RESEARCH ARTICLE
JIVA 18 (1) April 2020

Received: 31-03-2020
Accepted: 20-04-2020

MANAGEMENT OF INTELLECTUAL PROPERTY IN ANIMAL NUTRITION RESEARCH: A CASE STUDY

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ABSTRACT

National Institute of Animal Nutrition and Physiology (NIANP) is an animal science research institute functioning under the aegis of Indian Council of Agricultural Research. Intellectual Property Management System (IPMS) of the institute performs functions of technology creation, protection and transfer/commercialization. The study carried out an in-depth participatory analysis of strengths, weaknesses, opportunities and threats (SWOT) pertaining to the system. A comprehensive SWOT repository was developed based on documentary evidences and inputs from multiple stakeholders. Repository was further rated by scientists to reveal the top ten key SWOT factors. Quantitative SWOT matrix technique was employed to ascertain the finest strategies to promote and develop the IPMS further. Strategies were derived from the best combinations of key strengths and opportunities (S-O strategies), key strengths and threats (S-T strategies), key weaknesses and opportunities (W-O strategies) and key weaknesses and threats (W-T strategies). Key strengths included ‘State of the art laboratory facilities’, ‘Efficient monitoring of research progress under research committees’ and ‘Subject matter competence and active participation of scientists in various scientific forums, while, ‘Limited number of innovative and commercially viable technologies’ and ‘Dearth of technical staff for research and commerce experts for technology marketing’ were the key weaknesses. Top ranked opportunities included ‘Scope for utilization of agro- industrial by-products and wastes as animal feed ingredients’, ‘External research funds’, ‘Research in consortia mode’ and ‘Scope of feed formulation software’. The main threats were ‘Red tape delay for final approval of entrepreneurial projects’, ‘Reducing feed resource base for livestock', 'Safety issues and vested interests in animal feed market' and 'Undue delay in patent grant'. Key strengths of the system such as state-of-the-art laboratory facilities and subject matter competence of scientists could be utilized effectively to make use of the opportunities tendered by agro- industrial by-products and wastes in animal feed manufacture (S-O strategies). Dearth of marketable technologies could be overcome through research-farmer-industry interface for technology up-scaling (W-O strategies). The threat posed by reducing feed resource base could be addressed through alternative technologies (S-T strategies). Limitations arising from the combination of dearth of innovative technologies and reducing feed resource base deserve special attention (W-T strategies).

Keywords: Indian Council of Agricultural Research, Intellectual Property Rights, National Institute of Animal Nutrition and Physiology, SWOT Analysis

INTRODUCTION

Intellectual Property Rights (IPR) constitute strategic tools for technology management in the global academic research landscape. The Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) stipulates establishment of minimum standards for protection of intellectual property in all technology areas (WTO, 2008) including that of livestock sector. The post TRIPS era calls for radical changes in grass root ethos of technology generation and dissemination in traditional science and technology institutions of developing countries like India. National IPR Policy (GOI, 2016), Science, Technology and Innovation Policy (GOI, 2013) as well as National Innovation and Start up Policy for students and faculty of Higher Education Institutions (GOI, 2019) envisages strengthening academia industry interface with collaborative research and technology marketing for streamlining research outputs into commercial and societal applications.

Indian Council of Agricultural Research (ICAR), the apex organization of National Agricultural Research System (NARS) has established a tailor-made policy framework and institutional mechanism for the protection and dissemination of its intellectual property resources (ICAR, 2018). The institutional machinery constitutes a three-tier structure with Institute Technology Management Units (ITMUs) at institute level as the grassroot layer, five Zonal Technology Management Centres (ZTMCs) in selected institutes at zonal level as middle layer and Agro-Technology Management Centre (ATMC) at central level as topmost layer. Besides, the Intellectual Property and Technology Management unit at ICAR headquarters overseas functioning of these bodies. ZTMCs of different zones facilitate the functioning of ITMUs in respective zones. South zone ZTMC situated in Central Institute of Fisheries Technology, coordinates activities of ITMUs of twenty-two ICAR research institutes including four Animal Sciences research institutes under its ambit. IPR portfolios of institutes are vested with ample powers and internal capabilities.

