

Vision 2030



Guru Angad Dev Veterinary and Animal Sciences University
Ludhiana (Punjab), India

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Preface

India's livestock sector which is one of the largest in the world has been playing an important role in Indian economy and is an important sub-sector of Indian agriculture. In order to provide continuous technological and human resource support to livestock sector, the Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana, was established by an Act of Punjab Government in August 2005. It started functioning from April 21, 2006, after carving out the College of Veterinary Science and animal farm facilities from Punjab Agricultural University. The university is anchored on three key pillars i.e. Veterinary, Dairy and Fisheries Sciences.

Since its inception, the university has made remarkable growth and development wherein new academic programs in fisheries, dairy technology, and animal biotechnology were initiated. These programs have started yielding perceptible results. Efforts of the university are focused on improving livestock production and health, through integrated teaching, research and extension programs and imparting quality education for producing human resource in various sectors of animal husbandry and fisheries.

Punjab, today, is facing an unprecedented agriculture crisis mainly due to deteriorating soil health, water depletion levels, and high pesticide residues in foods of plant and animal origin. With depleting farm incomes, it has been realized that livestock and fishery hold a potential in enhancing farm income. Livestock farming especially dairying is seen as a viable diversification option to the declining economy of Wheat-Rice system. As livestock numbers in Punjab are getting stabilised, further increase in productivity is only possible through newer technological interventions which would require addressing challenges of effective breed improvement, managing high reproductive disorders, shortages of green fodder, quality feed, occurrence of diseases causing high economic losses, and adding value to livestock produce to enhance income and profitability.

In order to address challenges and exploit opportunities of livestock and fisheries sector, appropriate strategies supported with programs have been suggested. The document reflects the mission of a vibrant institution committed to accomplish goals in the mandated areas of teaching, research, extension education and technology transfer to meet the expectations of livestock farmers.

24 January, 2014
Ludhiana



(V K Taneja)
Vice Chancellor

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State Profile

Punjab is situated in the north-west of India; bordered by Pakistan on the West, the Indian states of Jammu and Kashmir on its North, Himachal Pradesh on its North-east and Haryana and Rajasthan on its South. The word “Punjab” consists of Persian words “Panj” and “Aab”. “Panj” means “five” and “Aab” means “water”. Before partition five rivers (Satluj, Ravi, Beas, Jhelum & Chenab) used to run through it. It has total geographical area of 5.036 million hectares which is only 1.53 per cent of the total geographical area of the country. About 83% of the state area is cultivated which is 2.95% of the country’s cultivated area. The state has excellent network of irrigation facilities: 98% of net sown area is irrigated (about 73% by tube wells and 23% by canals). The state is however facing the problem of declining underground water due to predominance of paddy-wheat rotation. Sixty-five percent of the operational holdings are less than 4 ha. The state is considered as the food basket of the country. It has produced 18.78% wheat, 12.61% rice and 8.35% cotton of the total production of these crops in the country and contributed 43.8% wheat and 30.4% rice to national food pool during 2011-12.

1.1 Demography

The state’s human population (2011 census) was 277.04 lakh with 173.20 lakh being rural (62.52%) and is inhabited in 12283 villages. Total number of workers in the state is estimated to be 91.27 lakh. The total number of agricultural workers is estimated to be 14.90 lakh. The literacy rate has increased from 58.51% in 1991 through 69.7% in 2001 to 76.7% in 2011.

1.2 Agro-Climate

The climate is mainly sub-tropical, semi-arid and monsoon type. The annual average temperature ranges from 29 to 32°C during summer and 15 to 17°C during winter months. The mean maximum temperature is 25°C in Rabi and 38°C in Kharif season. Temperature rises to a maximum of 44°C in the summer months

of May and June in South-western parts. The mean minimum temperature is 8°C in Rabi and 23°C in Kharif season. It drops to as low as 1°C in winter months of December in northern parts. The mean annual rainfall varies between 400 and 1300 mm, with more than 75 to 80% of the rainfall being received during four months of monsoon season (June to September).

1.3 Zones

The Punjab state is divided into three homogenous agro-climatic regions on the basis of interaction of several factors such as cropping pattern, soil type, water table, underground water quality, rainfall, etc. These zones are as under:

Zone-I: Zone-I is extended in the eastern border and runs along the sub mountain underlying region of the state. Wheat, Paddy and Maize are the predominant crops in this zone. This zone is called sub mountainous zone. The districts of SAS Nagar, Roopnagar, SBS Nagar, Hoshiarpur and Pathankot fall in this region.

Zone-II: This zone cuts through the state from north-west to south-west and extends along with the rivers of Ravi, Beas, Satluj and Ghaghar. Paddy-wheat is the dominant cropping system in this zone. This zone is called central plain zone. The districts of Ludhiana, Jalandhar, Kapurthala, Amritsar, Tarn Taran, Gurdaspur, Moga, Patiala, Sangrur, Barnala and Fatehgarh Sahib fall in this zone.

Zone-III: This zone is spread through south-western cotton belt of Punjab. Cotton-wheat and paddy-wheat are the dominant cropping system in this zone. This zone is known as south-western zone. The districts of Ferozepur, Faridkot, Bathinda, Muktsar and Mansa fall in this region.

1.4 Livestock

India's livestock sector which is one of the largest in the world has been playing an important role in the Indian economy and is an important sub-sector of Indian agriculture. Though animals serve a number of purposes but their utility has been undergoing a steady transformation driven by the changed agriculture and food consumption patterns. Livestock as source of draught power has declined considerably due to mechanization of agricultural operations and declining farm size. Their importance as a source of quality food has increased due to sustained income and economic growth, a fast growing urban population, burgeoning middle class, changing lifestyles, increasing proportion of women in workforce, improvements in transportation and storage practices and upcoming supermarkets, especially in urban areas. Livestock sector in addition to regular

income provides house hold nutritional security and employment to small and marginal rural households. The proportion of animal products in the total food expenditure is 25.67% in urban areas and 22.62% in rural areas in the country.

In Punjab, livestock contributed 8.4% to the Net State Domestic Product (NSDP) at constant (2004-05) prices in 2010-11. The per cent share of livestock in agriculture GDP has increased from 28.5% during 1990-91 to 29.6% during 2010-11.

Composition of Livestock Population: Punjab has 17.61 lakh cattle, 50.02 lakh buffaloes, 2.11 lakh sheep, 2.86 lakh goats and 0.25 lakh pigs (2007 livestock census, Table 1). Of the total livestock (excluding poultry), cattle and buffalo constitute 92.8 %; other species have little role to play. Up to 1997, growth in milk production was mainly due to increase in livestock numbers. Livestock population is getting stabilized now. Between 1997 and 2007, cattle population has declined by 33% while the buffaloes by 19%. The decline was mainly of males, un-productive animals and indigenous cattle. Apparently, unwanted and low producers are moving out of the production system. Average daily milk yield in Punjab in comparison to national average, both in buffalo (7.8 kg vs 4.2 kg) and crossbred cows (9.5 kg vs 6.5 kg) is much higher. Productivity potential of animals is still higher, and yield gap can be exploited through improved feeding, reproduction and breeding technologies.

Table 1: Livestock population statistics in Punjab (in lakhs)

Species	1997	2003	2007	% Change (1997-2007)
Cattle	26.4	20.4	17.6	-33.3
Buffalo	61.7	59.9	50.02	-19.0
Poultry	54.6	107.7	188.99	65.0

Proportion of female: male is around 76:24 in cattle (84:16 in crossbred and 55:45 in desi cattle) and 90:10 in buffaloes. With only 2.20% bovine population of country, Punjab accounted for 7.47% of the total milk produced in the country and stood 4th (after Uttar Pradesh, Rajasthan and Andhra Pradesh) in milk production. The per capita availability of milk in the state was 939 g per day as compared to national average of 246 g. Per capita availability of eggs is 131 against national average of 55 eggs per annum. Number of poultry birds in the state has increased between 1997 and 2007.

Table 2: Milk and egg production in Punjab vs India

Years	Milk Production				Egg production			
	Total (million tonnes)		Per capita availability (gram / day)		Total (million)		Per capita availability (number/ annum)	
	India	Punjab	India	Punjab	India	Punjab	India	Punjab
2000-01	81.43	7.77	223	870	36632	2964	36	121
2005-06	97.07	8.90	241	931	46235	3520	42	134
2006-07	100.22	9.16	247	939	50663	3774	45	141
2007-08	107.93	9.28	249	923	53583	3791	47	138
2008-09	112.18	9.38	264	920	55562	3679	48	132
2009-10	116.42	9.39	273	915	60267	3283	51	117
2010-11	121.85	9.42	281	931	63024	3544	53	128
2011-12	127.90	9.55	290	944	66450	3603	55	131

University Profile

Guru Angad Dev Veterinary and Animal Sciences University was established (Punjab act no 16 of 2005) on 9th August, 2005 at Ludhiana by carving out the Veterinary Science College and related animal science and farm facilities from the Punjab Agricultural University, Ludhiana, and started functioning from 21st April, 2006. The history of Veterinary College goes back to 1969 when this college was established at Ludhiana by shifting a section of faculty from College of Veterinary Science at Hisar, Haryana.

Keeping in view the multi-dimensional demands of livestock owners and industry, GADVASU has created new colleges / academic units viz. College of Fisheries, College of Dairy Science and Technology, School of Animal Biotechnology, School of Public Health and Zoonoses and a Veterinary Polytechnic. Three Regional Research and Training Centres have been established and three Krishi Vigyan Kendras have become functional at different locations within the state for catering to specific needs of livestock farmers of the area.

Goal: To generate knowledge, human resource, technologies, processes for enhancing productivity of livestock.

Vision: To see GADVASU as an institute of excellence in Veterinary, Animal Sciences, Dairy, Fisheries and Human Resource Development.

Mission: To serve the cause of Veterinary, Animal Sciences, Dairy and Fisheries by developing quality manpower, and generating and disseminating technologies relating to production, processing and marketing of products for the benefit of stakeholders.

