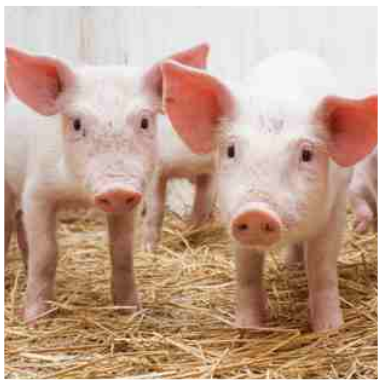
Govt. of Bihar

The Bihar Livestock Sector Analysis



Animal & Fisheries Resources Department, Government of Bihar

Technical support: ***International Livestock Research Institute (ILRI)***

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Abbreviations/Acronyms

AGSP	agriculture gross state product
AH	Department of Animal Husbandry
AI	artificial insemination
ASF	animal-source foods
ATMA	Agricultural Technology Management Agency
AU-IBAR	African Union Inter-African Bureau for Animal Resources (AU-IBAR)
BAU	business as usual
BCR	benefit-cost ratio
BMCU	bulk milk chilling units
BPL	below poverty line
BQ	black quarter
BYP	backyard poultry
COMFED	Bihar State Milk Co-Operative Federation Ltd.
CPR	common property resource
DOC	day-old chicks
DAFR	Department of Animal and Fisheries Resources
DCS	dairy co-operative societies
EANPV	equivalent annual net present value
e.g.	for example
etc.	additional items
FAO	Food and Agriculture Organization of the United Nations
FFS	farmer field schools
FMD	foot-and-mouth disease
GDP	gross domestic product
gm	gram
GMP	Good Management Practices
GoB	government of Bihar
GSDP	gross state domestic product
ha	hectare
HESM	herd and economic sector model
HH	household
HS	haemorrhagic septicaemia
ICAR	Indian Council of Agricultural Research
i.e.	that is
ILRI	International Livestock Research Institute

INR	Indian rupee
IRR	internal rate of return
kg	kilogram
L	litre
LMP	Livestock Master Plan
LSA	Livestock Sector Analysis
LSIPT	Livestock Sector Investment and Policy Toolkit
MAFW	Ministry of Agriculture and Farmers Welfare
MCC	milk collection capacity
MPCS	milk producer co-operative societies
MT	metric tonne or 1,000 Kg
MSP	minimum support price
N/A	not available
NGO	nongovernmental organization
NPV	net present value
NSS	National Sample Survey
OBC	other economically backward classes
POPt	projected population for a given time
PPP	public-private partnership
PPR	peste des petits ruminants
R&D	research and development
SC	Scheduled Castes
SHG	self-help group
SNF	solids not fat
ST	Scheduled Tribes
t	metric tonne
UHT	ultra-high temperature pasteurization
UK	United Kingdom
USD	United States dollar
WI	with investment intervention

Acknowledgements

The Bihar livestock sector analysis (LSA) and the master plan (LMP) were undertaken by a joint team of Bihar and ILRI livestock and planning experts. The analytical work was carried out under the guidance of Dr N Vijayalakshmi, the Secretary, Department of Animal and Fisheries Resources. This effort was generously funded and supported by the Bill & Melinda Gates Foundation, South Asia Agriculture Program.

A Technical Advisory Committee chaired by the Secretary periodically reviewed and made recommendations related to ensuring progress in achieving the outputs of the LMP project. It was comprised of the heads of key livestock departments and other relevant government agencies of Bihar, as well as representatives from civil society organizations and development agencies. Once completed, the commodity value chain roadmaps of the LMP were reviewed by eminent livestock scientists of ICAR, the Indian Council of Agricultural Research. They were found credible and defensible.

Many capable individuals and supportive institutions and agencies contributed to the genesis and realization of the Bihar LSA and LMP. Without the hard work and good-will of all of them the LSA and LMP would not have been completed.