An in-depth case study of this emulative model is essential to devise similar strategic technology management modalities in other constituent units of NARS including state veterinary universities. Keeping this in view, present study was undertaken to peruse the strengths, weaknesses, opportunities, and threats (SWOT) analysis pertaining to the intellectual property management system (IPMS) of National Institute of Animal Nutrition and Physiology (NIANP), a south zone Animal Science Research Institute of ICAR.The institute is mandated to carry out research based on physiological and nutritional approaches for cost-effective animal feed resource management for enhanced productivity and profitability.

MATERIALS AND METHODS

Procedures developed by Weihrich (1982); Collado *et al.* (2010) and Lu (2010) were employed to explore SWOT pertaining to IPMS of NIANP. SWOT analysis was performed in four sequential steps as follows.

Defining 'Institutional Intellectual Property Management system': IPMS was conceptualized as the system that performed functions of creation, protection, and dissemination or commercialization of intellectual property pertaining to the institute.

Internal and external factors influencing the functioning of the system were broadly categorized. Internal factors were conceptualized as those features of the system that could be modified and controlled to manage institutional IP more efficiently. These included both strengths and weaknesses. 'Strengths' implied attributes which might be tapped for efficient management of property, whereas, 'Weaknesses' entailed aspects that would be abated for more efficient working of the system.

The external factors comprised of environmental, political and socio-economic aspects that were largely beyond the control of IPMS. From SWOT analysis perspective, 'Opportunities' meant the external factors that fostered performance of IPMS whereas 'Threats' referred to factors that impeded performance.

Identification and Categorization of SWOT Factors: Based on inputs received from review of relevant studies, documentary evidences and discussions with experts, a comprehensive repository of strengths and weaknesses (internal factors) and opportunities and threats (external factors) was developed for the IPMS. Factors concerning strengths and weaknesses were classified under four factor domains: technology, human resources, infrastructure and technology transfer/marketing strategies. For opportunities and threats, the factor domains were: socioeconomic, market, policy, and outside organizations. Repository was further refined to reflect recommendations elicited from focus group discussions and personal/telephonic interviews with scientists and other stakeholders, who were selected based on the suggestions of ITMU personnel. The stakeholders included industry personnel, scientists from sister organizations, professional associations, and representatives from policy-making bodies such as National Academy of Agricultural Research Management (NAARM). After revisions, the final SWOT repository included 45 strengths (S), 23 weaknesses (W), 39 opportunities (O), and 18 threats (T).

Validation of SWOT Items: The exhaustive checklist of SWOT factors was further condensed into more focused ones through validation. While inputs from multiple stakeholders were used for development of SWOT repository, validation of SWOT factors was done through a rating procedure, involving institute's scientists who had direct stake in IP creation, protection, and transfer. Respondents rated the SWOT factors on a four-point Likert scale, that is, strongly agree, agree, somewhat agree, and disagree with scores of 4, 3, 2 and 1 respectively. Sum total of scores assigned by the respondents for a specific SWOT factor constituted the factor's score. The mean score of each factor was calculated using the formula:

$$\text{Mean score of SWOT factor} = \frac{\text{Score of factor}}{\text{Number of respondents}}$$

For each factor category, top ten rankings in the score-based ranking hierarchy, were identified as the most important or key factors.

Identification and Prioritization of Strategies for Efficient Functioning and Development of IPMS: At this phase, a weighted/quantitative SWOT matrix technique was used to enrich the output of SWOT analysis.