Mandate:

- To impart education in Veterinary, Animal, Fishery and Dairy Sciences for advancement of learning and to contribute quality human resource both to industry and educational institutions.

- To conduct research leading to excellence in areas of Veterinary, Animal, Dairy and Fishery Sciences for growth of livestock and fishery sectors.
- Dissemination of innovative technologies for socio-economic transformation.

2.1 Academic Units and Programs

The academic programs of the university are organised under five units which offer UG and PG programs. The university offers Master's (MVSc/MFSc/MSc/MTech) and Doctoral (PhD) programs in 20 and 18 disciplines, respectively. Currently 866 students are enrolled in Undergraduate, Master's and PhD programs. First convocation of the university was held on Dec. 9, 2011 in which a total of 238 students were conferred degrees (PhD, MVSc/ MSc and BVSc & AH).

College of Veterinary Science

- Undergraduate program : BVSc & AH
- Postgraduate programs : MVSc; PhD

College of Fisheries

- Undergraduate program : BFSc
- Postgraduate programs : Post Graduate Diploma in Inland Fisheries
MFSc and PhD in Aquaculture

College of Dairy Science and Technology

- Undergraduate program : BTech (Dairy Technology)
- Postgraduate programs : MTech (Dairy Technology)

School of Animal Biotechnology

- Postgraduate programs : MVSc, MSc and PhD

Polytechnic College, Kaljharani, Bathinda

- Undergraduate program : Diploma in Veterinary Science and Animal Health Technology

2.2 Regional Research and Training Centres and KVKs

In order to cater to the needs of training, extension education, technology transfer and research of different regions of the state, the university has established Regional centres and Krishi Vigyan Kendras:

- Regional Research and Training Centre, Kaljharani, Bathinda.
- Regional Research and Training Centre, Booh, Tarn Taran.

- Regional Research and Training Centre, Bhatoli, Talwara, Hoshiarpur.
- Krishi Vigyan Kendras, one each in Tarntaran, Mohali and Barnala.

2.3 Faculty

The total faculty position in the constituent colleges of the university is 187(2012). Of the total in-position strength, 50% are in the ranks of Assistant Professor and the remaining 50% are essentially equally distributed in Associate Professor and Professor categories. Around 75% of the faculty hold doctoral degree. About 17% have had a terminal degree or training from abroad and 51% are below the age of 40 years. On university-basis, 20% of the scientists are women. Many scientists have been recognized as leaders in their disciplines through national and international awards, and fellowships of societies/academies.

Significant number of faculty members either held various offices of the professional scientific societies or have been nominated to international/national/state level committee and expert groups. Since establishment of the university, a total of 1050 research articles have been published including 192 in the international journals of repute. Over 50 books/book chapters have been published by the faculty besides several practical manuals. The university has one South-African patent in diagnosis of brucellosis.

2.4 GADVASU Cyberary

Cyberary, a new centre of learning which integrates the state of the art information technology with traditional services bringing together all modes of information system available into one integrated system, has been established. It supports educational and research goals of the university through information and knowledge collection, organization, dissemination and application. It also provides a gateway to students and faculty for international networking on internet and video net. The university website www.gadvasu.in is updated at regular intervals.

The university is part of National Knowledge Network (NKN) project and National Information Centre (NIC). The Government of India has provided internet connectivity of 100 mbps, equipments and 15 IP addresses for connectivity under this project.

Library: The library is fully automated through Libsys (Library Automation Software), and is active member of Consortium for e-Resources in Agriculture (ERA) facilitating access to more than 2900 journals in the broad spectrum of

agricultural sciences including nearly 300 journals in veterinary & animal sciences, biotechnology, dairying, fisheries and related fields.

The library also subscribes to important Indian and foreign journals, with many journals having online access. The resources available in the library are digitized with local area network.

Computer Centre: The centre has 40 computers with high speed internet connectivity. These are also used for statistical analysis using latest softwares. Lease line internet connectivity to various departments, farms and clinics is available.

2.5 Student Development and Welfare

The infrastructure facilities for games and sports are presently shared with PAU, Ludhiana. Organization of Inter college sports and games meet as well as Annual athletic meet is a regular feature since the establishment of the University. The University students also participate in All India Inter University Tournaments held at different places in the country. Participation of students in North Zone Inter University competitions as well as in All India Inter Agricultural University Sports and Games Meet sponsored by the ICAR is also a regular feature.

The NSS Units are functional in the university under the NSS program. One Punjab Remount and Veterinary Squadron NCC is affiliated with the College of Veterinary Science. Regular parades and trainings are organized for the NCC Cadets. Cadets also participate in Annual Training Camps/ Republic Day/ Independent Day functions organized by NCC Group Head Quarters.

Students have won good number of seats in JRF examinations conducted by the ICAR at national level. There is hundred percent placements of students in the College of Veterinary Science. Some students opt for higher studies in India and overseas and for DVM. Veterinary graduates have made their niche not only in the state by providing health care and production services but also abroad in various capacities. Students graduating in newer academic programs like Animal Biotechnology, Fisheries and Dairy Science and Technology are finding fruitful placements. A number of students (8) of the university have won the INSPIRE fellowships for PhD programs.

2.6 Farm and Laboratory Facilities

The main campus at Ludhiana has an area of 300 acres. The university has made concerted efforts to modernize the existing infrastructure and create new facilities

for first rate teaching and research by procurement of state of art equipments. The university maintains different species of farms animals viz. buffaloes, cattle, goats, pigs, poultry including Japanese quail and emu, and fish. High genetic-merit and well-characterized germplasm of buffalo, crossbred cattle, broiler and layer chicken, and Japanese quails are systematically undergoing genetic improvement. Suitable facilities for multiplication and dissemination of improved germplasm are available.

The university has established a number of new laboratories and renovated/upgraded the existing laboratories/facilities for conducting research and for catering to the needs of the modern technology-driven teaching including experiential learning in its constituent colleges/schools. Some of the important laboratories include:

Clinical Diagnostics: The clinical diagnostic laboratory is equipped with latest instruments for biochemistry, hematology, urine analysis, blood gas analysis and photo micrography for quick and accurate diagnosis. More than 10,000 samples of blood, urine, faeces, body fluids and tissues from clinical cases are tested annually. Advanced Radio-diagnostic Centre offers facilities of ultrasound and digital radiography where approximately 2500 X-rays and 1000 ultrasound scans are done every year. Advanced clinical facilities of endoscopy, echocardiography, electrocardiography, peritoneal dialysis, ophthalmology and animal critical care unit for diagnosis and management of various disease conditions are also available.

Toxicology: The toxicology laboratory , established for conducting research in pesticide and mineral toxicity, endocrine disruption studies, chromatographic assays in pharmacokinetics as well as identification and detection of pesticides levels, has essential equipments viz. gas chromatograph with NPD, ECD and FID detectors, high performance liquid chromatography with UV and PDA detectors, autoanalyzer, closed cell concentrator, solid phase extraction assembly, ELISA reader, ion analyzer etc.

Immunopathology and Histopathology: The laboratory is equipped with cryostat for frozen sectioning, antigen retrieval system, chemilluminiscence reader for hormones and cytokines, vet Scan dry biochemistry analyzer, automatic tissue processor and staining instruments and histocentre work station. The laboratory caters to the research needs of various departments.

Mineral and Residue Analysis: The mineral analysis laboratory has facilities of atomic absorption spectrophotometer to evaluate the effect of environment

pollutants related to mineral imbalances including toxicities and deficiencies. The residue analysis laboratory caters to the field of toxic and environmental pollutant residues in foods of animal origin and their plausible human health impact. It is equipped with gas chromatograph with mass spectrometer, high performance liquid chromatograph, gas liquid chromatograph for providing all round residue analytical solutions. Routine analyses of organochlorine and organophosphorous pesticide residues in various types of food of animal origin (meat, milk, milk product, fish etc.) animal feed and fodder, and human samples are carried out.

Semen Freezing and ETT: The laboratory has state of art facilities to produce and store quality frozen semen. Semen collection, processing and freezing is done under strict sterile environment to meet international quality standards. Frozen semen is subjected to quality assessment through a battery of tests before its distribution. Semen of elite bulls is provided to dairy farmers and other agencies. The ETT lab is well equipped, and has been successful in production of elite calves in farmer's animals. Veterinary Officers of the State Animal Husbandry department have been trained in embryo transfer technology.

Genetic Engineering: The laboratory has been developed with focus of research on production and purification of recombinant antigens to be used in diagnostics and vaccine production. The laboratory is equipped with biosafety cabinets Class II B2 & Class III and equipments needed for gene cloning and expression.

Molecular Diagnostics and Vaccinology: A sophisticated tissue culture laboratory with the state of art equipment has been established to develop, formulate and evaluate molecular (PCR and Real Time PCR), recombinant protein/monoclonal antibody based diagnostics for sensitive, specific and rapid detection and quantification of microbial load of pathogens, tissue culture based multicomponent and new generation vaccines against important bacterial and viral diseases of livestock and poultry.

Product Development: The laboratory is equipped with various equipments such as meat-cum-bone saw machine, bowl chopper, dough maker, ice flaking machine, vacuum meat tumbler, hydraulic sausage filler, meat slicer, smoke oven, vacuum packaging machine, dansensor gas mixture for modified atmosphere packaging with oxygen, nitrogen and carbon dioxide gases, microwave oven, cooking range and other miscellaneous equipments.

Small Animal House: Small animal house maintains different species of laboratory animals viz. mice, rats, rabbits, hamsters and guinea pigs for research

needs of various academic units of the university. The animal house is registered with Committee for the Purpose of Control and Supervision of Exposure on Animals (CPCSEA), Ministry of Environment and Forest.

Multi-utility Teaching: It is a state of the art lab of its own kind having multipurpose teaching and extension facilities including microscopy teaching and demonstration, multimedia teaching and training of extension specialists. The lab is equipped with advanced microscopy unit with digital imaging and multimedia faculties. Twenty in house advanced binocular microscopes on the spot and ready to use purpose are available.