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Dr. Jagriti Prasad Singh, DAFR
Dr. L.N. Mandal, DAFR

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Dr. Surendra Narayan Mishra, Team coordinator, DAFR
Dr. Asmita Kumari, DAFR
Dr. Shambhu Kumar, DAFR
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Dr. Getachew Gebru, Animal Scientist
Mr Kidus Negussie, Animal Scientist
Dr Sirak Bahta, Agricultural Economist, ILRI
Mr Vijay Baskha Reddy, Dairy Processing Engineer and Marketing Specialist
Dr Thanammal Ravichandran, Gender Expert, ILRI
Dr Nicoline de Haan, Core Theme leader– Gender, poverty and institutions, ILRI

The work of the LMP/LSA team was aided by many livestock experts who sacrificially contributed to the numerous expert consultations held to get technical advice and validate the livestock sector analysis results. The institutions they represented are listed on the page of Contributors.

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1. Secretary, DAFR, Govt. of Bihar, Chair person
2. BMGF Asia Agriculture Director, Co-Chair person
3. Under-Secretary, DAFR, Govt. of Bihar
4. Director, AHD, Govt. of Bihar
5. Director, Fisheries Department, Govt. of Bihar
6. Director, Dairy Department, Govt. of Bihar
7. Assistant Internal Financial Advisor, DAFR, Govt. of Bihar
8. General Manager, NABARD, Patna, Bihar
9. Managing Director, COMFED, Patna, Bihar
10. CEO, Aga Khan Foundation, India
11. Representative of farmers from the Kaushalya Foundation, Bihar
12. Director, ICAR-RCER, Patna
13. Senior Program Officer, BMGF – ex officio
14. ILRI Project Leader – ex officio

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Finally, on behalf of the DAFR and ILRI team, I sincerely thank all these dear friends and colleagues for their invaluable contributions to the success of this critically important work! The team hopes the resulting LMP will prove useful to Bihar DAFR in its efforts to support the implementation of the Agricultural Road Map and will result in improved livelihoods for the livestock farmers of Bihar.

1 Introduction

Bihar is the third most populous state in India and the most densely populated, while per capita income is the fifth lowest across the states of India. Thirty-six per cent of the population was below the poverty line in 2012 (World Bank, 2016). About 89% of the population live in rural areas, the highest per cent in India after Himachal Pradesh (ORGI, 2011). Moreover, around 60% of the rural workforce is engaged in agriculture (NSSO, 2011), but agriculture contributed only 18% to total gross state domestic product (GSDP) in Bihar in 2012. Meanwhile, Bihar's economy has been growing rapidly since 2005, driven by the services sector, and poverty has been declining. According to the World Bank, agriculture adds greatly to GSDP volatility (World Bank 2016).

For all of India, the livestock sector contributes around 4% of national gross domestic product (GDP) and around 25% of total agricultural GDP. In comparison, the livestock sector of Bihar contributes 5% to total state GDP or GSDP, but this is lower than other mainly agricultural states such as West Bengal the sector contributes about 11% (Data.gov.in, 2016). The percentage of households which possess ruminant livestock (cattle and buffalo) is lower in Bihar (according to the last national livestock census) in comparison to comparable states, such as Madhya Pradesh, Haryana, West Bengal and Punjab. The low share of livestock production in total GSDP and the high poverty rate in Bihar compared to other Indian states can be related to the low livestock ownership rate (MOSPI, 2017). Meanwhile, Bihar has a large goat population (ranked fifth in India) and most goats are held by marginal castes and women, so goats are particularly important in poverty-reduction strategies.

