Apart from identification and development of pest and disease resistant genotypes of crop plants to reduce reliance on chemical pesticides, it would also involve care of soil microbial health with a focus on natural ways and economic use of modern methods to produce safe and wholesome food products that adhere to sanitary and phytosanitary regulations. More attention will be given to production and use of pathogen free planting materials. Bio-risk in agriculture is increasing due to trans-boundary insect pests, weeds and diseases. To overcome the problem of pest-risk,
intelligent systems such as early warning systems and web-based decision support systems will be developed to enable farmers to initiate timely measures. Populations of emerging insect pests, pathogens and weeds will be monitored in different cropping systems through regular surveillance and timely management strategies will be developed to avoid/reduce losses to crops. Eco-friendly non-lethal techniques for managing rodent and bird pests will be developed. Integrated pest management modules will be promoted for all the major crops for need-based application of pesticides.

Bio-diversity among insect species and microorganisms will be studied and propagated to find out beneficial insects and microbes for use as biocontrol agents in important crops like rice, maize, sugarcane, pulses, vegetables and fruits. Consortia of microbial organisms will be developed and promoted for healthy growth of crops and their protection from various pests and diseases. Similarly, for mitigating effects of abiotic factors like water and temperature stress, forewarning systems such as drought indicators will be developed. Management technologies for insect pests, diseases and weeds in organic farming systems will be refined.

Analysis of farm gate samples of vegetables, fruits, basmati rice and other crops for pesticide residues will be carried out and strategies to manage the build up of pesticide residues through judicious use of chemicals and bio-pesticides will be developed and propagated. Pre-harvest intervals (waiting periods) for commonly used and new pesticides will be determined and promoted to obtain pesticide free produce.

6. Agro-Processing

In view of the surplus crop produce, agro-processing is an essential component associated with agricultural growth that has a large potential in Punjab. Due to glut of fruits and vegetables in the peak season, the prices crash and the farmers suffer economic loss. At present, value addition of only 7% of the total agricultural produce is carried out in India and 2% of the total volume of the perishables is processed. The Punjab State is processing less than 2% of its perishable commodities. Post harvest losses of the agricultural produce amount to 10 - 30% which can be cut down by at least half of the existing levels through strategic development of efficient and economically viable agro-processing technologies. Under such circumstances, processing and value addition of fruits and vegetables is
essential. There is a need to promote primary processing involving grading, cleaning and packaging at the farm level. Future research will be focused on secondary and tertiary processing depending upon the crop produce.

The large crop and raw material base available in the State offers a vast potential for agro-processing activities. There is a need, therefore, to develop tools and techniques for pre-cooling of freshly harvested produce, controlled ripening, juice extraction & concentration, storage, handling and processing of vegetables, fruits, and mushrooms with a view to reduce post harvest losses and value addition. Emphasis will be given on the development of such economically viable technologies suitable for farmers and small-scale entrepreneurs. A Food Industry Centre is being established for developing linkages with agro-industries to promote post harvest handling and agro-processing. To ensure viability of processing units, multi-fruit/vegetable processing systems will be developed.

7. Farm Mechanization

Due to intensive agriculture, short window of time available between harvesting of one crop and sowing of the next, as well as the shortage of labour, farm mechanization is crucial for timeliness and precision in farm operations. Increase in the cropping intensity, change in cropping pattern, good cultivation practices, etc. demand mechanization of all field operations at affordable cost. There is a need to re-orient agriculture through precision farming technologies. A major shift in agricultural mechanization is required to realize the goal of eco-friendly sustainable agriculture with reduced cost of production and high quality of produce. This is necessary to make the farmers globally competitive and check further damage to natural resources like soil and water. Equipments for the mechanization of sugarcane harvesting, cotton picking and vegetable harvesting will be developed and promoted. Mechanization of sowing and harvesting of major crops, collection and management of residue of paddy and other crops and mulching will be given priority. Tractor mounted, sensor based fertilizer application and yield monitoring for combine harvester need to be developed for precision farming. Low cost multi task and multi crop farm machines will be developed for small and marginal farmers.
8. Bio-Energy

There is an urgent need to find out alternate energy sources, particularly for power generation and mobile applications. Field crops like napier bajra hybrid, sugarcane, sorghum, maize, bajra and short rotation forestry crops are the major high biomass crops in Punjab. For bio-energy production, paddy straw and paddy husk are the main available crop residues. Various thermo-chemical, chemical and biochemical technologies are being evaluated for generating thermal energy, electricity and liquid fuels from these sources. One possible future approach for utilization of paddy straw would be its utilization via anaerobic digestion for production of biogas. For high lignin biomass like short rotation forestry and some other crop residues, thermal routes like gasification and pyrolysis will be employed for decentralized power generation and production of liquid fuels. There is a great scope for the production of 3rd generation bio-fuels from algae in the long run. Because of their very high biomass production rates, algae not only provide bio-fuels like biodiesel but also capture carbon dioxide, thereby, fighting climate change.