The SWOT matrix was originally proposed by Weihrich (1982) for matching the external opportunities and threats pertaining to an organization with its internal strengths and weaknesses. On virtue of this, the interaction matrix could further contribute alternative strategies for problem solving or decision making in an organization. Figure 1, displays the strategies propounded by Weihrich. The strategies are based on functional reciprocity of internal and external factors. The four strategic options thus would be 'maxi-maxi' (utilize strengths to make use of opportunities), 'maxi-mini' (use strengths to reduce the impact of threats), 'mini-maxi' (overcome weaknesses by making use of opportunities) and 'mini-mini' (minimize weaknesses and reduce the impact of threats).

Present study, besides ascertaining the most influential driving and impeding factors, carried out a comprehensive analysis of the relationship between these factors to derive certain strategic decisions for refinement and further development of the IPMS. Accordingly, quantitative interaction matrices of key factors were developed, based on SWOT analysis (Fig. 2). The matrix entailed matching the five key internal factors with top scores under strength and weakness categories with corresponding external ones under opportunity and threat categories. The coefficient (r) proposed by Lu (2010) was used to denote the degree of matching or relationship between any two SWOT factors, wherein $r = 1$ showed a perfect match, $r = 0$ meant a non-existent relationship, and $0 < r < 1$ indicated relationship of different degrees ranging from non-relationship to a perfect match. Coefficients were assigned based on consensus among IPMS authorities. Subsequently, for the matched SWOT factor pairs, composite scores were calculated using the formula: Composite score =Product of the score values of internal and external factors matched x coefficient (r).

Based on composite scores, the degree of importance of consequent strategies was assessed. The scores were then fed into corresponding cells of the matrix. Further, matrix cells were coloured with shades as in "VIBGYOR" spectrum ranging from red to violet in the decreasing order of importance.

Fig. 1. Strategic options based on SWOT matrix- Weihrich (1982)

	Strengths	**Weaknesses**
Opportunities	SO Strategy (maxi-maxi)	WO Strategy (mini-maxi)
Threats	ST Strategy (maxi-mini)	WT Strategy (mini-mini)

RESULTS AND DISCUSSION

Results of the study are depicted in tables (1, 2) and Fig. 2. Table 1 reveals data on ten top rated strengths and weaknesses of the IPMS, based on respondent's rating, whereas, Table 2 shows the ten top ranked opportunities and threats.

Table 1. Perceived importance of internal factors affecting IPMS

<table>
<tr><th>Strengths</th><th>Score</th><th>Rank</th><th>Weaknesses</th><th>Score</th><th>Rank</th></tr>
<tr><td>State of the art laboratory facilities</td><td>4</td><td>I</td><td>Limited number of innovative technologies</td><td rowspan="2">3.25</td><td rowspan="2">I</td></tr>
<tr><td>Efficient monitoring of research progress under research committees</td><td rowspan="3">3.88</td><td rowspan="3">II</td><td>Shortage of technical staff in research</td></tr>
<tr><td>Scientists' subject matter competence</td><td>Scarcity of commercially viable technologies</td><td rowspan="2">2.88</td><td rowspan="2">II</td></tr>
<tr><td>Active participation of scientists in scientific forums</td><td>Dearth of qualified staff in commerce /business management for technology marketing</td></tr>
<tr><td>Support rendered by experimental animal and fodder production units in technology development</td><td>3.63</td><td>III</td><td>Lack of in-house faculty with legal expertise in IPR</td><td>2.63</td><td>III</td></tr>
<tr><td>Scientists' experiential learning through field visits</td><td rowspan="3">3.5</td><td rowspan="3">IV</td><td>Monitoring of marketing practices by licensees not observed</td><td rowspan="4">2.5</td><td rowspan="4">IV</td></tr>
<tr><td>Team work through inter disciplinary and multi institutional research</td><td>No Business Planning and Development (BPD) unit for commercialization of technologies</td></tr>
<tr><td>Frequent organization of conferences, workshops and short courses by institute</td><td>No effective mechanism for in-licensing of proprietary research tools</td></tr>
<tr><td>Periodic conduct of Farmers-Scientists Interface for technology transfer</td><td>3.38</td><td>V</td><td>Inadequate infrastructure for market watch mechanism to monitor commercial prospects of technologies</td></tr>
<tr><td>Publication of technologies in institute's website as a marketing strategy</td><td>3.0</td><td>VI</td><td>No specific protocols for marketing of technologies</td><td>2.38</td><td>V</td></tr>
</table>