At the same time, Bihar is particularly recognized for its high milk production from cows, buffalo and goats (ninth highest state in India), making the livestock sector one of the principle sectors with potential to help achieve the development goals of the state. The growth and performance of the dairy subsector in Bihar has been better than in many other Indian states (DAHDF, 2017). The Bihar State Milk Co-Operative Federation Ltd. (COMFED), which is supported by the government, has played a very successful role in developing the dairy subsector, and in raising dairy cow productivity and milk production, as well as in raising dairy farmer incomes. Thus, increasing livestock productivity and production further is seen by the government of Bihar (GoB) and its Department of Animal and Fisheries Resources (DAFR) as a key means of improving per capita incomes and reducing poverty.

To help raise more investment resources to achieve even greater livestock and overall economic development in Bihar, the GoB through DAFR asked the International Livestock Research Institute (ILRI) to provide technical assistance to carry out a Livestock Sector Analysis (LSA) to develop a long-term sector strategy, as a first step in developing a livestock master plan (LMP) or five-year livestock sector investment plan for Bihar. This effort was generously funded by the Bill & Melinda Gates Foundation, South Asia Agriculture Program. This initiative is meant to help increase and target public and private investment to further modernize the livestock sector and enable it to make an even more substantial contribution to achieving state development goals.

Ongoing efforts to help develop the Bihar livestock sector

At the same time, Bihar is implementing its third agriculture roadmap (ARM) or agriculture sector investment plan. These ARMs are meant to help modernize and transform the whole agriculture sector of the state. The ARM includes the following agriculture sub-sectors: livestock, crops, fisheries, cooperatives, water resources, minor water resources, land reforms, etc. The past ARMs have been successful in helping the livestock sub-sector of Bihar achieve significant modernization, especially in the dairy value chain, and more recenty in the poultry industry.

Each sub-sector roadmap of the ARM outlines a broad vision for the sub-sector, key strategies and activities, five-year targets for the output quantities to be produced, and the financial or investment costs required to achieve the targets for the sub-sector. Besides output targets, the ARM does not include targets for achieving other state development objectives. Moreover, the choice of the ARM investment interventions is not based on analysis of the impacts of proposed alternative investment interventions on state development indicators to prioritize the investments.

DAFR has decided to increase its support for the implementation of the current Bihar ARM specifically for livestock (for 2017-18 to 2021-22[1]), through the elaboration of a Bihar livestock sector analysis (LSA) and livestock master plan (LMP), in order to provide a more detailed and complete set of 5-year livestock commodity value chain investment plans to help achieve the targets of the livestock roadmap of the ARM.

In section 8 of the Bihar LMP, the the livestock segment of the Bihar ARM and the LMP roadmaps are analyzed to highlight the complementarities of each and the added value of the LMP, as well as overlaps between ARM and LMP strategies and activities, to help DAFR rationalize the ARM and LMP where necessary to improve implementation of the ARM livestock sub-sector plan.

The added value of the livestock sector analysis (LSA)

The main objective of the Bihar LSA is to provide quantitative and evidence-based justification for public and private investments in recommended and prioritized commodity value chains (VCs) of the Bihar livestock sector chosen based on analysis of the returns on investment (ROIs) from investments in new and/or additional combined technology and policy interventions. The LSA is thus meant to inform the development planning of DAFR, together with other Bihar government agencies working on livestock sector development in the state. It is also meant to provide direction for the investment planning of development partners or donors, nongovernmental organizations (NGOs), civil society organizations, private sector actors and development banks.

Investment in each commodity value chain in the 15-year LSA is analyzed based on the projected impacts of livestock improvement strategies and interventions chosen based on past research and recommended by senior livestock sector experts of Bihar. The LSA then complements the ARM by including ROI analysis, and also the projected investment impacts on both 5-year commodity production quantity and income targets, as well as an analysis of the challenges and opportunities facing each commodity value chain, and most importantly the impacts of the investments on indicators for achieving state development objectives.

1 The ARM and LSA/LMP do not match in years since the LSA/LMP were carried out in 2018. The15-year time period of the LSA is from 2017-18 to 2032-33 and the LMP from 2017-18 to 2022-23. The financial or budget year of the government of Bihar runs from April of one year to March of the next year. The base year for the LSA was designated as 2017-18 or April 2017 to March 2018, and subsequent one-year periods in this report are listed in the same way, from April of one year to March of the next year.

