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Assessment of intellectual property management and technology commercialization in animal science research

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ABSTRACT

To understand the innovation-based initiatives in the animal science sector, IP&TM Unit of ICAR has analysed IP management, and technology commercialization/licensing activities. The study provided a snapshot on IP portfolios of animal science-based institutes and universities in India and abroad. The IP based initiatives in the form of policy implementation, in-depth awareness and training programmes increased the ICAR's IP portfolio with 485 Patent applications, 40 Designs, and 87 Trademarks in animal science research in last 20 years. UGC affiliated 38 Animal Science research-based universities also benefitted with these efforts and added 564 patent applications at IPO. World Top-100 veterinary universities patent portfolio was accessed which brought a growing trend IP filing with 35.20% applications before 2006, followed by 14.82% in 2006-2010, 16.52% in 2011-2015, 18.58% in 2016-2020, and 14.88% after 2020, respectively. To transfer the ICAR's animal science-based innovations through technology commercialization, 473 licensing agreements were signed with 279 public and private organisations and entrepreneurs in which 234 technologies were transferred in between 2007 to 2024. These innovations have reached 25 states and union territories across the country. The continuous efforts of IP&TM Unit and ITMUs under NAIF, 43.96% licensed technologies were protected by filing of patents (34.62%), Trademark (6.41%), Design (2.13%), and Copyrights (0.42%). To institutionalize the agri-business environment in animal science research, seven ABI centres are working in the field of dairy, veterinary, meat, poultry, piggery, sheep, and animal health. These IP filing and technology commercialization trends prove that innovation management and its transfer to the industry is an important pillar of economic growth.

Keywords: Commercialization/licensing, Design, Innovation, Intellectual Property, Patent, Technology, Trademark, Start-up

Asset based economies are now moving towards Intellectual Properties (IPs), where creativity, knowledge, and innovation boost their progress, and open the doors for globalized market opportunities. South Korea with its 35% IP based Growth Domestic Product (GDP) and Israel as a Start-up nation with its 10% IP based GDP represent the real time examples of such transitions. Innovation and commercialization of intellectual assets (copyrights, designs, patents, plant varieties and trademarks) support this paradigm shift. The European Union (47%) and United States (41%) are raising their major stake of the employment generation and GDP from IP intensive industries (Toole *et al*. 2021 and EUIPO 2022).

Interconnected and inclusive innovation leads to economic recovery and high-quality transformation and development (APEC 2024). The importance of innovation has already been realized and systematized in the form of Global Innovation Index where India ranks 39th Position with 38.3 score, which is lead by Switzerland (67.5), Sweden (64.5), United States of America (62.4), Singapore (62.2), United Kingdom (61.0) etc. In this index, India is leading amongst Central and Southern Asia followed by Iran and Kazakhstan; and in the Lower Middle-Income Group followed by Vietnam, and Philippines (WIPO 2024).

In India, agriculture provides the livelihood to its 58% population. Due to innovation-based policy decisions and schemes in recent years this sector has shown a robust growth averaging 5% annually from 2017 onwards, which is 1.93% globally in the last decade (2011-20). The livestock sector alone represented 5.5 % of the total Gross Value Added (GVA), which supports its robust Compound Annual Growth Rate (CAGR) of 12.99 % (PIB 2025a).

India is ranked first in milk production contributing 24.76% of global milk production. Milk production is growing at Compound Annual Growth Rate (CAGR) of 5.62% over the past 10 years whereas world milk production has grown by 1.50% during 2023 (estimated) in comparison to the year 2022. FAOSTAT confirms India worldwide 2nd rank in egg and 5th in meat production (PIB 2024). The export of animal products viz. buffalo meat, sheep/goat meat, poultry products, animal casings, milk and milk products, etc. reached 4,5435.52 Millions USD in

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2023-24 (APEDA 2024). The market size of these products is showing an increasing trend at a CAGR of 6.8% (www.thebusinessresearchcompany.com).

In view of above facts about the importance of IP and its role in employment generation and economic development; market linked innovation, and agrarian economy of the country, where the livestock sector is maintaining its robust growth can never be overestimated. Therefore, this study was undertaken by Intellectual Property and Technology Management (IP&TM) Unit of ICAR under its National Agriculture Innovation Fund (NAIF) project to assess the status of IP filing scenario of national and international level organizations; to understand the impact of IP management and technology commercialization initiatives; and to have an insight about Start-up activities in animal science research and its management.

MATERIAL AND METHODS

The study focused on inclusive innovations with their relevant IP protection and transfer to business entities requiring valid data support, and literature. To execute this study with the above-mentioned objectives, primary and secondary data sources were used with relevant software's, and search engines, which were as follows:

Patent database: To get the latest trends of patents of Indian Patent Office (IPO), World Intellectual Property Organization (WIPO), European Patent Office (EPO), and United States Patent Office (USPTO) databases were accessed. Other than this, Questel Orbit (paid IP search engine) is a global intellectual property intelligence software dedicated to patent analytics and research was used to update the patent data and their legal status.