Perceived Strengths: State-of-the-art research infrastructure for technology development, experimental animal and fodder production units were the most remarkable strength perceived. Besides, merit of technology generation strategies was evinced by the perceived efficiency of research monitoring committees. It could be observed that most of the key strengths of the system pertained to human resources. Scientists' perceived competence, active participation in faculty improvement programmes, teamwork and interdisciplinary and multi-institutional collaborations revealed the richness of institute's research culture. Organization of farmers-scientists interface sessions on a regular basis was an exceptional technology transfer strategy. Regular publication of available technologies in institute's website was observed to be a good marketing strategy.

Perceived Weaknesses: The major technology related constraints were lack of innovativeness and commercial viability. These might be attributable to institute's mandate that focused mainly on basic and fundamental research in the subject matter areas of animal nutrition and physiology. Nevertheless, the institute reportedly filed eleven patent applications, in anticipation of grant.

The limitations reported in technology commercialization realm comprised of the dearth of qualified staff in commerce/business management, lack of business incubation facilities or market watch mechanism, ill-defined marketing protocols and ineffective monitoring of licensees' marketing practices. Srivastava and Chandra (2012) conceptualized university technology transfer/ commercialization as a complex process that involved Research and Development (R&D) structure, entrepreneurial culture and incentives of the university, industry enablers, intermediary facilitators and political, academic and corporate leadership as some of the major inputs.

When compared to the strength of scientific staff, technical staff strength of the institute was quite inadequate. Dearth of in-house faculty with legal expertise in IPR was also a perturbing factor. Mysore (2014) studied technology transfer models in universities of Brazil, USA and Chile and found that effectiveness of technology transfer offices in many universities was affected by the dearth of IP expertise.

Perceived Opportunities: Development of technologies for cost effective feed production from agro-industrial by-products for 'creating wealth from waste' was viewed as a prospective strategy. In view of this, the institute developed value added probiotics from

Table 2. Perceived importance of external factors affecting IPMS

<table>
<tr><th>Opportunities</th><th>Score</th><th>Rank</th><th>Threats</th><th>Score</th><th>Rank</th></tr>
<tr><td>Scope for utilization of agro- industrial by- products and wastes in animal feed manufacture</td><td rowspan="2">4</td><td rowspan="2">I</td><td>Red tape delay for final approval of entrepreneurial projects</td><td>3.25</td><td>I</td></tr>
<tr><td>External funding for research projects</td><td>Reducing feed resource base for livestock</td><td>3.0</td><td>II</td></tr>
<tr><td>Research in consortia mode envisaged by ICAR research policy</td><td rowspan="2">3.88</td><td rowspan="2">II</td><td>Safety issues and vested interests in animal feed market</td><td rowspan="2">2.88</td><td rowspan="2">III</td></tr>
<tr><td>Scope for development and up-gradation of feed formulation software and tools</td><td>Procedure for grant of IPR by Intellectual Property Office is time consuming</td></tr>
<tr><td>Scope for establishing linkages with industry and farmers for technology development</td><td>3.75</td><td>III</td><td>High cost of securing and maintaining IPR</td><td>2.75</td><td>IV</td></tr>
<tr><td>ICAR guidelines in place to facilitate IP management in the institute</td><td rowspan="2">3.63</td><td rowspan="2">IV</td><td>Lack of personnel with legal and commercial expertise in veterinary field</td><td rowspan="4">2.63</td><td rowspan="4">V</td></tr>
<tr><td>National agricultural innovation project for setting up business planning and development units in ICAR institutes</td><td>No centralized mechanism for procurement of proprietary research tools through in- licensing</td></tr>
<tr><td>Demand for safe and quality animal feed technologies</td><td rowspan="3">3.5</td><td rowspan="3">V</td><td>Farmers' lack of knowledge of scientific feeding and management</td></tr>
<tr><td>Demand for low cost feed technologies</td><td>Risks involved in public private partnership</td></tr>
<tr><td>National and international human resource development programs in core advanced technology areas</td><td>Competition faced from private feeds industry</td><td>2.5</td><td>VI</td></tr>
</table>