In carrying out the LSA, in order to choose the investment and policy interventions to be recommended in the 5-year LMP or sector investment plan for Bihar, the alternative investments in new technologies or innovations combined with changes in policy are tested to compare their impacts or contributions to the following specific development objectives (through measurable indicators) chosen by the Bihar sector experts and confirmed by DAFR:

- Poverty reduction (improvement in household incomes)
- Economic growth (contribution of livestock sector to Agricultural State Domestic Product (ASDP) and State Gross Domestic Product (GSDP)
- Improvements in food and nutritional security of rural people (more animal source foods (ASFs), including more protein and carbohydrate)
- Potential for surplus trade with the rest of India and surrounding countries (value of potential marketing to other states and exports to surrounding countries)
- Contribution to industrialization and employment (pre and post-production investment and employment increases)
- Contribution to social equity (household and post-production income, employment and investment increases for women, youth and scheduled minority groups)

The livestock sector analysis or LSA methodology

The livestock sector analysis or LSA presented in this document has been done for the 15-years period from 2017–18 to 2032–33 and leads to a long-term strategy which then informs the development of the 5-years investment plan of the LMP, which is described in the Bihar LMP report. The analysis done to develop the LSA entailed first creating a livestock herd and economic sector model (HESM) using quantitative tools from the Livestock Sector Investment and Policy Toolkit (LSIPT). This toolkit was developed by a group of international agencies[2] under the aegis of the African Union Inter-African Bureau for Animal Resources (AU-IBAR). The methodology for the LMP was developed by ILRI by modifying the LSIPT and other tools to perform a five-years analysis for investment planning.

Once the model or HESM was developed it was used to evaluate current productivity and production, and carry out investment returns analysis based on the present technical and economic performance of the sector, given current investments in technologies and policies. Then, it was used to analyze changes in of the future potential of the sector to produce positive economic impacts on households, venture capital, the livestock subsector, the agricultural sector and the national economy given the economic contribution of potential interventions that entail new and additional investments over the 15-years period.

Meanwhile, qualitative survey and analytical tools were used to filter and interpret the outputs of the analytical results of the HESM analysis of proposed technology-policy interventions for their potential impacts on gender and disadvantaged groups in Bihar. Based on these results the investments and policies with the most positive potential impacts on gender and disadvantaged groups have been identified in the LSA and LMP recommendations.

2LSIPT was developed by a team of livestock experts from the World Bank, the Agricultural Research Centre for International Development of France and the Food and Agriculture Organization of the United Nations (FAO), working under the auspices of AU-IBAR.

The LSA and LMP development process

To accomplish its mission, the ILRI LMP team engaged with senior technical staff of the Bihar DAFR and formed a joint Bihar and ILRI LMP team. This joint team then engaged with other Bihar livestock experts to understand the existing development priorities of the Bihar government, to agree upon the relevant framework of key species, production systems and a typology of agro-ecological zones to be analysed, as well as the commodity value chains to be included in the LMP diagnostic process, to agree upon the relevant investment options to be tested and compared, to collect relevant and reliable livestock data and parameters to build the HESM, and finally to carry out the sector analysis to understand the current situation and future potential of the sector.

The full explanation of the Livestock Sector Investment and Policy Toolkit or LSIPT methodology and the process for developing the herd and economic sector model or HESM which was followed to carry out the Bihar sector analysis or LSA is given in Annex 1.