Technology Commercialization and other database: ICAR Annual Reports (www.icar.org.in/annual-report); IPO Annual Reports (www.ipindia.gov.in/annual-reports-ipo.htm) WIPO, EPO, and USPTO Reports and Publications; Start-up India Mission Reports and Publications; Research.com (is a leading educational platform was used to select top 100 veterinary universities); and University Grant Commission (UGC) approved list of universities etc. were used.

The compiled databases, information and literature were analysed with relevant statistical tools, and presented in different heads viz., IP Portfolio and its legal status, with transfer to industry; technology commercialization with IP and non-IP protection, and its time and business span; IP and start up initiatives and their impact.

RESULTS AND DISCUSSION

Intellectual property management: IP could support the inflow of knowledge, innovation, technology transfer and boost up the trade of the nation. Such IP should be managed properly and prioritized with policy and academic involvement. India has well-defined IP systems and policies, which strengthen its R&D institutions and provide assurance to regional and international agreements, commitments and treaties.

In this study, three types of IP databases were used for analysing status and their legal aspects and impact of ongoing initiatives viz. ICAR's IP Portfolio (Patent, Design and Trademarks), UGC approved agriculture and veterinary university patents, and World's Top-100 veterinary universities patent, scholar, and publication database.

ICAR's IP portfolio: IP creations and its management is always a priority of ICAR. Its three tier IP management system is well known for its systematic approach in which every research institute is empowered to take decisions on IP related issues. Such systems are already recognized by different national and international educational institutions (Lekashvili and Bitsadze 2021). ICAR's 19 institutes are dedicatedly involved in animal science-based research activities, and generating IPRs. To equip this system with policy and budgetary support, one specific scheme was launched in 2007-08, which is continuing with its updated assignments viz. NAIF which comprises two specific components for IP Management and Agri-business initiatives. The results are as follows:

Patents: Animal Science based research institutes started patent filing activities for their innovations from 1960 onwards, where this important IP tool is providing 20-year exclusive right for its claims and business opportunities. Up to the year 2000, only five institutes filed 20 patent applications, which increased by seven times (137) in next 10 years (2001-10) which had happened due to implementation of ICAR's specific guidelines on IPRs and technology commercialization in 2006. These guidelines were in line with World Trade Organization's (WTOs') Trade-Related Aspects of Intellectual Property Rights (TRIPs) agreement where India became signatory in 1997. These guidelines and the enhanced support to the institutes through NAIF again raised the patent filing trend of these institutes with 62.7% growth in the period of 2011-20, which is continuing with 25% increase in the last four years (2021-24) also. This growing trend of patent filing in animal science sector is in line with a WIPOs 1990 to 2022 patent database where 26.1% growth recorded in this sector (Anwer *et al*. 2023). The year wise trend of these applications can be seen in Fig. 1. So far, Council has filed 485 patent applications in the field of animal science research.

Protected inventions are always vital for research and business (Chaudhary 2022) to explore new avenues and

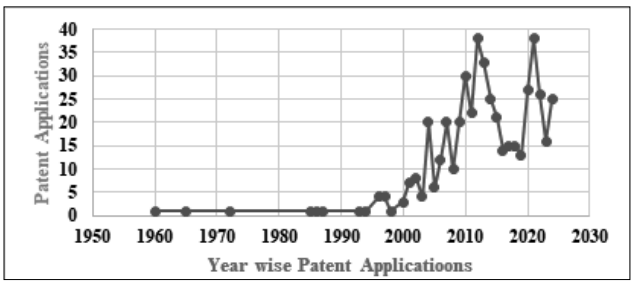

Fig. 1. Year-wise Patent Filing Trends at Animal Science Research Institutes of ICAR

add monetary value. In this line, National Dairy Research Institute (NDRI), Karnal is the leading institute with a share of 28.25% to total filed patent applications followed by Indian Veterinary Research Institute (IVRI), Izatnagar (21.24%), Central Institute for Research on Goats (CIRG), Makhdoom (7.63%), and others. These applications were filed in 21 different animal-based research areas viz. Milk Based Food Products (15.67%), Animal Health Diagnostic Methods (15.46%), Animal Nutrition (11.34%), Animal Medicine (9.69%), Animal Biotechnology (9.28), and others. The subject-wise details of these patent applications can be observed from Fig. 2.