agricultural by-products. Scientists reported that two patent applications had already been filed for process patents in this regard. They perceived that this would open up new vistas for collaborative research with eminent international research organizations. Novel feeding options based on agricultural waste and agro-industrial by-products, when adopted on a large scale through public private partnership, would reduce food-feed competition and broaden feed resource base, resulting in both economic and environmental efficiency and sustainability of livestock rearing operations (Makkar, 2018).

The facilitating role of external funding avenues in IP management was also perceived as a great opportunity. Scientists had relentlessly been pursuing several externally aided projects in strategic areas. Scope for development of feed formulation software and tools was also appreciated by scientists. In the Vision 2050 document, NIANP envisages development of real time databases on animal feed resources as well as touch screen based least cost feed formulation software for rural areas. Precision livestock farming integrated with digital technologies such as Internet of Things (IoT) displays the most influential trend in sustainable livestock production in the coming decade (Gheorghe, 2017).

Some other prospective strategic initiatives from the parent institute included consortia mode of research, well-crafted IP management framework and entrepreneurial development schemes such as National Agricultural Innovation Project and National Agricultural Innovation Fund Component II that would provide incubation fund for establishing agri-business incubation centers. Edwin *et al*. (2011) opined that ICAR policy guidelines would help R&D scientists to have a reasoned and professional approach towards protection, disclosure and transfer/ commercialization of all intellectual assets.

Scientists, seemingly, appreciated the Public Private Partnership (PPP) mode in technology development. Spielman *et al*. (2009) reaffirmed that some research centers used PPP as a vehicle for joint development of technological innovations and to interact constantly with private sector and leverage their expertise and assets in order to augment the value of innovation.

The R&D prospects pertaining to ever-increasing demand for safe and quality animal feed was widely appreciated. Animal nutrition and crop breeding research had in fact generated several innovative technologies that could enhance nutritional quality of feed and fodder and augment production (Birthal and Rao, 2002). Institute's increased focus on research in developing high value nutraceuticals from low cost agricultural waste could be attributable to the growing demand for low cost feed technologies.

Scientists reported tremendous opportunities for capacity building in advanced technology areas through national and international training programmes. Moreover, international collaborative research projects reportedly, had much

Figure 2. Weighted SWOT Matrix showing strategies (S-O, W-O, S-T, W-T) for further development of IPMS of NIANP