9. Subsidiary Agriculture

Beekeeping

The PAU has made pioneering contributions in development of technologies on different aspects of Italian honey bee (Apis mellifera) husbandry which are being disseminated to the farmers of Punjab and other states. However, there is a further scope to strengthen beekeeping in the State for producing better quality honey and related products. The role of honey bee as a pollinator to increase crop yield will also be promoted. Thus, research work will focus on (i) evolving technologies to increase production of various hive products and their validation at field level, (ii) promoting apicultural diversification for higher profitability and (iii) value addition of hive products including packaging for domestic and international markets.

Mushroom Cultivation

Mushroom cultivation has become an important part of subsidiary agriculture in the Punjab. The PAU has developed a round-the-year mushroom cultivation technology calendar for growing five mushroom
varieties. To meet the growing demand of mushrooms an annual production growth rate of 24% is required against 7% at present. Research efforts will be strengthened to further refine the existing technologies with the view to improve productivity and quality of mushrooms. Hence, further efforts will focus on (i) strain selection/development and improvement of recommended varieties of mushrooms for higher productivity and (ii) isolation, partial purification and characterization of the bioactive molecules from biomass and fruiting bodies of medicinal mushrooms for use as functional food.

11. Institutional Mechanism and Policies

As Punjab’s agriculture was structured to produce food in response to the national food security requirements, the increased production of food grains, particularly that of wheat and rice, resulted in over-use of natural resources. For sustainable agricultural development, diversification of agriculture and efficient use of natural resources is the need of the hour. Undoubtedly, wheat and paddy crops provide high net returns to the farmers but paddy is a water-intensive crop. To save water, alternative crops having less water requirement like pulses, oilseeds, maize, fruits, vegetables, etc. will be promoted in the State. Although, the Minimum Support Price has been fixed for 25 crops by the Government of India, the effective public procurement is in place only for wheat and paddy. For diversification of agriculture, the market support needs to be provided to the farmers in the form of contract farming, cooperative/group marketing, public procurement, processing, etc. Contract farming does not have any legal status in the State and has not been very successful. For successful implementation of crop diversification programs in the State, formulation of policies for market support is required to watch the interest of farmers having marginal, small and medium land hoardings comprising the largest farming segment in the State. There is a need of market reforms through amendment of Agricultural Produce Market Committee Act so that private markets may be set up, particularly for perishable commodities like fruits and vegetables. Specialized markets also need to be developed for maize and basmati rice. There is a need to establish agro-export zones for kinnow, basmati, potato, chilli and honey. The PAU will continue to play its role in technology generation, its transfer and impact assessment for the success of diversification of agriculture in Punjab.
12. Agri- Business and Public-Private Partnership

The PAU has developed several technologies that have the potential to be commercialized. Public-private partnership needs to be strengthened as the scope for public investment in infrastructure development is limited. Efforts will be focused on commercializing post-harvest technologies, seeds of high yielding varieties, micro-propagated crops, bio-fertilizers, bio-agents, fermentation technologies, mushrooms, honey and related bee products, specialized farm machinery, etc. This will not only popularise the PAU-developed technologies among the masses, but also help in resource generation.

13. Seed and Nursery Production

Quality seed and nursery production will be strengthened for its distribution in the State. The PAU has a large, well organized seed production programme and still there is a need for its improvement and to make it more competitive. Seeds of all the released/recommended varieties of field and vegetable crops are produced and supplied regularly to the farmers and public/private seed agencies at the state as well as the national level. However, the seed production programme will be reoriented in view of the technological developments in seed production and the huge demand for seeds of crop varieties developed by the PAU. Likewise, the focus will be on developing and implementing suitable technologies for production of disease free nursery of major fruit crops like kinnow, daisy tangerine, guava, mango etc. Production of super-elite disease-free planting material, especially of vegetatively propagated crops such as potato through tissue culture, will be strengthened. Future thrust will be on (i) hybrid seed production of vegetable and field crops, and (ii) fine tuning of seed processing, grading, and storage technologies, and bringing seed production under public-private partnership mode. Seed health management through disease free seed production and seed priming will be given due attention. Emphasis will be given to develop and refine technologies for viable storage of seed.