Post Harvest Technology: The laboratory has been developed for conducting research on value addition of fish flesh. The instruments available in the laboratory include meat-bone separator, ice flaking machine, vacuum packaging machine, meat mincer, fish filleting machine and deep freezer.

The various laboratories of the university are well-equipped with modern facilities and high-end equipments viz. portable ultrasound cum Doppler cum echocardiography of small and large animals, bronchoscope, fully automatic somatic cell counter, fully automatic biochemistry analyzer, veterinary holter, liquid nitrogen handling system, pulse field gel electrophoresis etc.

A bio-gas plant comprising of two 90 cu m modified fixed domes type has been constructed at the university dairy farm. The plant has a capacity to handle 4500 kg (daily) of cow dung and poultry droppings. The plant produces 240 kw hours of energy daily with which a 40 kva bio gas genset can be operated for 6-8 hours daily to produce electricity which is used for chaffing of green fodder, machine milking and to operate fans, coolers & foggers in the animal sheds.

2.7 National and International Collaboration

Since its establishment, the university has expanded its research and academic initiatives through Memorandum of Understanding (MOU) at national and international levels. At national level, the university has entered into collaboration with National Dairy Research Institute, Karnal in the area of Dairy technology and Animal Biotechnology, Central Institute on Buffalo, Hisar, National Research Centre on camels, Bikaner, ISF College of Pharmacy, Moga and at international level with University of Saskatchewan, Canada. Environmental pollutants affecting animal and human health are the major concerns today. In order to address this issue, the university has started a collaborative program on 'Environmental

pollutants and zoonotic pathogens in Punjab: their impact on animal and human health' with University of Saskatchewan, Saskatoon, Canada under International Partnership Fund Program. This project focuses on increasing the role of veterinary medicine in protecting and enhancing not only animal health, but human and environmental health as well. In tune with that, an International Workshop on Environmental Pollutants and their Impact on Human and Animal Health has been held. The School of Public Health and Zoonoses has a Collaborative Research and Training Experience (CREATE) on Integrated Training Program in Infectious Diseases, Food Safety and Public Policy funded by Natural Sciences and Engineering Research Council (NSERC), Canada in collaboration with University of Saskatchewan, Canada and Free University, Berlin, Germany. Under this program, there is provision for exchange of scientists and postgraduate students for collaborative research.

Growth and Accomplishments

3.1 Academics and Facilities

The University at the time of its establishment had only one college viz. the College of Veterinary Science offering three programs viz. BVSc&AH, MVSc and PhD. Within a short span of time, GADVASU, taking into consideration the demand and opportunities available, has added five more colleges/academic units. The number of programs offered by the university has increased from three to eleven. The student enrollment has been consistently rising and currently 866 students are enrolled in various programs (2013).

Table 3: Student enrollment (numbers) of the university

Program	08-09	9-10	10-11	11-12	12-13
Under Graduates	403	438	524	606	580
Post Graduates	98	131	147	243	286
Total	501	569	671	849	866

School of Animal Biotechnology: Revolutionary advances in molecular biology during the last three decades has put molecular biology and biotechnology at the heart of all the biological sciences with extensive applications in Agriculture, Animal Husbandry, Medicine, Industry and Environmental sciences. Recognizing the immense potential of biotechnology in animal sector, the university established the Department of Animal Biotechnology in January, 2008 under the aegis of Post Graduate Institute of Veterinary Education and Research. Recognizing the accomplishments and the potentiality and opportunities available in biotechnology, the department was up graded to School of Animal Biotechnology in 2010 for conducting integrative research in various facets of molecular biology, and to serve as a platform for inter-departmental and inter-institutional collaboration.

The School of Animal Biotechnology since its inception has made fast growth and development in terms of scientific manpower, students, infrastructure and

laboratories and garnering of extra-mural funding. The Department which started with five scientists derived from different departments of the university now has grown up to ten; all holding PhD, and majority having undergone advanced foreign training. The School has developed state of art laboratories in cutting edge areas of biotechnology viz. molecular diagnostics and vaccinology, genetic engineering, hybridoma cell and molecular biology and stem cell biology. The laboratories are well-equipped with latest instruments and facilities to conduct research and teaching/training.

The school has made remarkable progress in garnering extra-mural funding. The department which started with a single institutional funded establishment scheme is currently having 20 extra-mural funded projects (DBT/ DST/ UGC/ ICMR). The large body of research fellows and PhD scholars is serving as a productive scientific pool. Of various projects, two prestigious ones include the HRD project of DBT and FIST program of Department of Science and Technology. Under HRD project, six students are admitted to MVSc/MSc through National Test conducted by Jawaharlal Nehru University. Every admitted student is provided scholarship in addition to research/thesis grant and book purchases. Under the DST-FIST program, high end equipments are being added besides the establishment of a bioinformatics and computational biology laboratory. So far four batches of Masters and one batch of Doctoral students passed out in the school.

School of Public Health and Zoonoses: The School of Public Health and Zoonoses was established in December 2011 by upgrading the Department of Veterinary Public Health, keeping in view the importance of emerging problems of zoonoses, environmental pollutants and food safety and quality control. After establishment of the school, Residue analysis, Zoonoses, Food safety and Quality control and Heavy and toxic metal analysis labs have been renovated and strengthened. Keeping in view the emerging problems that affect public health in the region, the school has strengthened its research in the areas of environmental pollutants viz. pesticides, drug residues, heavy and toxic metals; zoonoses viz. brucellosis, cysticercosis, hydatidosis, listeriosis, viral zoonoses; and antibiotic resistance to develop base line data and mitigation strategies.

Presently the School has twelve research projects funded by DBT, UGC, ICMR, PHFI, RKVY etc. and two International Collaborative research and training projects/programs. The first is a Collaborative Research and Training Experience Program (CREATE) on Infectious Disease, Food Safety and Public Policy in collaboration with University of Saskatchewan and Free University,

Berlin. In this program existing students for Masters, Ph.D. and PDF are being enrolled in Integrated Training Program for Infectious Diseases and Food Safety and are jointly supervised by faculty at Canadian universities along with online courses, summer schools and hands on training. The second one is International Partnership Fund Program, a collaborative research proposal initiated with University of Saskatchewan, Saskatoon, Canada.

College of Fisheries: College of Fisheries is the outgrowth of Fisheries section which was shifted to GADVASU from the Department of Zoology & Fisheries, PAU on its establishment. In order to boost fisheries in the state, separate Fisheries Unit was established in 2007 under the Directorate of Research. It was upgraded to College of Fisheries in April, 2008 with the mandate to develop technically and scientifically qualified human resource; carry out basic, applied and adaptive research for higher fish productivity and disseminate developed technologies to the farmers and entrepreneurs for commercial adoption. The college now has four departments viz. Department of Aquaculture, Department of Fisheries Resource Management, Department of Aquatic Environment and Department of Harvest & Post-harvest Technology.

The college has steadily created infrastructural facilities catering to its expanded activities of teaching, research, training and consultancy. At the main campus, facilities for teaching & research built over the years now spread over 16 acres area having four blocks and full fledged fish farm.

In addition to 17 research schemes, the college has ICAR's prestigious "Niche Area of Excellence". So far one batch of BFSc and two batches of MFSc have completed their degree programs.

College of Dairy Science and Technology: The College of Dairy Science and Technology was established in 2008 with the objective to produce quality human resource to meet the manpower requirement of flourishing dairy industry, and develop and transfer appropriate milk processing technologies to the end users. Presently, the college is offering four year program in BTech (Dairy Technology) and two year program in MTech (Dairy Technology). The college has five departments viz. Dairy Technology, Dairy Engineering, Dairy Chemistry, Dairy Microbiology, Dairy Economics & Business Management.

Beside teaching and research laboratories, the college has an experimental dairy plant of 5000 LPD milk processing capacity and facilities for preparing dairy products such as butter, ghee, paneer, lassi, ice cream and cheese etc. The

experimental dairy plant provides practical and hands-on-training to BTech students.

Veterinary Polytechnic, Kaljharani (Bathinda): With an aim to produce trained supporting man power capable of handling livestock health and production, GADVASU has established a Veterinary Polytechnic at Kaljharani, District Bathinda for imparting Diploma for Veterinary Pharmacist in 2010. The diploma for Veterinary Pharmacist has been designed for the training of Veterinary Pharmacists to support and complement Veterinary practitioners, in order to provide better care and guided treatment to domesticated animals within Veterinary Hospitals, Veterinary Colleges, Research Institutes etc.

3.2 Research

Research is one of the three major functions of Guru Angad Dev Veterinary and Animal Sciences University. The research programs are formulated taking into consideration the local, regional and national needs of livestock farmers.

3.2.1 Genetic Enhancement

Cattle Breeding

- Average 305-day milk yield of crossbred cows has increased from 4201 kg (in 2006) to 5240 kg (in 2013). An elite herd of crossbred cows has been produced for the production of future bulls. The average 305 days milk yield and average peak yield of the elite herd with more than 75% exotic inheritance are 5851 kg and 32.7 kg, respectively. Highest peak yield of 52.5 kg has been achieved. The average content of fat, protein, lactose and SNF in buffalo milk was 4.02, 8.55, 3.07 and 12.57 per cent, respectively. One crossbred cow has created a National milk production record by producing 10,493 kg milk in a standard lactation period of 305 days with peak yield of 47.2 kg and fat content of 3.5%. The total lactation yield was 12260 kg.
- The average first lactation 305-day milk yield of crossbred progenies in the adopted villages which was 1698 kg in 1979 has increased to 3256 kg in 2012-13. This is a result of supply of high quality semen of the test bulls. A number of farmers have now established large dairy units for undertaking commercial dairy farming.
- The university supplies the bull calves, bulls and semen of crossbred bulls to the farmers and other agencies. About 9.08 lakh doses of liquid and frozen semen have been sold so far.