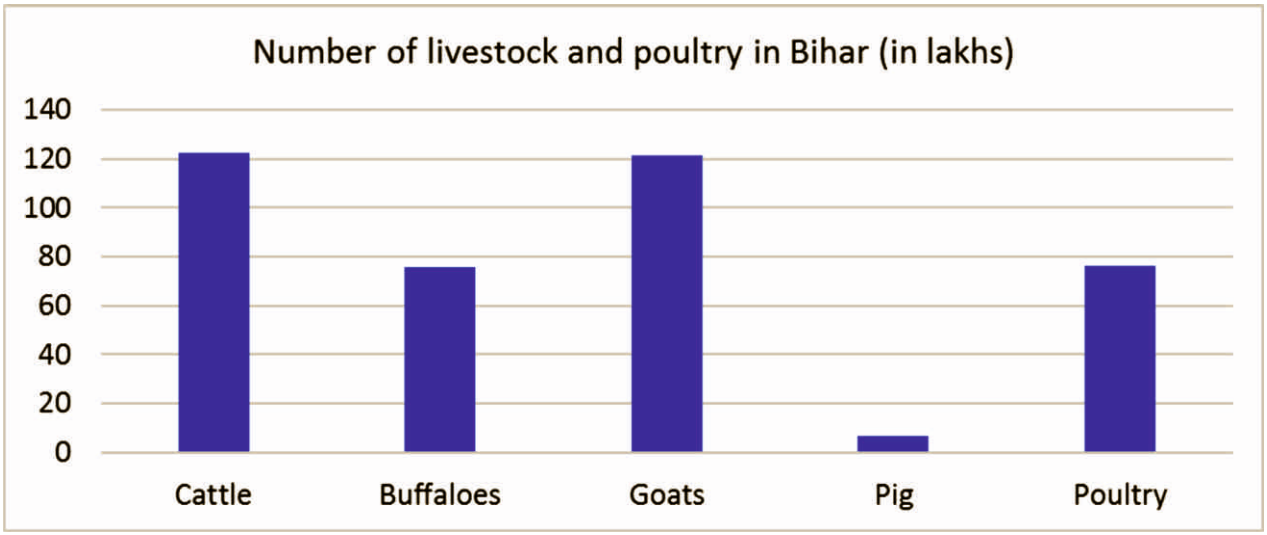
2 Livestock in Bihar—overview

The development of the agricultural sector has great significance for the overall growth of Bihar's economy. Bihar is divided into two distinct agricultural regions, north and south of the Ganges river. The economy of both regions is based mainly on crop agriculture. Bihar has good soil, as well as abundant water resources, particularly ground water. The portion north of the Ganges river has rich alluvial soils which are very fertile. The proportion of total land used for agriculture is high compared to other states of India. This is because of Bihar's topography, as it falls in the riverine plains of the Ganga basin.

Bihar is thus predominantly an agricultural state and there is also a large scope for improving animal husbandry. Apart from agriculture, animal husbandry is one of the key sectors which plays an important role in employment and income opportunities for the rural population of Bihar. This sector contributes about one-fifth total rural income and provides large scale employment to women and workers belonging to the marginalized sections of society. Livestock contributes 38% to the gross value of agricultural output in Bihar. Furthermore, since many households are either landless or land poor in rural Bihar, this sector supplements the income they generate from their other agricultural enterprises and farm labor.

The livestock herd of Bihar is very large and the species makeup diverse. According to the livestock census of 2012, the total livestock population was 329.39 lakhs. Figure 1 below presents the comparative numbers of selected species predominant in the livestock sector of Bihar in 2012.

Figure 1: Livestock numbers for selected species in 2012 (in lakhs)



The livestock herd of Bihar has also been growing fairly rapidly. In Table 1 below, the livestock population for selected species is projected for the 5 years from 2012 to 2017, based on Bihar census data. The projection shows that the goat and buffalo populations have grown most rapidly, at 17.9% amd 16% over 5 years, respectively. Cattle (both dairy cows (exotics and exotic crosses and indigenous cattle)) also grew at an impressive rate of 8.5% over this 5 year period, while pigs grew little at 3%.[3] No projections were available for chickens.