14. Technology Transfer Mechanism

The University has a strong technology transfer mechanism through various modes such as farmer training programmes, method demonstrations, frontline demonstrations, field days, campaigns, exhibitions, extension
bulletins, farm magazines and farmers’ fairs. However, there is a need to revitalize the extension services and strengthen extension network through integration of advanced information and communication technology modules specifically developed for agriculture of the State. The endeavour will be to build well organized, efficient and result-oriented extension network for timely dissemination of required information to the farmers so as to solve their crop related problems. Farmers will be sensitized about conserving natural resources for ecological sustainability and will be motivated to adopt cooperative culture, particularly for marketing of produce and use of farm machinery. Awareness will be created among the farmers to follow Global GAP in raising the crops having export potential. Efforts will be made to develop niches for specialty crops such as basmati rice, mungbean, baby corn, turmeric, groundnut, guar and chilli. Agri-clinics and agri-informatics will be strengthened to facilitate technology transfer to farmers. Research efforts will be focused on developing new extension modules for efficient transfer of new technologies to the end users.

15. Quality Human Resource Development

In the wake of changing agricultural scenario and to redress the problems of agrarian society, there is a need to develop globally competitive human resource and a regular updating of their knowledge and skill. A periodic revision of the course curricula will be ensured to keep pace with the expanding knowledge so as to meet the national and global challenges in agricultural education. To break the inbreeding barrier, students will be exposed to teaching and research programmes of reputed national and international institutes. Capacity building of young and mid-career faculty members in cutting edge technologies relevant to the emerging needs of agricultural research and education will be further strengthened. A provision will be made for ICT based skill development programmes in agriculture and allied areas. Necessary infrastructure and expertise will be developed for creating facilities for e-education such as e-learning modules, interaction through video-conferencing, online admission, registration and examination, etc. To retain brilliant students in agriculture and allied fields, a policy to ‘catch them young’ will be developed and efforts will be made to start 6-year programmes in other disciplines on the lines of 6-year B.Sc. Agri. (Hons.) programme.
Curriculum delivery systems will be made more effective and interactive to impart comprehensive knowledge to the students. Class seminars on the topics of current interest will be regularly organized for confidence building among the students. A congenial environment will be created to improve the quality of interaction between the students and faculty members. More emphasis will be given to the practical aspects of the education and the students will be regularly exposed to various farm operations and the related field problems. Provision will be made for training of the students in established industrial houses for skill development. A system will be evolved for continuing education programme in agriculture and allied areas so as to equip the agricultural professionals with latest knowledge.
## 5. Strategies and Framework