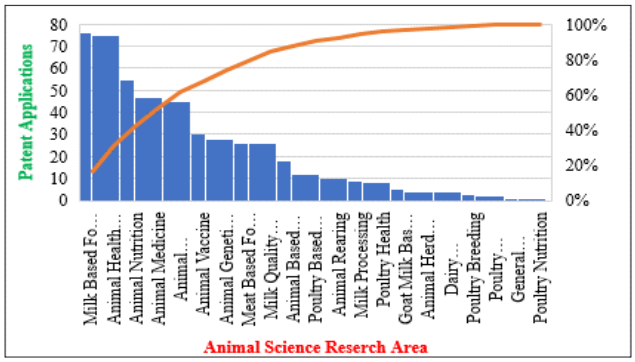

Fig. 2. Subject-wise Patent Filed by Animal Science Research Institutes

Broadly these research areas were grouped into five sub-heads viz. Animal Health (31.34%), Animal Based Food Processing (30.10%), Animal Production (29.48%), Poultry Production (5.36%), and Animal based By-products (3.71%).

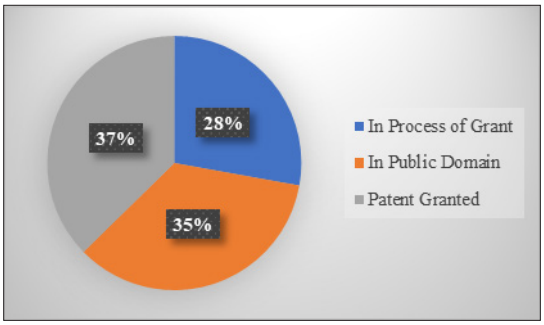

Fig. 3. Legal Status of ICAR's Patent Filed at IPO

As per the patent application grant process at IPO, the legal status of these applications in Fig. 3 shows that 37% applications are already granted to the Council, and 28% are in process of grant e.g. Application Awaiting Examination. Other than this 35% patent application are in public domain due to expiry/laps of the patent term i.e. 20 years, and abondoned or refused due to lack novelty and other criteria. These results show that 65% patent applications are in active status, which are in line with USPTO (55.8%) and EPO's (68%) ratio of filed and granted patent applications. (www.uspto.gov. and www.epo.org). The filed patents were classified as per the International Patent Classification and found that the spread of these innovations starts from Class A to H and their 24 sub-classes, which are in line with earlier study of NAIF (Singh *et al*. 2015).

These findings are in the wavelength of world intellectual property indicators where residents of China, the Republic of Korea, the United States of America, Japan and India being the main drivers of growth, where India recorded a remarkable growth rate of 15.7 percent, its fifth consecutive year of double-digit growth (WIPO 2024). It has also been observed that for the first time, applicants residing in India submitted more than half of all patent applications (55.2%) received by India's IP office.

The results of this study reflect better outcomes than presented by Basunathe *et al*. in 2017, where they had summarized that the patenting in veterinary sciences is meagre due to different provisions of patent act; and supports to the results revealed by Chandrasekharan *et al*. in 2020, that the majority of the animal scientists belonged to high perception group under technology generation, transfer/commercialization, and protection in their domains, respectively, while technology generation domain displayed highest mean score.

Design: The importance of this IP tool has been confirmed by 2020-21 to 2022-23 design filing growth at IPO i.e. 33.88%. The same trends are also confirmed by WIPOs with 8,566 international applications for design protection under The Hague System for the International Registration of Industrial Designs in the year 2024 which represents a healthy 7.4% increase on the previous year (www.wipo.int/ipstats). These results also indicated that Indonesia and India recorded the sharpest increases in designs (WIPO 2024).

The provision of the design act and its broad-spectrum scope with increased filing trends at IPO in 2023-24 (www.ipindia.gov.in), and WIPO motivates the animal scientists of the Council to start filing their innovations under these provisions. The first design applications in the animal science research area at Council was filed in 2011 with the name of Bulk Milk Feeder for Kids, which was continuing with 40 applications up to 2024. These applications were filed in the area of Animal Health (42.5%), Animal Nutrition (30.0%), Animal Production Process and Devices (17.5%), Animal Breeding (7.5%), and Animal Based Food Processing Machines (2.5%). As per the design act these applications are filed under 13 different classes viz, Apparatus Equipment for Doctors, Hospitals and Laboratories; Medical Instruments, Instruments and Tools for Laboratory Use; Feeders and Waterers; Miscellaneous and other etc.

Trademark: India secured its position in IP filing among top 10 countries for patents, trademarks, and industrial designs (Kumar *et al*. 2024). Among the IP industry clusters analysed by EPO and USPTO, the trademark-intensive industries contributed the most to national output and employment, followed by the design patents which revealed a share of United States of America (37%), and European Union (21%) (Toole *et al*. 2021, EUIPO 2022).

In 2023-24, IPO had received 4,76,089 trademark applications, the highest in the last five years, where 5,553 applications were received in Class-10 which is meant for Surgical, Medical, and Veterinary Instruments, and Apparatus.