Buffalo Breeding

- The 305-day lactation yield of buffalo herd has increased from 1670 kg in early seventies to the present level of 2528 kg. The 305-day milk yield of elite herd which is used for production of future sires is 3457 kg. With systematic selection and optimum management, it has been possible to produce buffaloes with peak yield as high as 25 kg a day. The average content of fat, protein, lactose and SNF in buffalo milk was 7.60, 4.30, 4.78 and 9.65 per cent, respectively. A Murrah buffalo bull has been ranked 1st in Progeny Testing Program of Indian Council of Agriculture Research, with first lactation 305-day milk yield of 2357 kg. Semen of top proven bulls is used to produce future young bulls, and is also made available to farmers.
- The university has sold 720 bulls/male calves and 6.21 lakh doses of high genetic merit semen to farmers and other development agencies.

Broiler Chicken Breeding

- Two strains of broilers (PB 1 and PB 2) have been developed. This germplasm has been supplied to the Project Directorate on Poultry, Hyderabad for the National Poultry Breeding Program.
- Based on performance evaluation of the cross of pure strains in national Random Sample Tests (RST), a commercial stock, designated as IBL-80, was released at the national level by the Variety Release Committee constituted jointly by the ICAR and the Department of Animal Husbandry and Dairying, Government of India. The IBL-80 was the first indigenous broiler released at the national level. In the recently conducted RST, the stock attained 7-week body weight of 2.0 kg with the feed conversion ratio of 1.91 which is the best performance from amongst the public sector entries.

Layer Chicken Breeding

- Two strains of White Leghorn (PL1 and PL2), synthesized from divergent genetic sources in early seventies, had been improved through selection for various traits related to productive and reproductive performance. Based on performance evaluation of the reciprocal crosses of the two purebred stocks (PL 1 and PL2), the crossline stock was released by the 'Varietal Release Committee' of the State for commercial use under the patent name 'Satluj layer'.
- Two strains of Rhode Island Red (RIR-B and RIR-C), a stock of Dahlem Red and a synthetic stock designated as 'Punjab Red' have been developed. These

coloured stocks are popular with small/marginal farmers as brown eggs get sold at a premium. Since the birds are heavier at the end of the lay, the income from the spent hens is also higher than White Leghorn females.

Quail Breeding

- Two strains of Japanese quail, a broiler quail with a 5-wk body weight of 240-250 g and a layer stock with a potential to lay more than 280 eggs per annum, have been developed through long term intra-population selection.
- A strain of quails with white plumage has been developed and genetically improved over generations. Based on its growth performance, the strain was released for commercial production under the name Punjab White Quail. Average body weight is around 250g with egg weight of 13g; the eggs are used for preparation of pickles.

3.2.2 Nutritional Interventions

- **Naturally fermented straw:** The natural fermentation of poor quality crop residues with urea, which is economically viable, has been perfected and accepted by the farmers. The treated straw serves as a maintenance ration when supplemented with 25 g salt, 50 g mineral mixture and 2 kg green fodder.
- **Non-conventional feed resources as livestock feed:** Sarson saag waste, tomato pomace, food processing industry wastes, baby corn husk, spent straws and non-conventional straws have been established to hold potential as livestock feed. Forest tree leaves and grasses of semi-hilly arid zone have been evaluated for their nutritional worth and found to useful as livestock feed.
- **Rumen protected fat:** Fortified fat, which has 80-85% bypass fat and 5-6% calcium, helps in reducing negative energy balance, provides essential fatty acids for milk fat and hormone synthesis, and in turn improves productive and reproductive performance of high yielding dairy animals.
- **Enteric methane production:** Complete feed containing maize, waste bread, cotton seed cake, tomato pomace, corn gluten meal, spent brewers grains, deoiled rice bran, green bajra and rice straw have been found to reduce enteric methane production, without impairing the productivity of animals. Essential oil's carvone dissolved in methanol can mitigate enteric methane production.
- **Uromin-lick and mineral mixture:** Uromol, a heated product of urea and molasses (1:3 ratio for 30 min), was effective in partly meeting animal's mineral,

energy and protein requirements, checking mal-nutrition, improving productive and reproductive performance of animals. Mineral mixture formulated by the university improves digestion, production and reproduction, and has found wide acceptability with the dairy farmers.

3.2.3 Livestock Production and Product Technologies

- **Sustainable farming system:** A National Agricultural Innovation Project (NAIP) has been in operation in Hoshiarpur District, the only backward district of Punjab, with the objectives to enhance productivity of animals through adoption of improved interventions; enhancing crop production and promotion of agro-forestry with fodder trees and medicinal plants, promote processing and marketing of various products, and for development and training of self-help groups for sustainability of various enterprises. The project has made inroads through a series of farmer friendly activities viz. deliverables like mineral mixture, uromin lick, fodder, cereal, pulse seeds, deworming, vaccination, supply of improved bucks and allied income generation activities, and creation of self-help groups. Various interventions under NAIP led to increase of annual family income from Rs 12,000/- to 25,000/-.
- **Livestock products and technologies:** Various meat value added products like chicken nuggets with ground carrot, low-fat buffalo meat patties, turkey meat patties, chicken snacks sticks, chicken nuggets with mashed green banana, chevon patties and nitrite-free cured goat meat patties have been developed, evaluated for their quality and shelf life, and popularized. An edible protein film for packaging and extending shelf life of milk and meat products has been developed. Various value added emu meat products have been developed, and process protocol of refining of emu oil and extension of storage life has been standardized.
- **Transfer of technology:** The University transferred three main technologies for egg jam, ready-to-eat meat snacks products such as Meat cutlets, meat croquette, meat samosa and emu meat products such as pickle, burger patties, nuggets, balls/koftas to four budding entrepreneurs.

3.2.4 Animal Health

Treatment of Animals

- More than 28,000 animals are registered annually at the university clinics for treatment and advice which include ruminants, equines and pets. The discipline wise cases received were medicine (73%), surgery (22%) and gynecology

(5%). Besides providing clinical service at campus, the university is operating Ambulatory Clinics on regular basis to cater the needs of farmers in the adjoining villages, and training the undergraduates.

Disease Diagnosis

- A “state of the art” Clinical Diagnostic Laboratory has been established where more than 13,000 samples of blood, urine, faeces, body fluids and tissues from clinical cases are tested annually.
- Advanced Radio-diagnostic center with facilities of ultrasound, endoscopy, and digital radiography has been established where approximately 2500 X-Rays and 1000 ultrasound scans are done every year.
- A Radio-immunoassay laboratory for reproductive management of dairy animals has been established which has facility of reproductive hormone estimation of farm and pet animals.
- Pressure Mini Column (PMC) technique has been standardized for detection of aflatoxins in feed.
- ELISA test for the diagnosis of Newcastle disease, infectious bovine rhinotracheitis, infectious bursal disease and mycotoxins in feed and milk samples have been standardized.
- PCR technique for the diagnosis of hemorrhagic septicemia, brucellosis, campylobacter infections, salmonellosis, colibacillosis, infectious bursal disease, avian adenovirus, canine parvo virus and bovine herpesvirus-1 has been standardized.

Clinical Interventions

- Techniques for intermedullary interlocking, nailing and bone plating for management of long bone fractures in dogs have been standardized.
- Ultrasonography has emerged as a reliable tool in diagnosis of diaphragmatic hernia and reticular, omasal and peritoneal affections in cows and buffaloes.
- Safer protocols for general anesthesia in small and large animal surgery have been developed.
- Fetotomy procedures to handle cases of dystokia in cows and buffaloes have been standardized. Technique has also developed for the management of uterine torsion in buffaloes.

- Intra-peritoneal lubrication technique, a method for administration of lubricant in the peritoneum for prevention of uterine adhesion, has been developed.
- Blood transfusion and peritoneal dialysis techniques for handling emergency in small animal veterinary medicine have been standardized.
- Bovine lameness which is a major problem in high yielding dairy animals of organized farms due to intensive feeding and managemental practices has been effectively managed by formalin foot bath with supplementation of biotin and Zn. Hoof trimming chute has been designed to restrain the animal for examination and trimming of hoof.

Animal Reproduction

- Use of ultrasonography has been standardized in implementation of estrus synchronization protocols in anestrus buffaloes.
- Role of melatonin implants for breaking summer anoestrous in buffalo heifers has been established.
- Progesterone release device (Ovsynch plus CIDR) for optimization of fertility status in pre-pubertal buffalo heifers has been standardized.
- A CIDR-based protocol has been found to be a highly effective therapeutic strategy in ovarian cysts. Conception rate to first AI was seen 62.5% for cystic cattle receiving this treatment.
- Conception rate in cases of prolonged estrus exhibiting repeat breeder cattle has been improved to 33% through administration of GnRH on day 6 post-ovulation.
- Cervical massage with warm Sodium carboxymethylcellulose has been effective for achieving complete cervical dilatation followed by per-vaginal fetal delivery in uterine torsion affected buffaloes.
- Administration of small volume of hypertonic saline (7.2% @ 4ml/kg) and Dextran-40 (10ml/kg), as an alternative to conventional fluid therapy for resuscitating the dystokia affected buffaloes with variable degree of toxemia and hypovolemia.
- Intrauterine infusion of *E. coli* LPS (100 µg) and oyster glycogen (500 mg) was found to enhance the uterine immunity and cleared the infection.