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<th>Goal</th>
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<tr>
<td>Developing improved varieties of major field crops and viable crop alternatives for higher productivity and early maturity</td>
<td>Re-orienting crop breeding programmes by precision breeding for higher yield, multiple stresses and quality</td>
<td>Regular and timely supply of new, improved cultivars of various crops leading to increase in income of the farmers while ensuring sustainability of agriculture.</td>
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<td>Broadening the genetic base of germplasm to ensure genetic gain for desirable traits</td>
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<td>Assembling and propagating super gene complexes in breeding populations</td>
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<td>Refining and using doubled haploid breeding, marker assisted selection and GM technology</td>
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<td>Regular and timely supply of new, improved cultivars of various crops leading to increase in income of the farmers while ensuring sustainability of agriculture.</td>
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<td>Developing improved varieties and production technologies for vegetable crops for diversification</td>
<td>Identification of superior breeding lines/ hybrids having better yield and quality traits using MAS.</td>
<td>Regular and timely supply of new, improved varieties of various vegetable crops</td>
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<td>Incorporation of insect-pest and disease resistance for different agro-ecological conditions</td>
<td>Diversification of agriculture in the State and prolonged availability of vegetables through protected cultivation</td>
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<td>Assessment of suitability of promising lines for agro-industrial use</td>
<td>Improvement in the economic condition of the farmers</td>
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<td>Improvement in protected cultivation technology for high-value vegetable crops</td>
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| Developing improved varieties and production technologies for fruit crops | • Collection of germplasm of different fruit species from indigenous and exotic sources and identification of superior material having better traits using MAS.  
• Identification of potential rootstocks for resistance to biotic and abiotic stresses  
• Improvement in production and protection technologies of important fruit crops  
• Evaluation of different fruit crops for better post-harvest quality and processing attributes | • Availability of improved fruit varieties of good quality to consumers and processing industry  
• Availability of better production technology  
• Higher net returns to the fruit growers |
| Climate resilience and adaptation                                      | • Characterization of climatic variability  
• Simulation of crop productivity using actual weather data and futuristic climate change scenarios  
• Development of fore-warning systems for emerging pest and disease problems due to climate change  
• Development of cultivars which are more tolerant to abiotic stress | • Availability of crop germplasm capable of withstanding adverse effects of climatic change  
• Management strategies and contingent plans for crops against inclement weather  
• Suitable fore-warning systems for emerging pest and pathogen populations of important crops |
| Efficient management of natural resources for sustainable crop production | • Characterization and mapping of soil and water resources  
• Developing decision support system for aiding fertilizer management and pesticide use decisions  
• Evaluating long-term effects of different crop management systems on physical, chemical and biological health of soil | • Improved crop yields, and better water and fertilizer use efficiency  
• Improvement in physical, chemical and biological properties of soil and water  
• GIS-aided maps for improved land and water use planning |
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| • Developing/evaluating emerging water-saving technologies by exploring synergies among water, nutrients, tillage, residues and other agronomic interventions  
• Developing and fine-tuning technologies of conjunctive use of ground and surface water, and designing suitable drainage system for management of poor-quality water in the south-west region of the State  
• Conservation of beneficial bird species | |  
| Developing eco-friendly management technologies for emerging insect pests, vertebrate pests and diseases  
• Developing techniques for laboratory rearing of promising natural enemies of insect pests including entomo-pathogens  
• Devising pesticide resistance management strategies  
• Developing Decision Support Systems for need-based pesticide application  
• Developing superior strains of bio-control agents and bio-pesticides to regulate populations of important insect pests, and control soil borne plant diseases.  
• Developing non-lethal, environmentally safe technologies for rodent pest management | • Lowered crop losses due to insect pests and diseases and increase in crop yields with better quality  
• Reduction in the use of pesticides in important agricultural crops |
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<th>Strategy</th>
<th>Performance index</th>
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| Development/refinement of agro-processing and value addition technologies to minimize post-harvest losses | - Developing low-cost process/equipment/pilot plant for farm/village level processing of food grains, pulses, oilseeds, vegetables and fruits  
- Developing ready-to-eat convenience food products, and functional foods  
- Utilizing agricultural wastes and byproducts as food/animal feed/fuel | - Utilization of surplus food and value addition  
- Availability of low cost agro-processing technology to farmers/entrepreneurs  
- Availability of a diverse range of locally made, ready to eat food products  
- Increase in farm income |
| Development of improved species of trees suitable for agro-forestry | - Developing clones of forest trees having faster growth and high biomass  
- Identifying crop varieties suitable for inter-cropping in forest plantations | - Availability of high biomass for timber and related industry and for bio-energy  
- Resilience against adverse climate  
- Increase in income of farmers |
| Improvement in seed production programme                             | - Fine-tuning of seed processing, grading and storage technologies  
- Hybrid seed production of vegetable and field crops  