Lowest Score → Highest Score

		Strengths					Weaknesses				
		State of art lab facility	Efficient monitoring system for research progress	Experimental animal and fodder production units rendering support in technology development	Subject matter competence of scientists	Active participation of scientists in scientific forums	Limited number of innovative technologies	Commercially viable technologies are scarce	Lack of in-house faculty with legal expertise in IPR	Shortage of technical staff in research	Dearth of qualified staff in commerce business management for technology marketing
Opportunites	Research in consortia mode envisaged in ICAR research policy	15.5	7.5	7	15	7.5	3.8	4.4	1.0	2.6	2.2
	Linkages with industry and farmers for technology upscaling	12	11.6	6.8	11.6	8.7	3.4	6.5	3.9	4.8	5.4
	Scope for up-gradation of feed formulation software and tools	12.4	12	5.6	12.0	6.0	2.5	2.2	2.0	1.3	1.1
	Utilization of agro-industrial by-products and waste in feed manufacture	16	11.1	8.7	13.9	7.8	6.5	5.8	1.1	2.6	1.2
	External funding for research projects	12.8	6.2	11.6	15.5	12.4	6.5	4.6	1.1	2.6	1.2
Threats	Reducing feed resource base for livestock	6	5.0	6.5	6.9	4.7	7.8	5.2	3.2	2.9	1.7
	High cost of securing and maintaining IPR	2.2	3.2	3.9	3.2	1.1	3.6	1.6	1.4	0.9	0.8
	Red tape delay for final approval of entrepreneurial projects	1.3	0	2.4	0	0	5.3	1.9	1.7	1.1	0.9
	Safety issues and vested interest in animal feed market	3.5	2.2	2.1	0	0	2.8	1.7	0.8	0.9	0.8
	Procedure for grant of IPR for patent office is time consuming	2.3	3.4	2.1	0	0	1.9	0	3.8	3.7	0.8

bearing on building domestic capabilities in advanced technology areas (ICAR-NIANP, 2013).

Perceived Threats: Scientists found it hard to deal with the problem of red tape delays in approval of projects. In their opinion, this was mainly attributable to bureaucratic mediocrity and politics. Another critical challenge raised was the reducing feed resource base for livestock. Many policy reports had highlighted feed and fodder scarcity as the major limiting factor in enhancing livestock productivity. (Birthal and Rao, 2002; Makkar, 2012; ICAR- NIANP, 2013). Despite launch of feed and fodder development schemes, fodder banks and supply of fodder mini kits, the gap in demand and supply persists (Dhobi and Malla, 2015). This implies that much thought has to be given for devising and implementing improved strategies. According to Ramana *et al.* (2018), it is imperative to develop a comprehensive regional feed library for livestock production in south Asian countries like India which lack dynamic feed quality information at the regional level for existing varieties of feed and fodder and their by-products resulting in misuse of precious crop residues and supplements.

Yet another formidable challenge perceived was the safety issues as well as vested interests imminent in animal feed market. Murali and Dominic (2014) described the issues that crippled market quality of feed as those pertaining to supply chain integrity, warehousing and logistics problems affecting the keeping quality of feed. A study on livestock feed analysis labs in developing countries underscored the need to improve quality control systems in animal feed analysis laboratories, as poor practices would adversely affect the quality and safety standards of feed (Makkar, 2012). Dhobi and Malla (2015) claimed that Indian scientists pursued research in upgrading feed quality to render it safe for animal feeding. Despite existence of legal standardizations and regulations for feed quality like Bureau of Indian Standards (BIS), the compliance aspect is weak in general and adulteration is rampant. Moreover, standards have not been revised for long time and those for poultry are obsolete. As innovations have to be cleared by BIS, BIS is perceived as an impediment to innovations (Murali and Dominic, 2014; Dhobi and Malla, 2015). In addition to quality gaps, vested interests like unhealthy competition and price wars prevail in the feed industry (Murali and Dominic 2014).

The scientists also expressed their concern that the procedures for grant of IPR by patent office were time consuming and by that time, the technologies would get out-dated. Suman and Pandey (2014) pointed out that the ICAR patent applications filed after 2010 were still awaiting acceptance. Scientists also perceived that veterinary field was deprived of personnel with legal (IPR) and commercial expertise. Samuel *et al.* (2014) advocated that India being an agrarian country, in the context of agribusiness growing increasingly global, the IP awareness process could be accelerated only through education on the significance of IPR and technology management among different stakeholders like academia, researchers, policy makers, consumers, farmers and public. This necessitates a paradigm shift in policies of agriculture and veterinary education.