Management of Common Animal Health Problems

- **Mastitis in dairy animals:** Incidence of subclinical mastitis in the state has been found to be 49% in cows and 25% in buffaloes while clinical mastitis affected 6.5% cows and 4% buffaloes. Since the drug sensitivity pattern of mastitis pathogens keeps on changing, it requires regular monitoring. The Sodium Lauryl Sulphate (SLS) and Electrical Conductivity (EC) tests have been found to be most economical, efficacious and easy to use for diagnosis of mastitis particularly at farmer's level. A combined regimen of complete dry therapy and post milking teat dipping in iodine based teat dip has been highly effective in reducing the incidence of mastitis.
- **Mineral disorders:** In Punjab, various mineral disorders such as copper deficiency, chronic fluorosis and subclinical iodine deficiency have been identified in the state. Selenium toxicity has been identified in some villages of Hoshiarpur, Nawanshahar and Ropar district. Appropriate amelioration measures were recommended against mineral imbalances in the form of area specific mineral mixture.
- **Parasitic diseases:** The overall prevalence of GI parasites in adults and calves has been established at 37.8 and 68.2%, respectively. *Toxocara*, *Vitulorum*, *Strongyloides* spp., *Eimeria* spp. and *Moniezia* spp. were the common internal parasites while *Rhipicephalus* and *Hyalomma* were major ecto-parasites. High degree of acaricide resistance has been established in *Rhipicephalus microplus* with deltamethrin (96.6%) and cypermethrin (93.3%).
- **Infectious diseases:** Occurrence of various infectious diseases viz. FMD, HS, TB, JD, swine fever, BT were reported and their incidences established. Molecular characterization of specific genes of bovine salmonellosis indicated that Inv-A and Stn genes were widely distributed. The 17 (65.38%) isolates carry sop E gene and 24 (92.31%) isolates carry Hil gene. The drug sensitivity test against almost all the bacterial isolates from the skin affections in fish revealed chloramphenicol as the drug of choice.
- **Zoonotic diseases:** An epidemiological survey on occurrence of brucellosis in persons associated with animal husbandry practices in Punjab revealed disease prevalence of 6.25 to 10.50%. The prevalence was found to be higher in the age group of 30-39 years. The disease was found to be more frequent in dairy cattle than in buffaloes. Antibiotic sensitivity study revealed 100% sensitivity of *Brucella abortus* to tetracycline and ampicillin.

- **Nitrate poisoning:** In clinical outbreaks of nitrate/nitrite poisoning, fodder samples were found to have > 2500 ppm of NO₃-N content on dry matter basis. The high levels of nitrate may affect immune system of animals and making them vulnerable to infections.
- **Toxicological studies:** The adverse effect of insecticides (Chlorpyrifos, imidacloprid, thiacloprid, cyfluthrin, indoxacarb, acetamiprid, fipronil, carbendazim), drugs (Ofloxacin, moxifloxacin and ceftazidime) and minerals (Selenium, molybdenum, fluoride and cadmium) were investigated, and their safety was established for use in cattle and buffalo species. Effect of minerals on biochemical and hematological profile and antioxidant status has been elaborated. Interaction of insecticides and minerals was studied in buffalo calves
- **Neoplasms in poultry:** Neoplasms caused by avian oncogenic viruses using immuno-histochemical techniques revealed that mixed infections were more prevalent (52%) than single virus infections. Marek's disease virus, Reticuloendotheliosis virus and Avian Leukosis virus were found equally prevalent. Immuno-histochemical techniques were found to be more sensitive as compared to histopathology for diagnosis of various neoplasms caused by avian oncogenic viruses in poultry.

3.2.5 Animal Biotechnology

Molecular Marker Based Characterization

- Extensive polymorphism, both between- and within-stocks of chicken germplasm (White Leghorn, Rhode Island, Dahlem Red and Punjab Red), has been established. The Nei's genetic distance and the dendrogram of different strains paralleled with the genetic selection history of the strains. Randomly amplified polymorphic DNA (RAPD) in buffaloes, using 25 random primers, revealed that the degree of inbreeding matched perfectly with the estimates computed through path coefficient and RAPD assay method.
- Restriction Fragment Length Polymorphism (RFLP) has been accomplished on a number of genes affecting the growth and production performance (viz. chicken growth hormone, Neuropeptide Y and Leptin genes) in both the layer and broiler genomes. The leptin gene polymorphism using PCR-RFLP (*Alu* I R.E.) in Murrah, Mehsana, Surti and Nili-Ravi breeds of buffalo revealed conservation of secondary structure elements and active sites.

- The major histocompatibility complex using sequence specific primer (SSP) has been characterized in broiler chickens.

Cloning and Sequence Analysis

- **TLR:** Toll-like receptor 2 (TLR2) EST of Murrah buffalo has been cloned and sequenced. PBMCs isolated from whole blood and stimulated with soluble peptidoglycan (sPGN from *Bacillus subtilis* cell wall) to activate TLR2 signaling cascades of Th1 and Th2 cytokine (dose- and time- dependent manner) followed by mRNA quantification (qRT-PCR, TaqMan assay), has implicated sPGN in upregulating the TLR2 transcription.
- **HSP 70:** The gene heat shock protein 70 (Hsp70) and its transcription factor 1 (HSF1) have been established to have highest expression during summer as compared to winter in leucocytes of milking buffaloes. Expression of chicken Hsp70 (Ch Hsp70), TNF- α and IL-1 has been evaluated (using Real Time PCR, TaqMan assay) in six breeds under normal and varying degree of induced heat-stresses (42°C-48°C) *in vitro*. The expression of Ch Hsp70, TNF α and IL 1 was highest at 44°C. The expression was established to be higher in colored (plumage) breeds (RIR and Punjab Red) than the white Leghorn varieties.

Diagnostics and Vaccinology

- Immunodominant outer membrane protein LipL32 from *Leptospira interrogans* serovar *canicola* has been expressed successfully in prokaryotic expression vector pProExHT for use as recombinant antigen in ELISA or for subunit vaccine. Immunodominant outer membrane protein LipL32 has been cloned and the sequence has been submitted to National Center for Biotechnology Information (NCBI).
- New diagnostic Polymerase Chain Reaction assays for leptospirosis (based on 16srRNA gene and LipL32 gene), brucellosis (based on OMP31) and salmonellosis (based on invasion A gene and outer membrane protein gene) have been developed and standardized for rapid diagnosis of these infections.
- Immunodominant outer membrane protein C from *Salmonella typhimurium* has also been expressed successfully in prokaryotic expression vector pProExHT for use as subunit vaccine against salmonellosis.
- Glycoprotein (gC) of BHV-1 was successfully expressed in sf-9 insect cells by Baculo Direct™ Baculovirus expression system. The recombinant glycoprotein

C reacted well both with polyclonal and monoclonal antibody in western blot and dot-ELISA indicating its potential to be used as a coating antigen in gC-based diagnostic ELISA.

- The fish immune system recognizes microbes via TLRs, and TLR2 is the one that recognizes bacteria and thus help in induction of immune response. A study carried out to sequence the TLR-2 gene of Indian major carp *Catla catla* and to investigate its differential expression in various tissues revealed that partial coding sequence of TLR-2 gene of *Catla catla* had a close evolutionary relationship with *Cyprinus carpio* and *Ictalurus punctatus* with 93% sequence similarity. Maximum expression of *Catla catla* TLR-2 gene was found in head, kidney followed by spleen and least in the liver tissues by SYBR green assay in Real-time PCR.

3.2.6 Dairy Technology

- Various technologies have been developed viz. carrot lassi, whey based drinks Jaljeera and Mango, *Low/ Reduced Calorie Mitthai Dathi* (sweet curd), Fibre enriched *Dhodha burfi* with mass acceptability and optimized process parameters for the manufacture of *Milk Cake*, *Banana ice cream* and *Yog-Ice cream*.

3.2.7 Dairy Economics

- A research project entitled “*Economics of Milk Production and its Regular Monitoring in Punjab*” has been in operation since 2008-09 in three zones viz. Central, Sub-mountainous and South-Western for working out the conducting of dairy farming. About 600 farmers of various size categories from six districts are participating in the project. The study revealed that variable cost constituted about 87% of the total cost of milk production and that per litre cost of milk production was higher on domestic and small-sized dairy farms and lower on large-sized farms. Cost of milk production increased by about 30% whereas, milk prices increased by 18% leading to lower profits. It was suggested that farmers make efforts to cut down the per litre cost of milk production by adopting better dairy farming management practices. At the same time, cost of milk production should be considered as one of the parameters by procurement agencies while fixing the milk procurement prices.

3.2.8 Fisheries

- **Aquaculture in inland salt affected and waterlogged areas:** The scope of aquaculture in south-west district of Punjab which is affected by salinity /

water logging (zero earning land) has been evaluated. Maximum salinity (upto 165 ppt) in district Muktsar followed by Ferozepur (upto 47 ppt) and Faridkot (upto 6 ppt) was observed. Bioassays studies revealed that carps and freshwater prawn survived up to 10 and 15 ppt salinity, respectively in inland saline waters. On-farm aquaculture trials in salt affected water logged areas revealed that carp productivity of 3.5 t/ha/yr (if the salinity is maintained below 10 ppt by adding canal water) can be achieved with an expected net income of Rs. 100,000/ha/yr. Success was achieved in breeding and seed production of common carp in inland saline waters with salinity 6-8 ppt, and with over 90% fertilization and hatching success. Fish seed exhibited satisfactory growth in Inland saline waters upto 8 ppt.

- **Low cost carp feed formulations and feeding strategies:** Several locally available low cost agricultural (deoiled forms of mustard, groundnut, sunflower, soybean, cotton seed) and agro-industrial (molasses, press mud, poultry hatchery waste) by-products and aquatic plants (*Azolla* and *Spirodela*) were successfully incorporated in supplementary feed of carp fishes to reduce cost (up to 50%) on supplementary feed (protein level of 30%).
- **Diversification of carp culture with high value species:** In view of the need for diversification in aquaculture, successful breeding and rearing of catfish, Indian magur (*Clarias batrachus*) and Singhi (*Heteropneustes fossilis*) was carried out. Post larvae of fresh water prawn (*Macrobrachium rosenbergii*) that were reared successfully from April to October obtained size of 50-80 g. Overwintering (November to March) of prawn in poly house conditions (with aeration and supplementary feed) despite the adverse climatic conditions of winter has been successful (more than 90% survival).
- **Fish processing and value addition:** Aquaculture in Punjab is 100% carp culture based. Domestic consumption of carp fish is very low due to presence of intra-muscular spines. In order to enhance local consumption of fish and increase profitability, work has been initiated for value addition of carp fishes. Ready to cook and ready to eat products (fish fingers, fish balls, fish patties, fish cutlets) from Carps deboned with deboning machine have been prepared.
- **Ornamental fish breeding and seed production:** Brood stock rearing, breeding and seed production of egg bearers like Koi carp (*Cyprinus carpio*) and Gold fish (*Carassius auratus* Var. Shubunkin) and live bearers like molly (*Poecilia phenops*), platy, swordtail (*Xiphophorus spp*), and guppy (*Poecilia reticulata*) were carried out successfully.