ICAR has also developed an in-house knowledge base on this IP tool by organizing different awareness and training programmes which resulted in filing of 87 Trademark applications in animal science research in the last 15 years (2009-2024) where 14 animal research institutes were protecting their logos, devices and trademarks. Central Avian Research Institute, Izatnagar has filed highest number of trademarks (23), followed by Directorate of Poultry Research, Hyderabad (11), National Research Centre on Camel, Bikaner (10), Centre Sheep and Wool Research Institute (CSWRI), Avikanagar (9), and other. These trademarks were filed in 16 different classes of Trademark Act-1999 viz. 1, 3, 5, 7, 9, 10, 18, 29, 30, 31, 35, 40, 41, 42, 44, and 45. As per the IPO's legal status of these trademarks, 64.36% applications have already been granted to the ICAR and others are in process.

Veterinary universities' patent portfolio: In India, 54 (42 Agricultural and 12 Animal Science) universities are having animal science education and research activities.

To know about the IP filing trends and portfolio, Questel Orbit patent search engine was used. The patent data were accessed from this software in between Sept-Oct, 2024.

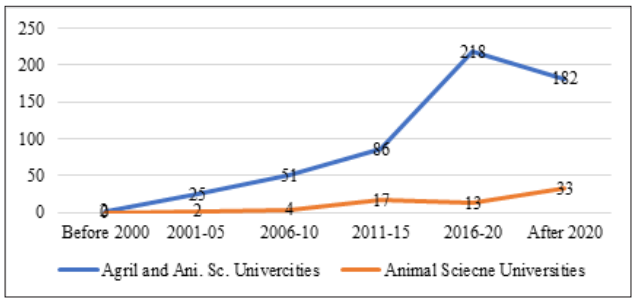

Fig. 4. Patent Filing Trends at State Animal Science Research and Education Universities

As per the Questel Orbit patent database, out of these 54 universities, 38 (including 11 animal science universities) were involved in patent activities by filing 564 applications up to Oct, 2024. Most of these applications (56.02%) are in process of grant at IPO and 36.34% has already been granted to these universities. Only 7.62% applications lapsed/expired due to completion of their 20 years' time span. These filing trends can be seen in Fig. 4. In this process of patent filing 12.23% patent applications were filed by purely dedicated animal science universities. Five Agricultural Universities also filed international patent applications through Patent Cooperation Treaty (PCT). The filing trend of these patent applications shows that the implementation IPR guidelines in the ICAR system (where all the universities are connected for their education and research as well budgetary support) in 2006, and introduction of India's' new IPR policy, 2016 supported, and motivated with different awareness and training programmes as well as rebate in patent filing fees (Ravi and Janodia 2022) gave such proven results, and open the windows for innovation protection.

Patent trends at top-100 veterinary universities: Southeast Asia has emerged as a prominent global frontrunner in patent filings in agriculture and its allied sector. In an analysis of WIPO's patent database from 1990 to 2022, National Institute of Agricultural Economics and Policy Research (NIAP), New Delhi has found that 21.8 lakh patent applications were filed by 37 countries in the field of agriculture and allied sectors. It has also been observed that Animal husbandry recorded the highest number of patents (5,68,000) which accounts for 26.1% of the total (Anwer *et al*. 2023). The growing trends of patent filing in animal science in India and all other agri-intensive economies becomes the driving force to know about the status of these trends in World's Top-100 Veterinary Universities, with scholar and publication base.

To identify such universities Research.com (which is an online platform founded in 2014 by Imed Bouchrika, a computer scientist and researcher that compiles academic rankings and educational resources) databases were used.

The 3rd edition of Research.com ranking of the best universities in the discipline of Animal Science and Veterinary was created using data consolidated from a wide range of data sources including OpenAlex and CrossRef. The bibliometric data for estimating the citation-based metrics were gathered on 21-11-2023. Position in the ranking is based on a sum of D-indexes (Discipline H-index) of all ranking scholar's affiliated with a given institution. D-index takes into account only publications and citation data for an examined discipline (https://research.com/university-rankings/animal-science-and-veterinary).

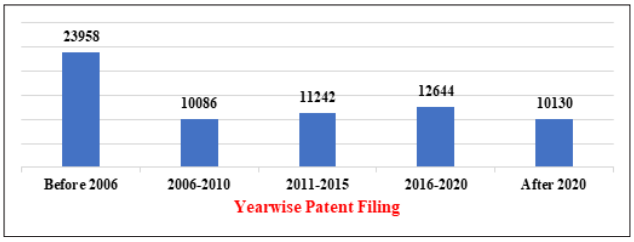

Fig. 5. Worlds' Top-100 Veterinary Universities Patent Filing Trends

This database has recorded 424 veterinary research and education-based universities details from 64 countries of the world. Top ten countries of America and the European Union are having 63.67% veterinary universities, amongst which USA is the leading country with 93 universities followed by the United Kingdom (30), Brazil (27), Italy (23), Canada (20) and others. India stands at 24th position with its four research organizations and universities.