Table 1: Livestock population (lakhs) in 2012, with 2017 projections and 5-year growth rates

Livestock species	2012	2017[4]	Percent increase (2012-2017)
Cattle	122.3	132.7	8.5%
Buffalos	75.7	87.8	16.0%
Goats	121.5	145.5	17.9%
Pigs	6.5	6.7	3.0%

(Department of Animal Husbandry, Gov't of Bihar, 2017)

Factors constraining livestock productivity and production

As was stated earlier in the introduction, an increase in livestock productivity and production is viewed by the GoB and DAFR as a way to improve per capita incomes and reduce poverty in the rural areas of Bihar. This belief is based in part on the past performance of the milk subsector (with the milk coming mainly from cows and buffalos). This performance has been better in comparison to the livestock subsectors in many other Indian states (DAHDF 2017). As well, goats and chickens have significant importance of to women, and pigs to marginalized groups. Yet, milk productivity from cows, buffalos and goats is still low in Bihar compared to the all-India average or that of many similar states (DAHDF 2017), and pig production and its value chain is in its infancy. In addition, more attention has also been proposed to raise chicken and egg production in Bihar (DAHDF 2017). Smallscale farm household poultry productivity and production also needs serious attention, and even the poultry industry, baed on broilers and layers, needs to be expanded greatly to meet rapidly growing demand.

There is significant evidence[5] that livestock production in Bihar is constrained by the main factors determining livestock productivity and production, the breeding, health, nutrition and management of animals (Singh 2013). Bihar faces major challenges from animal diseases due in part to limitations in health services, as well as insufficient animal feed for all species (Rahman 2017). Problems related to animal health account for over one-third of the losses, followed by breeding and reproduction (31%) and feed and nutrition (28%). The constraints and challenges tare related to achieving better genetic potential for higher yields are due to lack of progeny-tested bulls, and infertility, while those related to better feeding include mineral deficiency and lack of availability of green fodder. Moreover, a further challenge is how to convert the prevalent food grain-based agriculture n Bihar into a food-fodder based crop-livestock sector (Rahman 2017). The constraints related to achieving better health include first and foremest require addressing foot-and-mouth disease (FMD). Notably, the challenges identified at the Bihar LMP stakeholders' consultation workshops held during the LMP project in Patna are in line with those outlined above.

3 The annual rates of population growth will be presented, analyzed and discussed in Section 3

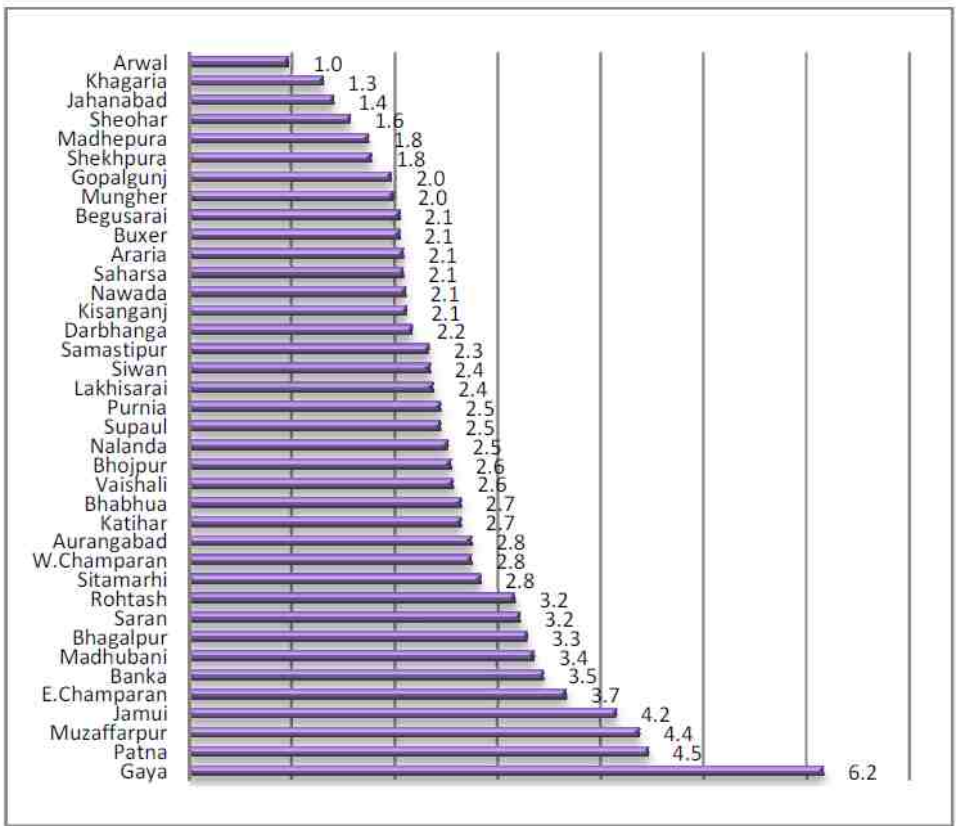
4 Projection from the 18th and 19th Livestock Census data