- **Ecology and Fisheries:** Water quality of River Satluj from Ropar head works to Harike barrage (15 spots) in Punjab has been assessed vis-a-vis the impact of sewage/industrial pollution on its fisheries. Discharge of untreated industrial effluents/domestic sewage of Ludhiana city into the river through Buddha Nallah has been found to cause deterioration of water quality beyond the permissible limits with respect to conductivity, hardness, free CO₂, alkalinity and biological oxygen demand.
- **Azolla culture:** *Azolla* culture technology under local climatic conditions has been standardized for utilization in fish and livestock feeding.
- **Bioremediation model for aquaculture:** Duckweed based bioremediation model for dairy shed waste water for aquaculture has been established for recovery of nutrients with dual benefit of recycling of remediated water into aquaculture as liquid manure and production of protein rich duckweed biomass for utilization as fish feed. Duckweeds have been found to remove 100% of ammonical nitrogen in two weeks, 88% of nitrate nitrogen and 83% orthophosphate in three weeks from the waste water.
- **Fish-duck farming:** Successful hatching and rearing of exotic layer variety of Ducks (Khaki Campbell) and fish-duck model was demonstrated to encourage farmers to take up fish cum duck farming, which is a low input, eco-friendly and sustainable technology for higher economic returns especially for the small and marginal farmers.
- Brackish water shrimp ‘Vannamei’ has been reared successfully in inland salt affected waterlogged waste land attaining an average weight of 20 gm in three month culture period.

3.2.9 Extension Education

The university has a well-structured program for extension education and transfer of technologies related to animal health, production, fisheries and value addition to the end users through its’ Directorate of Extension Education.

- **Farmer’s associations:** Various forums such as Progressive Dairy Farmers Association (Regd.), Innovative Fish Farmers Association (Regd.), Punjab Piggery Farmers Association and Punjab Goat Farmers Association are working under the aegis of GADVASU. Regular monthly meetings and seminars for members of these associations are held.

- **Village adopted program:** An animal welfare centre was established at Village Gureh to provide scientific and other inputs to develop it as a model village. Interventions resulted in improved productivity, reproductive fitness and reduced mortality/morbidity of the livestock.
- **Training programs:** Trainings/Workshops of varying durations are organized for professionals and livestock owners besides conducting seminars for dairy, piggery, goat and fish farmers.
- **Field outreach activities:** Various extension activities viz. Animal Welfare Camps, Expert Lectures/Technical guidance/Field days, Animal Husbandry Officers Workshop, Dairy Show, Pashu Palan Melas, Regional Pashu Palan Melas, Farmers Advisory Service/Helpline, Zonal Livestock Shows, Dog shows and TV/Radio talks are regularly organized.
- **Publications:** Some of the university publications are: Package of Practices for Livestock Health Management, Progressive Livestock Farming and Vigyanak Pashu Palan (Monthly Punjabi Magazine), Handbook on Infectious Animal Diseases, Veterinary Punjabi Shabadkosh, Dairy Farming, Goat Farming (English & Punjabi), GADVASU handbook, Poultry Farming and GADVASU News letter.
- **Farmers advisory service:** Telephonic helpline in the department of Veterinary and Animal Husbandry Extension Education under the motto “you ask we reply” is in existence and working successfully.
- **Chief Minister Award:** University confers Chief Minister Awards in dairy, poultry, fishery and piggery to innovative and progressive livestock farmers every year.
- **Regional trainings:** The regional training and research centres, which are well-equipped with audio-visual gadgets for effective communication, have been instrumental in dissemination and transfer of knowledge. Camps/ Melas/ Trainings are regularly conducted for adopting new practices and technologies by the farmers and self-help groups in the Kandi area of the State.

Vision and Strategies

Livestock is an integral component of rural economy of Punjab and is driven by structural changes in agriculture and food consumption patterns. Livestock over time has undergone steady transformation with the non-food functions viz. draft power becoming weaker. There is rapid increase in consumption of animal food products both in rural and urban areas.

Livestock population in the State is getting stabilised. Further increase in productivity and production is possible only through technological interventions. For meeting the ever increasing demand for livestock products, a sustained growth rate in excess of 5 per cent per annum as against present 3.7 per cent would be essential. This, however, would require addressing challenges of effective breed improvement programs, high reproductive disorders, shortage of fodder, quality feed, occurrence of diseases causing high economic losses and adding value to livestock produce to enhance income and profitability.

Guru Angad Dev Veterinary and Animal Sciences University which was established in 2006, has made significant progress in its trinity functions of education, research and extension. The academic programs of the University have expanded where five new colleges/schools/polytechnic viz. College of Fisheries, College of Dairy Science and Technology, School of Animal Biotechnology, School of Public Health and Zoonoses and Veterinary Polytechnic have been added. The future thrust would be to further strengthen its existing goals and objectives especially job oriented quality education, need and problem based research, and establishing and strengthening close linkages with livestock and fish farmers, and related industries for delivery of goods and services, knowledge, technologies and processes for increasing income through productivity enhancement, value addition and ensuring quality and safety of animal based foods while protecting environment using sustainable production systems.

4.1 Academics, Laboratory Facilities and Human Resource

The focus in education would be to further improve knowledge and skills of graduates so that they render effective services, and have better employment opportunities in the current scenario of increasing competition. Academic programs would be strengthened and newer courses, curricula and laboratory facilities added to meet the emerging challenges and harness the innovations in educational technologies to produce quality human resource. Courses in veterinary, dairy and fisheries would be restructured to cater the requirements of industrial sector. Library information system which is modern, automated, bar-coded, digitalized shall be further strengthened with e-books for knowledge gathering, dissemination and application with textbooks.

Wildlife, which is under threat of extinction due to industrialization, is both a national and regional issue of significance vis-a-vis ecological balance. In order to address issues in basic wildlife management and health, and to educate veterinary students in zoo medicine, the University has established a 'Wildlife and Zoo Animal Disease Diagnosis and Management Centre'. This centre shall build up scientific knowledge on wildlife epidemiology, disease diagnosis, treatment, nutritional strategies and managerial practices. A centre on Pets shall be established to generate information on management, nutrition and healthcare. Addressing zoonotic issues concerning pets shall be priority of the centre.

A Collaborative Research and Training Experience Program (CREATE) which involves problem-based learning has been initiated in collaboration with the University of Saskatchewan (Canada) and Free University, Berlin (Germany). Online courses and video-linked classes with subject matter specialists for improving academic standards are in progress. Exchange of students and teachers for enhancing their academic and research skills is receiving high priority under this program. Experts and subject matter specialists shall be invited for 'Hands on training' of students and the faculty. Many more Memorandum of Agreements (MoA) with institutes of excellence both in India and abroad would be signed to achieve academic excellence.

The University has adopted a model of establishing self-contained academic/research schools for integrated training and research. Both, the School of Animal Biotechnology and School of Public Health and Zoonoses, established under this model, have been successful in building up academic and research capacities through

extra mural funded projects, and through national and international collaborations. Excellence in clinical services for super-specialty at species level and advancements in microbiology, medicine, surgery and reproduction would be accomplished by establishing new Schools of Clinical Sciences, Veterinary Microbial Diseases and Pathobiology, and a Diagnostic Imaging Centre having digital radiography, MRI and CT procedures and other diagnostic facilities (endoscopic/ laparoscopic/ Nuclear Scintigraphy Unit). These schools/ centres would provide a platform for integration of clinical sciences and give further boost to early disease diagnosis. A critical care unit shall be established with all modern life saving devices.

An Educational Museum of Animal Diseases, a Modern Necropsy Complex and Animal Disease Registry and Tissue Bank are being established for better understanding of disease process, surveillance and epidemiology of important economic diseases and training of students and faculty.

Quality human resource is a critical input for academics, training and research. Currently there is a large gap between availability and requirement of manpower in the area of animal and veterinary science, dairy science and fisheries. Student's intake both at undergraduate and postgraduate level shall be increased, and infrastructure and faculty positions appropriately strengthened to manage both teaching and research responsibilities. Postgraduate programs (Master's and Ph.D.) in Dairy Science and Technology and Dairy/Livestock economics shall be initiated.

Academic inbreeding, in general, today is a major concern. Fortunately the recruitment policy of GADVASU has facilitated recruitment of around one-fourth of its faculty from other states. The University would continue with its policy of attracting the best scientific manpower. Knowledge improvement and information management being an ongoing process, faculty would be trained at regular intervals in institutions of excellence both in India and abroad for wider exposure, scientific growth, and to meet the challenges of technology driven growth. A corpus fund for Human Resource Development has been created through contributions from alumni and faculty.

4.2 Research

Research focus would be to develop cutting edge technologies to increase animal and fish productivity and income through genetic, nutritional, health care (diagnostics, vaccines, immunobiologicals) and value addition interventions to ensure safe and quality animal based foods while mitigating the effects of climate change on livestock health and productivity.

4.2.1 Animal and Fish Genetic Resources

Genetic improvement of crossbred cattle and Murrah buffaloes shall be further augmented through intensive progeny testing of bulls using field and farm records. Sexing of semen and embryo transfer technologies would be integrated in the progeny testing program. Traditional quantitative genetic methodologies would be augmented with molecular markers for enhancing genetic gains. Superior germplasm (quality semen, bulls and bull calves) would be disseminated to the end users.

Punjab and its adjoining areas are the native tract of some of the superior breeds of livestock viz. Sahiwal cattle, Nili Ravi buffaloes and Beetal goats. Elite herds of these breeds shall be established for conservation, concurrent utilization and dissemination of quality germplasm. In chickens, the focus will be on development and distribution of stocks suited for low-input conditions. Superior germplasm of Japanese quails shall be made available to the farmers for commercial ventures. The nucleus flock of Emu would be further strengthened to standardise management, health and oil extraction protocols.

Genomics research shall focus on genes implicated in disease and stress tolerance. Whole genome associations would be carried out to identify key genes contributing to production. Database of the identified SNP's and QTL's of livestock breeds shall be developed.