On the basis of the criteria of Research.com, top 100 universities were sorted out and their patent portfolio was accessed by using Questel Orbit patent search engine in

Table 1. Patent Filing Trend of Top 100 Veterinary Science Universities across the world

Country	Universities	Year wise Patent Filing Trend (Nos.)						Legal Status		Active Applications (%)	Share of Country (%)
		Before 2006	2006-2010	2011-2015	2016-2020	After 2020	Total	Alive	Dead		
Australia	7	2220	505	500	525	336	4086	1084	3002	26.53	6.004
Austria	1	1					1		1	0.00	0.001
Belgium	3				1	3	4	3	1	75.00	0.006
Brazil	4	446	629	911	938	631	3555	2411	1144	67.82	5.223
Canada	7	1625	577	685	555	424	3866	1323	2543	34.22	5.680
China	1	84	119	202	413	628	1446	1155	291	79.88	2.125
Denmark	3	48	70	84	163	94	459	254	205	55.34	0.674
Finland	1	17	47	32	55	43	194	90	104	46.39	0.285
France	4	3			3		6	2	4	33.33	0.009
Germany	2	1		1	2	4	8	5	3	62.50	0.012
Ireland	1	60	130	86	126	66	468	218	250	46.58	0.688
Israel	2	370	184	98	11	7	670	142	528	21.19	0.984
Italy	9	3		1	2	2	8	6	2	75.00	0.012
Netherlands	2	27	42	42	60	31	202	95	107	47.03	0.297
New Zealand	1	62	6	9	13	8	98	33	65	33.67	0.144
Norway	1	2	10	7	12	12	43	24	19	55.81	0.063
South Africa	2	78	33	48	49	23	231	131	100	56.71	0.339
Spain	7	8	11	2	5	3	29	13	16	44.83	0.043
Sweden	1	1					1		1	0.00	0.001
Switzerland	2	64	41	51	69	57	282	145	137	51.42	0.414
United Kingdom	9	1760	845	657	740	696	4698	1420	3278	30.23	6.903
USA	30	17078	6837	7826	8902	7062	47705	22933	24762	48.07	70.093
Grand Total	100	23958	10086	11242	12644	10130	68060	31487	36563	46.26	100.000
% Share		35.20	14.82	16.52	18.58	14.88		46.26	53.72		

between Nov-Dec., 2024. The compiled patent database was classified in six time zones viz, before 2006, 2006-2010, 2011-2015, 2016-2020, and After 2020 for the analysis purpose. These universities are institutionalized in 22 countries of Africa, Asia, Europe, North America, Oceania, and South America.

The patent portfolio of these universities reveals that the USA is the leading country by filing 24,762 patent applications with its 30 universities followed by United Kingdom (3278/9), Australia (3002/7), Canada (2543/7), Brazil (1144/4) and others. All these universities recorded 68,060 patent applications at different Intellectual Property Offices (IPOs) of the world. The year wise patent filing trend of these universities indicates that 35.20% applications were filed before 2006, followed by 14.82% in 2006-2010, 16.52% in 2011-2015, 18.58% in 2016-2020, and 14.88% after 2020, respectively. Fig. 5 is showing the rising trends of these patent applications. This IP filing trend is an indication of early awareness and IP policies support to American and European universities. The growth pattern of these patent applications after 2006 is also in line with ICAR and Indian agriculture and veterinary universities patent portfolio growth. The legal status of these patent applications shows that 46.26% applications are in active position. The country and veterinary university wise patent filing trend of Top-100 universities can be seen in Table 1. The continent wise trend of these applications reveals that North America is leading with 75.77% patent applications followed by Europe (9.40%), Oceania (6.14%), South America (5.23%), Asia (3.10%), and Africa (0.33%). Most of these applications were filed in the field of pharmaceuticals and medical biotechnology.

As per the IPOs' database, the growing trends of patent filing in most of the sectors in India started after signing the TRIPS agreement and enactment of 2005's amendment in the Indian Patent Act-1970; and more specifically after implementation of the country's new IPR Policy in 2016. The IP intensive industries' role in USA and EUs' GDP and employment generation is an outcome of early awareness about IP in these countries, which can be observed from results of this study where 35.20% patent applications were filed before 2006.

Academic scholars are traditionally more interested in publishing their research outcomes in the peer reviewed journals as per their respective domains. Research.com has taken this into account and published the details of top-100 veterinary universities Scholar, publications and D-Index database. These results of these indicators are exactly (except fifth position of D-Index) in line with patent filing trends which can be observed from Table 2, where USA is leading with 47,706 patent applications, 378 Scholars, 62803 publications and 14957 D-Index, followed by Australia, United Kingdom, Canada, and Brazil. Only Brazil lost its position in D-Index where Italy took 5th position. These results reveal that educational and research activities are the baseline for intellectual assets generation, where policies and business orientation connect the dots of development.