- Producing disease free nursery of major fruit crops | - Availability of better quality seeds of improved varieties/hybrids to farmers  
- Availability of elite disease free nursery plants of fruit crops to farmers  
- Income generation for PAU |
| Production of bio-fuel/bio-energy from crop residues                 | - Developing thermo-chemical and biochemical technologies for producing biogas/bio-ethanol/producer gas/bio-oils for power generation/thermal applications from crop residues | - Reduction in the burning of paddy straw and other crop residues in the fields  
- Availability of biogas/bio-fuel at competitive market price |
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<th>Strategy</th>
<th>Performance index</th>
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| Improving subsidiary agriculture technologies | • Evolving region- and season-specific management technologies for higher growth of bee colony and productivity  
• Evolving disease resistant and mite tolerant bee strains, through selective breeding following instrumental insemination and molecular techniques  
• Value addition of by-products  
• Evolving eco-friendly IPM strategies including the use of bio-agents for the management of bee enemies and diseases  
• Improving in production technology of recommended varieties of mushrooms  
• Identifying strains of medicinal mushrooms possessing higher levels of bioactive molecules  
• Commercial exploitation of the purified molecules | • Increased productivity and production of honey and mushrooms  
• Year round cultivation of mushrooms  
• Availability of specialty mushrooms/honey-bee by-products/bioactive molecules as functional food  
• Improved socio-economic conditions of small and marginal farmers |
| (a) Apiculture | | |
| (b) Mushroom cultivation | | |
| Farm mechanization for precision farming | • Design and development of farm machines for major crops under cultivation  
• Development of machines for conservation and precision agriculture, straw management and use of remote sensing for crop management  
• Use of information technology and computer concepts for the designing, manufacturing and management of agricultural machinery | • Availability and use of rice transplanter, sugarcane harvester, cotton planter, cotton picker, forage harvester, vegetable harvester, fruit tree pruner-cum-harvester  
• Improvement in inputs use efficiency and saving on labour |
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| Policy planning for making agriculture more profitable | • Development/ strengthening of public-private partnership  
• Strengthening institutional mechanism and market support to farmers | • More efficient marketing system  
• Enhanced profit for farmers |
| Developing and strengthening efficient technology transfer mechanism | • Strengthening of ICT mediated extension strategies to reach large number of farmers within shortest possible time not only to assist in transfer of technologies but also to address farmers’ problems.  
• Development of Information Expert System on agriculture in Punjab and documentation of database of all the available practices followed by the farmers.  
• Research on new, innovative extension methods | • Rapid adoption of new technologies  
• Enhancement of productivity and remunerative marketing for bringing about economic well being and livelihood security of farming families. |
| Developing globally competitive human resource to address emerging challenges in agriculture | • Breaking the inbreeding barrier  
• Developing state-of-the-art infrastructure and expertise for imparting quality education  
• Attracting and retaining talent in agriculture | • High-quality, globally competent human resource trained in modern agriculture, agricultural research and agribusiness |
| Empowering women to be self reliant for livelihood security | • Imparting vocational training and capacity building for financial empowerment and improving the quality of life | • Self reliance among rural women  
• Livelihood security of women  
• Fulfillment of nutritional, educational and psycho-socio needs of the families |
Punjab Agricultural University has the mandate of carrying out teaching, research, and technology transfer programmes, and is committed to work for continuous improvement in agricultural productivity and profitability. The University has re-oriented its programmes to focus on the challenges that have emerged over time. Its initial thrust was on crop productivity enhancement, whereas, the current focus is on sustainable development of agriculture i.e. productivity enhancement, input use efficiency, natural resource conservation, agro-processing, mechanization and allied enterprises. The University has expanded its teaching programmes and has revised the curricula in tune with the emerging educational needs. It has exemplary strong linkages with farmers and line departments which are being continuously nurtured to meet the new challenges in transfer of technology.

The PAU envisions that innovations in agricultural production, processing, policy and technology transfer mechanisms would lead to a sustainable growth of the sector. The research and development activities at the University would augment farmers’ income, generate employment opportunities, create trade surplus, and be catalyst in social and environmental sustainability of agricultural production system in the country in general and Punjab in particular. There would be a two-pronged strategy to harness the potential of Punjab agricultural sector; the short/medium term approach for realizing the gains would emphasize on value addition aspects while the longer term approach would be crop improvement and application of biotechnology for sustaining agricultural productivity. To sustain the benefits of research and development, the University would create an enabling policy environment, favourable work culture and infrastructural support at different technical and administrative levels. The close interface with various stakeholders, farmers, processors, policy makers, extension agencies, etc. at the state, national and
international levels has been the strength of PAU that would be further intensified for holistic development of agricultural sector.

Concerted efforts would be made to uplift the stature of PAU as one of the best agricultural R&D and HRD institutions of the world which is responsive to the techno-economic needs of the farmers, including the small and the marginal ones. The University will develop mechanisms to regularly monitor the agricultural scenario at the global level, and develop strategies to address the changes for the benefit of all the stakeholders in the agriculture value chain.
Museum of Social History and Rural Life of Punjab at PAU