4.2.2 Stem Cell Engineering

Altered persistency in lactation, long dry periods, abrupt cessation of lactation and disease conditions like mastitis greatly reduce milk production potential and cause great financial losses. Cellular and molecular regulation of mammary stem cells shall be utilized to increase cell turn over and tissue repair of the mammary gland, which will in turn reduce length of dry period and increase persistency. Stem cell therapy as supportive therapy in case of disease like mastitis would be targeted to enhance lactation performance.

Research strategy shall also be focused on utilization of stem cells and induced pluripotent stem cells (iPSC) for the regenerative therapy. In small animals, autologous and allogenic transplantation would target use of stem cells to treat soft and bone tissue injuries especially in canines.

4.2.3 Feeding Strategies

Animal nutrition research has so far centered on evaluation of feed resources, improving digestibility and adding value to low quality roughages. Future research

priorities would be on neutragenomics and evaluation of genetically modified feeds and forages entering into food chain. Research work on rumen microbiology would be strengthened to understand the mechanism of feed degradation and energy extraction, studying rumen microbial diversity, and to identify consortium of microbes required to maximize extraction of nutrients from poor quality crop residues. Applied animal nutrition research areas such as strategic supplementation of limiting macro and micro nutrients, probiotics/ prebiotics, feed additives (enzymes, methane inhibitors etc.), development of Total Mixed Ration technology for improving efficiency of ruminant digestion, nutrition-reproduction interaction assessment with special reference to feeding of transition and sick animals would be considered both for current and future applications.

4.2.4 Enhancing Reproductive Efficiency

Poor reproductive efficiency in dairy animals, besides direct and indirect losses to farmers, also hinders genetic improvement. A systemic mapping of reproductive disorders of dairy animals in the state shall be taken to develop package of practices for their optimal management.

Major issues of concern in buffaloes are delayed onset of puberty, poor signs of estrus, seasonal suppression of reproductive activity, poor libido in buffalo bulls and poor fertilizability of spermatozoa. About one third buffalo bulls exhibit poor libido which is an impediment in semen collection. About 50% crossbred bulls fail to produce semen of freezable quality. Attempts would be made to develop optimal buffalo semen freezing protocols to address issues related to cryo-injury and capacitation. Endocrine and nutritional interventions for hastening the onset of puberty, improving fertility especially during summer and protocol for synchronized estrus in late pubertal and anestrus buffaloes would be developed. Identification of early-age expressed molecular markers for selection of high fertility male calves would also be targeted. The existing techniques of ovum pickup, IVM-IVF, sexing of sperm shall be integrated for improving reproductive efficiency and multiplying superior genotypes.

Poor semen quality, freezability and libido are some of the most commonly encountered problems in crossbred bulls. These problems would be targeted using proteomics, transcriptomics and genomics. The presence of fertility associated proteins and metabolites in serum, urine and accessory sex fluids shall lead to identification of factors contributing to poor performance of crossbred bulls.

4.2.5 Climate Change and Livestock

Rising temperatures and humidity adversely affect livestock growth, reproduction and production efficiency. Climate change also affects rate of transmission of many infectious and vector-borne diseases. Research and strategy focus would be to provide comfortable housing to reduce stress, and studying effects of rising temperatures and humidity on reproduction, disease patterns and fodder quality and quantity, and identifying suitable genotypes which can better withstand the changes in climate.

4.2.6 Processing and Value Addition of Milk, Meat and Egg

Milk processing to value added products in the state is around 35%, of which organized dairy industry accounts for only 16-18%, while the rest is either consumed at farm level or sold as fresh, non-pasteurized milk through unorganized channels. Processing, value addition and quality control aspects of milk would receive special focus because of perishable nature of the produce.

Milk product industry is very large, unorganized and needs support for process mechanization and technology upgradation. Value addition of milk and milk products with the integration of fruit, vegetables and cereals has also a large potential especially buffalo milk. Work in the area of processing, composite and functional fermented dairy foods, production of nutraceuticals, nutrigenomics, mineral and vitamin fortification to milk and milk products with incorporation of probiotics and prebiotics using techniques like micro-encapsulation and nanotechnology and extending the shelf life, monitoring residues in milk and dairy products would form priorities. Mapping of bioactives in milk of various species shall be taken up to elucidate their therapeutic potentials, extraction of these invaluable nutrients/therapeutic agents, and for designing functional and health dairy foods. A training-cum-demonstration unit shall be established to disseminate knowledge and technologies to stakeholders/entrepreneurs.

Only about 2% of meat is processed in Punjab. Focus of research would be on quality meat production by standardizing pre-slaughter handling and implementing HACCP and GMP practices, fresh meat processing, value added functional/health-oriented/designer meat and egg products and extension of shelf life using natural compounds as antioxidants and antimicrobials. Novel bioactive edible antimicrobial films from milk, meat and egg proteins, chitosan, starches and polysaccharides which extend shelf life and nutritive value of products shall be developed. Low-

cost byproduct processing technologies for development of pet foods and high value low-volume processed products including functional biopeptides, ossein, neat's foot oil, emu oil would also be targeted. Developed technologies shall be transferred to end users through training and extension education programs.

4.2.7 Epidemiology of Diseases, Toxicities and Deficiencies

Surveillance and monitoring system for important diseases of livestock shall be strengthened through use of web-based epidemiological software and using Geographic Information System (GIS) and satellite images. Modern information and communication technology on real time basis for forecasting and forewarning diseases, however, calls for disease management system from village to laboratory. An authentic epidemiological data base for realistic assessment of prevalence and emergence of economically important infections (FMD, HS, Brucellosis), parasitic diseases (primarily haematozoa e.g., Theileriosis, Trypanosomiasis, Babesiosis and Anaplasmosis), sub-clinical and clinical forms of production diseases (mastitis, lameness), mineral imbalances and toxicities (nitrate/nitrite) in animals across different agro-climatic zones of Punjab shall be established and used for identification and prioritization of most important diseases causing heavy economic losses. Strategies for prevention and control of important diseases shall be put in place. Reliable estimates of economic losses due to diseases are not available; realistic figures of such losses in context of prevailing conditions would be worked out.

Livestock diseases like FMD, IBR, HS, Brucellosis and Haemoprotozoan require timely and accurate diagnosis. Conventional methods of diagnosis like detection and isolation which are laborious and time consuming shall be replaced by rapid, highly sensitive, specific and cost effective assays. Development of pen-side diagnostics based on recombinant proteins/ synthetic peptides/ monoclonal antibody/ genome of the pathogens for rapid and simultaneous detection of multiple etiological agents would receive high priority.

The principle approach for control of infectious diseases is by vaccination. Most of the currently available vaccines (live, modified/killed) are either only partially effective and/or have short protective period. Recent advances in protein biochemistry, molecular biology and immunology shall be utilized to facilitate development of potent, cost effective, novel and new generation vaccines (marker/subunit/DNA) against major livestock diseases (IBR, HS etc.). Research shall also be targeted to enhance the efficacy of existing vaccines using novel

adjuvant formulations with an ultimate aim to differentiate vaccinated and infected animals. The focus shall also be on developing novel targeted and controlled release veterinary drug delivery systems. Phytochemical/ pharmacological screening of indigenous medicinal plants (lemon grass, nirgundi, kari patta, ashwagandha etc.) which have some established medicinal values shall be the other focus of research for developing herbal drugs. Research on adult stem cells (mesenchymal and spermatogonial) shall also be initiated as potential therapeutics.

4.2.8 Food Safety and Zoonoses

Creation of state-of-the-art infrastructure on Food Safety and Quality Control to evolve into a self-reliant centre of excellence in the area of food safety, quality assurance, monitoring and surveillance systems for control of food borne diseases is immediate need. The priority would be to establish a referral laboratory for livestock related food borne pathogens, environmental pollutants, contaminants and toxicants, and preparation of inventory database of pesticides, heavy and toxic metals and veterinary drug residues in foods in Punjab and other northern states to develop strategies for quality food production. Genotoxicity and biomarker studies for environmental pollutants and their effect on animal health and production particularly fertility in dairy animals shall also be taken up.

Beside food safety, zoonotic and transboundary diseases would receive special focus due to intimate involvement of human and animals. Emerging and widely prevalent zoonotic diseases such as brucellosis, listeriosis, methicillin-resistant *Staphylococcus aureus*, cryptosporidiosis and rotavirus would receive higher attention. One Health initiative shall be promoted with greater cooperation among multiple disciplines-veterinarians, medicos, environmentalists and wildlife experts to ensure optimal health for humans, animals, and environment. Strengthening 'One Health' concept shall help to address issues of zoonoses, food safety, bioterrorism and enhancing our capacity and capability for emergency preparedness and managing emerging and re-emerging zoonoses.

4.2.9 Enhancing Fish Productivity

Although Punjab has made great strides in fish production, and its productivity from both capture (50 kg/ha/yr) and aquaculture (6.04 tonne/ha/yr) is highest in the country, the State holds great potential to enhance fish production through both horizontal (increasing area under aquaculture) and vertical (enhancing pond/reservoir productivity) expansion. The priority would be to develop a data base

on natural fishery resources with respect to water quality, biodiversity and ecology, technology, landing sites and marketing, to be used as inputs to develop package of practices for enhancing productivity and income through appropriate interventions. Culture based capture fisheries involving cage culture in natural water resources (like reservoirs and lakes) shall be taken up for productivity enhancement along with conservation and stock enhancement through ranching.

Research priorities would be to optimize aquaculture technologies with respect to brood stock improvement for quality seed production, culture and seed production of new candidate species and fish processing. Diversification of carp culture with high value species like catfishes, murels and freshwater prawns will be carried out for higher profitability per unit area. Efforts shall be made to enhance profitability and net income per unit area through standardizing zero wastage post-harvest fish processing technology, involving production of value added products from de-boned carp meat and by-products like fish meal, bone meal, fish oil etc.