Table 2. Country Wise Research Protection and Publications Activities of Top-100 Veterinary Science Universities

Name of the Country	Veterinary University (Nos)	Patent Application Filed (Nos)	Veterinary Scholars (Nos)	Publications in Vet. Sci. (Nos)	D-Index
Australia	7	4086	92	18415	3591
Austria	1	1	21	3620	747
Belgium	3	4	34	11079	1647
Brazil	4	3555	73	14961	2227
Canada	7	3866	80	13239	3308
China	1	1446	4	916	178
Denmark	3	459	49	6929	1700
Finland	1	194	10	1230	301
France	4	6	28	3572	965
Germany	2	8	15	2448	567
Ireland	1	468	16	2590	616
Israel	2	670	12	1695	439
Italy	9	8	72	11391	2464
Netherlands	2	202	48	9825	2074
New Zealand	1	98	16	3354	611
Norway	1	43	15	1750	510
South Africa	2	231	18	3338	616
Spain	7	29	62	8938	2265
Sweden	1	1	30	3476	1120
Switzerland	2	282	15	3786	717
United Kingdom	9	4698	83	12934	3358
USA	30	47706	378	62803	14957
Grand Total	100	68061	1171	202289	

Technology commercialization

To complete the triangle of innovation cycle, technology should reach the implementation stage where industry can manufacture or expand its scope, which is known as Technology Commercialization (TC)/transfer. Systematic technology transfer is the reliable source for diffusion of innovation (Es-Sadki 2023, Fang and Xie 2023), which is an outcome of combined effort of different stakeholders in academia and industry (Meijer *et al*. 2019, UNIDO 2023). To strengthen the TC's business competitiveness (Kim *et al*. 2022), IP and non-IP protected intellectual assets are the major driving force (Bhardwaj *et al.* 2021) to fulfil the demands of customers, and confirm the quality of the products. To stimulate the patent filing and commercialization initiatives, there is a need to support the R&D ecosystem prevailing in the universities, institutes and industries (Cudi 2020). Technology Transfer Office (TTOs) are playing a critical role in bridging the gap between lab to land, which ensures that the valuable innovations do not fall into the valley of death.

Most of the countries in America and Europe have established their rules to regulate the technology transfer (Correa and E-Beneke 2024) in effective manner, but in the Indian subcontinent it started very late, which leads to the barriers like technology with a significant gap between demand and supply of industry and academia (Singh and Kumar 2022, Santhalia and Singh 2024).

To fulfil these requirements of TC, ICAR has empowered its institutes with a single window system for IP protection and technology commercialization with the name of Institute Technology Management Units (ITMUs). These units are headed by senior level research scientists and supported by zonal and central level for their policy and budgetary support; and also connected with a national level public funded for profit company viz., AgrInnovate India Limited (AgIn).

To assess the outcome and impact of these initiatives, ICAR's 18 institutes are dedicatedly involved in animal science-based technology transfer activities, and generated different technology commercialization agreements. In subsequent discussion, word technology commercialization will be used as licensing agreements. The results are as follows:

Year wise trends: The first technology commercialization activity was started in 2007 by NDRI, Karnal for its Continuous Paneer Making Machine by licensing which was an IP protected technology with patent application no. 1125/DEL/2003. After institutionalizing the three tier IP management system in the ICAR, these activities increased their span with 91 licensing agreements signed between 2010 to 2014. After the revised scheme of IPR with the name of NAIF in 2014 this trend again continues with 93 licensing agreements in next five years (2014 to 2019), but the enactment of country's new IPR policy in 2016 and regular awareness and business incubation support under NAIF boost up these trends in next five years (2020 to 2024) by signing 286 agreements, which scores 60.47% of total licensing. These results are the real-time impact of IP initiatives in the country in animal science research. The year wise trend of these technology commercialization activities can be seen in Fig. 6.

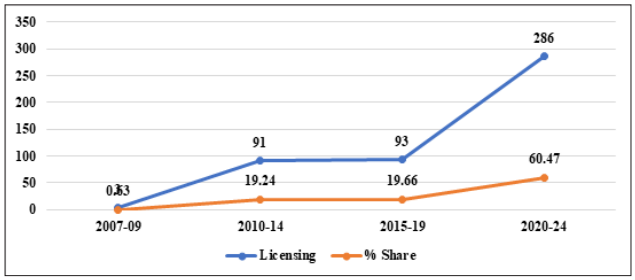

Fig. 6. Technology Commercialization Trends at Animal Science Research Institutes

Technology wise trends: The technologies transferred through these agreements were classified in five major heads and 16 sub-heads as per their industry scope. Milk Based Food Products are the leading sub head with its 47 technologies and 71 licensing agreements, followed by Animal Health (29/31), Milk Quality Testing Kits (25/61), Animal Nutrition (20/41), Poultry Based Food Products (20/25), and others. CARI, Izanagar is an institute which is working in the area of avian research, licensed its 51 innovations (21 Poultry based food product processes and recipes; 18 poultry breed and 3 varieties; and 9 poultry production technologies) by signing licensing agreements. These trends can be observed from Fig. 7. It is also an important outcome of the study that 35.29% technologies are having repeat licensing trends from 2 to 10 times.