Absence of a centralized mechanism for procurement of proprietary research tools through in-licensing was perceived as another emerging challenge. Ramasamy (2013) stated networking arrangement of institutions as one of the options to share IPR, knowledge, HRD and financial resources. Creation of a public patent pool integrating the IP resources of NARS partners and other public sector organizations would be a good initiative that would assure freedom to operate in research and product development.

In the opinion of scientists, farmers' lack of knowledge of scientific feeding management was another crucial challenge. In the changing paradigm towards participatory research, farmers play a crucial role in field trials, technology validation and product development.

Despite initiatives in setting up R&D facilities through PPP mode, scientists were not devoid of fears about risks involved in PPP projects.

Strategies for future development of NIANP's IPMS:

S-O Strategies: These strategies (Fig. 2) describe how well system's strengths could be used to take advantage of the opportunities.

Many research reviews reported the potential of agro-industry by-product-based technologies in animal feed manufacture. Owen and Jayasuriya (1989) predicted the possibilities of a 'crop revolution' in developing countries through practical applications of relevant research findings. Several other reviews also reiterated the relevance of crop residue enrichment technologies for improving feeding of livestock in developing countries where acute fodder shortage periods prevail (Bhandari and Bahadur, 2019). FAO (1982) reported that a large number of R&D institutions seemed pursuing research on agro-industry by-products utilization. It would pay rich dividends if NIANP with its enabling research infrastructure and competent scientists could reorient its research priorities in this direction. Research in consortia mode envisaged in ICAR research policy was widely recognized. Creation of consortia research platforms in collaboration with other R&D organizations in vital areas would add to the quality of research output of NIANP in its priority research areas.

An examination of facts and figures clearly brings out that Indian NARS ranks fourth in the world in terms of total investments in public R&D (Bientema *et al*., 2008). The external aided projects including World Bank assisted ones have helped NARS to develop research infrastructure and human resources in a big way. Sustainability of external aided funding depends on the efficient use of resources and relevance of technologies for enhancing productivity (Ramasamy, 2013). Obviously, the competence of scientists has a strong bearing on realizing full potential of funding opportunities.

W-O Strategies: Perceived dearth of innovative technologies could probably be overcome by prudent strategies for research fund utilization. The potential of innovation funds to bridge infrastructure, resource and other input gaps could be leveraged to spur creation of innovative technologies by the talented pool. The research agenda has to make space for agro-industry by-products-based technologies for animal feed manufacture, as this area has inherent potential to drive innovation.

The scarcity of both commercially viable technologies and in-house expertise in technology marketing was perceived as a formidable challenge by the scientific community. This necessitates development of marketable technologies through research- industry- farmer interface. Ramasamy (2013) enunciated that as the public sector lacks market network when compared to private sector, it would be beneficial for the public sector to collaborate with private sector to promote institute's products. The effective role of PPPs in invigorating agricultural R&D has been asserted by many analysts. Synergistic effect arising from the combination of public sector R&D institutions and private sector industries assures returns on investment by utilizing the technical expertise of private sector and the knowledge of local needs and networks of public sector (Syngenta foundation, 2012). PPPs offer opportunities to overcome each sector's limitations: the public sector's limited capacity to market research outputs and the private business sector's inherent inability to function where there is no market (Castle and Ferroni, 2011).

S-T Strategies: The problem related to reducing feed resource base for livestock necessitates well planned combating strategies. Deployment of institute's research competence and infrastructure strength is essential in this regard. Technological and management alternatives are the only options to enhance productivity growth that is severely constrained owing to feed fodder deficit and diminishing per capita land. There are reports on the potential of many technologies generated by animal nutrition research to alleviate feed and fodder scarcity, reduce feed requirements and avoid feed wastage. (Birthal and Rao, 2002; Makkar, 2018).

W-T Strategies: Much thought has to be given on constraints arising from the combination of depleting livestock feed resource base and technology pitfalls. Nonetheless, due diligence could pay much dividends in this regard.

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