South-west districts of Punjab, comprising Muktsar, Ferozepur, Fazilka, Faridkot and Mansa are affected by underground salinity and/or water logging. The affected lands are either less productive or unfit for any profitable agriculture practice. Total waste land in these districts (including salt affected, waterlogged, swampy/marshy lands and sand dunes) is about 35,695 ha, out of which 9050 ha is salt affected/waterlogged land. On farm research trials in salt affected/waterlogged areas revealed an average fish (fresh water carps) productivity of about 3.5 t/ha/yr, besides successful brood stock rearing, breeding and seed production of common carp (freshwater carp) in inland saline waters (salinity up to 8 ppt). Apparently, aquaculture is the most viable option for reclaiming these salt affected/waterlogged waste lands for economic returns. The priority would be to further enhance productivity and profitability by producing genetically improved seeds, nutritionally balanced feeds and technologies for value added products/by-products using zero wastage processing technology.

Non-food aquaculture (ornamental fish and pearl culture) shall also be developed and promoted. Other research priorities would include developing cost effective feeds utilizing non-conventional feed resources (aquatic weeds) and recycling of farm waste including waste water through bio-remediation technology. More attention shall be given to the improvement of water quality, fish health management and impact of climate change on aquaculture. Public private partnership shall be encouraged to bring 'Blue Revolution' in the State.

4.3 Extension, Economics and Marketing

Livestock extension is different from agriculture extension and calls for delivery of services and inputs at the farmer's door. Approach would be to work with the farmers through adopting villages, transferring technologies and studying their impact on productivity and farm income. National Agriculture Innovation Project in Hoshiarpur had made inroads through a series of farmer's friendly interventions viz. supply of various feed ingredients (fodder blocks, uromin licks and mineral mixture), fodder seeds, medicinal and agro-forestry plants and trainings in dairy, poultry, piggery, goatry and bee-keeping. These greatly helped in capacity building of beneficiary farmers for sustaining project activities. The above model shall be used to cater the needs of farmers and field functionaries through adoption of a cluster of villages around KVKs and Regional Research Centers for demonstration and better acceptance of technologies. Forming women self-help groups, empowering them and providing training to rural women and youth in various areas of animal management, feed manufacturing and value addition of livestock products would receive high priority. Attempts shall be made to develop farmer-friendly digitalized trainings/teaching modules and to introduce distance learning through e-extension, cyber extension and virtual classrooms. New courses, modules and models on entrepreneurship development in livestock would be developed. Tele-medicine services shall be strengthened for rapid and effective treatment. Data base on cost of production of milk, meat and eggs shall be generated for forecasting demand, supply and prices of livestock products.

Programs and Activities

The following major programs and activities are envisaged to accomplish and realize the vision 2030.

5.1 Academics and Human Resource

- Development of text books and teaching resource material in electronic format including incorporation of project-and problem-solving approach in curricula.
- Course content generation, development, management and dissemination through on-line and e-Learning.
- Introduction of new academic programs in wildlife; distance education and new courses in emerging areas viz. livestock business management, bio-security, bioinformatics and disaster management.
- International collaboration in academics and regular faculty upgradation through national and international trainings.

5.2 Animal Genetic Resources, Production Systems and Climate Change

Germlasm Management and Improvement

- Characterization of candidate genes associated with milk production, fertility and stress tolerance in buffaloes and Sahiwal cattle, and generation of phenomic and marker data-sets for prediction of genomic breeding values.
- Manipulation of mammary stem/progenitor cells for enhancing lactation performance, and application of adult and induced pluripotent stem cells for improved health and productivity.
- Development of a strain of crossbred cattle through germlasm infusion (Holstein Friesian), and selection including genomic technologies with target yield of 8000 kg/lactation.

- Comparative evaluation of Murrah and Nili Ravi buffalo breeds for various performance and adaptability traits, and developing elite herds with yield target yield of 4000 kg/lactation.
- Development and genetic improvement of broiler chicken specially suited for low-input/ rural conditions.
- Shelter management and mechanization of farm operations.

Reproductive Efficiency

- Discovery of biomarkers using metabolomic, proteomic and genomic approaches for predicting fertility in crossbred and buffalo male calves.
- Physiological and genomic regulation of summer heat stress-induced infertility in buffaloes and its alleviation through genetic selection and endocrine interventions.
- Indigenous production of reproduction related hormones and their antisera for efficient reproductive management.

Feeds and Feeding Strategies

- Studying rumen microbial diversity and fiber degrading consortium of buffalo and wild ruminants.
- Development of database on methane production potential of different feedstuffs and mitigating enteric methane production through dietary manipulation, herbal feed additives and alternate hydrogen sinks.
- Development of vaccine against cell-surface proteins to a broad range of methanogen species as a strategy to mitigate methane emission.
- Working out carbon foot prints of a range of animal feeds/feeding systems to improve efficiency of livestock production and environment.

Climate Change

- Evaluating potential risks and developing appropriate strategies to mitigate/ reduce effects of changing climate on feed and fodder availability, production related parameters and breeds.
- Monitoring of diseases and vectors affected by climate change, as well as related forecasting and early-warning systems for improved disease control and prevention.

5.3 Diagnostics, Vaccines, Drugs and Clinical Interventions

Diagnostics

- Standardization of specific and sensitive laboratory assays based on recombinant proteins, synthetic peptides, monoclonal antibody, bacteriophage and genome (DNA/RNA) of important pathogens viz. *Brucella*, *Leptospira*, *Campylobacter*, mycobacteria, bovine herpes virus-1, classical swine fever virus, canine distemper virus, hepatitis-E virus, Marek's disease virus.
- Development of simple, economical and reliable pen side diagnostic kits for important livestock diseases viz. brucellosis, infectious bovine rhinotracheitis, hepatitis-E, Marek's disease including simultaneous detection of multiple etiological agents.
- Mining of biomarkers for development of non-invasive techniques (serological assays) for the diagnosis and prognosis of canine mammary tumors.
- Elucidation of molecular mechanism underlying host pathogen interaction of economically important infectious diseases.

Vaccines

- Molecular characterization of isolates of some pathogens (canine distemper virus, canine parvovirus, Marek's disease virus) to understand their changing virulence and comparison of field isolates with vaccine strains for developing interventional strategies by upgrading vaccine strains and altered therapeutic regimens.
- Evaluation and development of new generation (gene deleted/ virus like particle/ phage based/ differentiation of infected and vaccinated animals) single or multi-component vaccines with local isolates of pathogens for japanese encephalitis, infectious bursal disease, infectious bovine rhinotracheitis, brucellosis, tuberculosis, Johne's disease and improvement of existing vaccines using novel adjuvants.

Drugs

- Screening (phytochemical, pharmacological) of some indigenous medicinal plants (lemon grass, nirgundi, ashwagandha etc.) for developing formulations for use in animal health.
- Development of novel targeted and controlled-release drug delivery systems.

Clinical Interventions

- Advance imaging techniques like magnetic resonance imaging, computerized tomography scan, thermography and other techniques viz. echocardiography, electrocardiography, Holter, Treadmill Test for early and accurate diagnosis of various ailments including cardiovascular diseases in small and large animals.
- Establishment of dentistry (orthodontics, root canal treatment), ophthalmology (phacoemulsification and intraocular lens implantation) and nephrology (haemodialysis) clinics for improving companion animal health.
- Creation of disease registry and tissue bank for important production and infectious diseases, and toxicities of livestock.

5.4 Food Safety and Zoonoses

- Molecular characterization of food borne/zoonotic pathogens and parasites to develop rapid, cost effective and specific diagnostic kits.
- Genotoxicity and biomarker evaluation of environmental pollutants (pesticides and endocrine disruptors) and heavy metals (cadmium, arsenic, nickel, lead) vis-a-vis their effect on animal health and production particularly fertility in dairy animals.
- Emergence of antimicrobial resistance in relation to food safety and veterinary practices.

5.5 Processing, Value Addition and Waste Management

Processing and Value Addition Development of:

- Functional dairy products incorporating nutraceuticals (minerals, vitamins, prebiotics, probiotics, herbs etc.) using micro encapsulation and nano particles.
- Technologies for extraction of bioactive peptides from milk and milk by-products and their utilization in developing functional dairy foods.
- Energy efficient equipments for process mechanization of indigenous dairy/composite dairy products.
- Novel value added meat and egg products with improved functionality by enrichment with fiber, minerals, vitamins, omega-3 fatty acids, conjugated linoleic acid, bioactive peptides etc.

- Processing technologies for extension of storage life of meat and egg products by incorporating antimicrobial and antioxidant compounds of plants and animal origin and coating with bioactive nano-composite films.

Waste Management

- Development of high-value low-volume processed products (ossein, bone morphogenic proteins, gelatine sheets, neat's foot oil etc.) from slaughter house by-products for environmental safety.
- Fish waste processing to fish meal, bone meal, fish oil, fish gelatin etc.
- Development of natural scavengers (microbes, enzymes etc.) for reduction of biological oxygen demand of effluents from animal industry to check environmental degradation.

5.6 Fish Production and Productivity

- Development of low cost larval and grow out 'Aqua-feeds' for carps, catfishes, murrels and prawn/shrimps.
- Productivity enhancement (vertical expansion) through shifting from existing semi-intensive to intensive aquaculture technology and development of genetically improved carp fishes through selective breeding.
- Culture, breeding and seed production technologies for high value species for diversification of low value carp dominated fish farming.
- Developing inland saline water aquaculture models for salt affected waterlogged waste lands.

5.7 Economics, Policy Planning and Extension

Economics and Policy Planning

- Generation and updating of data base on cost of production of milk, meat and eggs for forecasting demand, supply and prices of livestock products.
- Policy research on returns to investments on genetic enhancement, animal health, nutrition and food security and poverty alleviation to identify investment priorities and institutional arrangements for faster, sustainable and inclusive growth in livestock sector.
- Livestock marketing and supply chain management including value addition

and food safety to improve farmers' access to domestic and international markets.

Extension

- Studying various extension models for efficient demonstration and delivery of knowledge and technologies including entrepreneurship programs in value addition, feed manufacturing, clean milk production, ornamental fish culture and fish seed production.



Guru Angad Dev Veterinary and Animal Sciences University
Ludhiana (Punjab), India

www.gadvasu.in