Institute wise trends: ICAR institutes are playing critical role in generating innovations and their transfer in animal sector industries, where NDRI, Karnal licensed its 67 innovations through 126 licensing agreements, followed by CARI, Izatnagar (49/146), IVRI, Izatnagar (38/74), NRC on Pig, Guwahati (14/17), CIRG, Makhdoom (11/14), and others. In this process four ICAR institutes which are working in different fields of agricultural sciences also generated animal science research-based technologies.

State wise trends: These innovations were transferred to 279 public and private organizations and individual entrepreneurs, which are having their business span in 25 states and union territories of the country. These states were classified as per their administrative zones, where Southern Zone is leading with its 28.75% share in total licensing, followed by Central Zone (25.15%), Northern Zone (23.46%), Western Zone (13.95%), Eastern Zone (5.70%), and North-Eastern Zone (2.95%). The details of these trends can be observed from Table 3.

IP protected technology commercialization: IP protected innovations always lead to enhanced business as well as academic opportunities, which we have observed in IP intensive industry and their scope in USA and Europe. The continuous efforts of IP&TM Unit and ITMUs under NAIF, 43.96% licensed technologies were protected by filing of patents (34.62%), Trademark (6.41%), Design

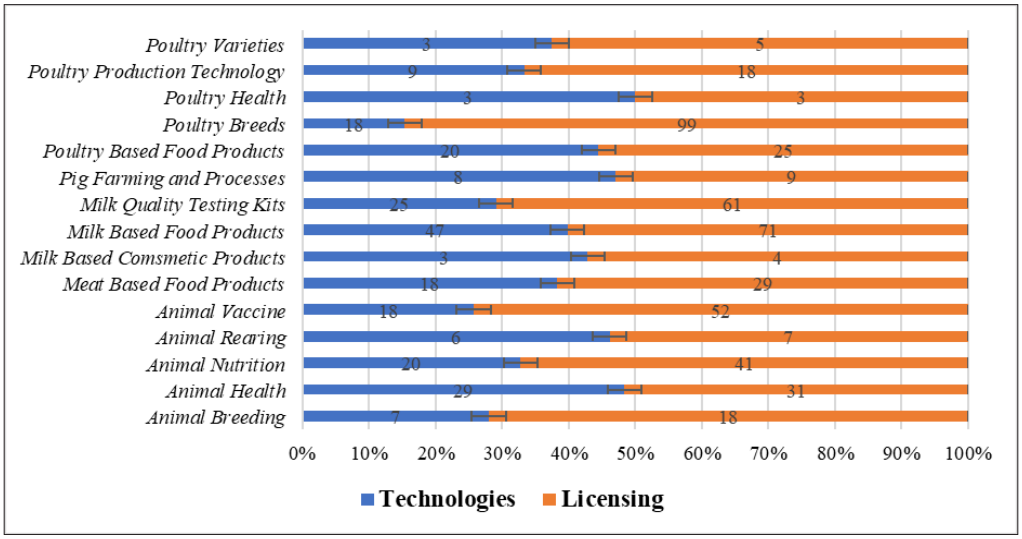

Fig. 7. Research Areas-wise Technologies and their Licensing Trends

(2.13%), and Copyrights (0.42%). IVRI, Izatnagar has licensed its 31 IPRs followed by NDRI, Karnal (19), CARI, Izatnagar (16), National Institute of Animal Nutrition and Physiology (NIANP), Bengaluru (10), CIRG, Makhdoom

Table 3. Zone and State Wise Technology Commercialization Activities at Animal Science Research Institutes

Administrative Zone of India	State	Animal Sc. Institute Involved	Technologies Licensed	Licensing Agreement Signed	Licensee Organization
Central	Chhattisgarh	1	5	5	2
	Madhya Pradesh	5	8	8	6
	Uttar Pradesh	6	61	106	59
Eastern	Andaman & Nicobar	1	1	1	1
	Bihar	2	6	6	4
	Jharkhand	1	1	1	1
	Odisha	2	4	6	5
	Uttarakhand	4	11	13	7
North-Eastern	Assam	1	4	6	5
	Meghalaya	2	4	4	3
	Nagaland	1	1	1	1
	Tripura	1	3	3	2
Northern	Chandigarh	1	7	7	3
	Haryana	6	27	36	21
	New Delhi	6	22	25	16
	Punjab	3	5	6	5
	Rajasthan	4	30	37	21
Southern	Andhra Pradesh	5	6	7	4
	Karnataka	9	38	45	24
	Kerala	5	9	10	9
	Lakshadweep	1	4	4	2
	Tamil Nadu	5	22	25	9
	Telangana	10	35	45	26
Western	Gujarat	7	24	34	15
	Maharashtra	9	29	32	25

(7) and others. The animal science research-based industry wise protection reveals that the Animal Health sector is leading with 24 IPRs followed by Animal Vaccine, and Milk Quality Testing Kits (14 each), Animal Nutrition (11), Milk Based Food Products and Poultry Breeds (9 each), and others. These IP protected technologies contributed 50.31% of total licensing agreements.

These motivating trends of IP protected technology licensing at ICAR animal science research institutes are the outcomes of policy support and continuous efforts in the direction of IP awareness. Though the technology commercialization of the patents or technologies from academia is very low (Bhardwaj *et al*. 2020). But, in academic patents, such interest and trends of commercialization were not shown in the EU countries as compared to USA and Asia (Miranda *et al.* 2024, Singh and Chakraborty 2019). But, an analysis of EPO's patent database for Small and Medium Enterprises (SMEs) shows that 67% inventions were commercially exploited (EPO 2020). As per the 2020 China Patent Investigation Report issued by China National Intellectual Property Administration (CNIPA) the commercialization rate of valid invention patents reached 34.7% throughout the entire 13th Five-Year Plan (2016-2020) (www.lungtin.com/).

Start-up initiatives in animal science sector

India has the third largest start-up ecosystem in the world with its 1.57 lakh recognized start-ups, and more than 100 unicorns. Country is witnessing this entrepreneurial culture by having its major start-up hubs in Bengaluru, Hyderabad, Mumbai, and Delhi-NCR, and also expanded this scope to the Tier II/III cities where 51% start-ups are executing their business. All this happened due to a visionary initiative named as Start-up India Mission which was launched in 2016. The government has played a pivotal role in nurturing this growth and empowering the next generation of entrepreneurs (PIB 2025b). This entrepreneurial culture and such new initiatives were started across the government and private institutions in the country with different names and mandates. As per start-up India platform database 1130 incubators are in function across the disciplines in 33 states and union territories out of that 14.42% are working in the area of agriculture and allied disciplines (www.startup india.gov.in).

ICAR has also introduced these entrepreneurial initiatives with the name Agri-Business Incubation (ABI) Centres which function at its 50 research institutes. Out of that seven centres are working in the field of dairy, veterinary, meat, poultry, piggery, sheep, and animal health. As per the start-up India database 6472 start-ups are working in the field of agriculture and its allied sectors, where Agri-Tech Start-up are leading with 2791 start-ups, followed by Food Processing (1104), Organic Agriculture (976), Dairy Farming (251), Horticulture (225), Animal Husbandry (159), Fisheries Science (105), and Others (858). These start-ups are having their business span in 34 states and union territories, where 53.61 start-ups are in Maharashtra (1268), Gujarat (622), Karnataka (570), Uttar Pradesh (532), and Tamil Nadu (478).

Innovation management and its transfer to the industry is an important pillar of economic growth. Asset based economies are now moving towards IPRs, where creativity, knowledge, and innovation boost their progress, and open the doors for globalized market opportunities. Innovation and Investment are the two sides of a coin, and incubation or business practice can help in joining these sides, which make the innovation complete and useful.

In view of above facts about the importance of innovation and its linkages with economic growth of a nation. The present study was organized to know about the IP filing trends and innovation transfer in animal science research. The results of this analytical study reveal that IP filing trends in the animal science sector are increasing across the globe. It is also observed that Southeast Asia has emerged as a prominent global frontrunner in patent filings in agriculture and its allied sector. Systematic technology transfer is the reliable source for diffusion of innovation, which is an outcome of combined effort of different stakeholders in academia and industry. In the last 15 years 35.29% of ICAR's animal science-based technologies had shown their repeat licensing trends from 2 to 10 times with 43.96% IP protected technologies.

In view of the above trends of IP filing and technology commercialization/licensing in ICAR and other animal-based research organizations around the world, we may conclude that innovation management and its transfer to the industry is an important aspect which is based on public policies, initiatives and budgetary support. To take these initiatives on the forefront of research and development in the animal science sector, innovation management, start-up ecosystem and Technology Transfer Offices (TTOs) need to be be supported by suitable policies, budgetary provisions and national and international exposures.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest, including any financial, personal or other relationships with other people or organizations that could inappropriately influence, or be perceived to influence the present work.

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