5 Singh, R. K. 2013. Livestock Research and Development Priorities for Bihar and Odisha. Available at the Social Science Research Network (SSRN): https://ssrn.com/abstract=2391607 or http://dx.doi.org/10.2139/ssrn.2391607

Meanwhile, a study led by RK Singh (Singh, 2013) was done to recommend R&D investment priorities, taking into consideration the developmental goals of increasing production efficiency, improving per capita income equity and enhancing the sustainability of the production systems in Bihar. It considered 'value of production of a species' as a proxy for efficiency, 'number of poor' as an indicator of equity and 'land available for livestock production' as a proxy for sustainability. Assigning equal weights for these 3 developmental goals/objectives and their associated intensity parameters, district and species priorities were developed.

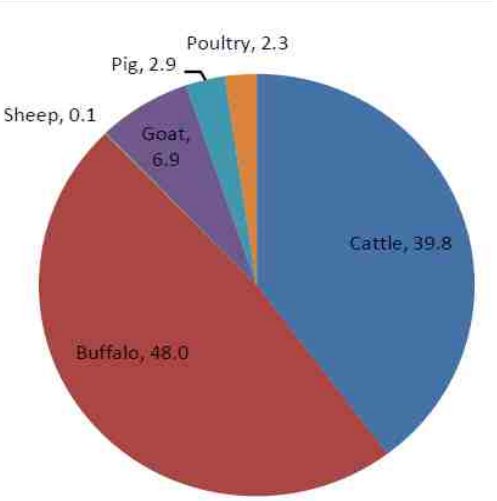
The analysis to prioritize resource allocation showed that livestock R&D resources could be streamlined and prioritized by district and species (Singh, 2013). As resented in Figure 2 below, the geographic prioritization led to a recommendation that some of the more densely populated and developed disctricts should be prioritized: Gaya followed by Patna, Muzaffarpur, Jamui, East Champaran, Banka, Madhubani, Bhagalpur and Saran should receive higher resources than other districts in the state.

Figure 2: Per cent share of resources for livestock research and development (R&D) in the districts of Bihar



In terms of allocation of R&D resources across species (see Figure 3 below), the study proposes that R&D for buffalos receives the most resources (48%), followed by cattle (40%), while other species, i.e. goats, pigs and poultry receive lower allocations. Sheep are the lowest priority in terms of the proposed resource allocation (0.1%). This proposed allocation of R&D resources is meant to help guide relative geographic and species priorities to enhance livestock productivity and production in the state of Bihar, yet it has not been related to the potential returns from investment in new technologies and complementary policies which would be the outcomes of potential investments in livestock R&D.

Figure 3: Proposed allocation (%) of resources across livestock species in Bihar

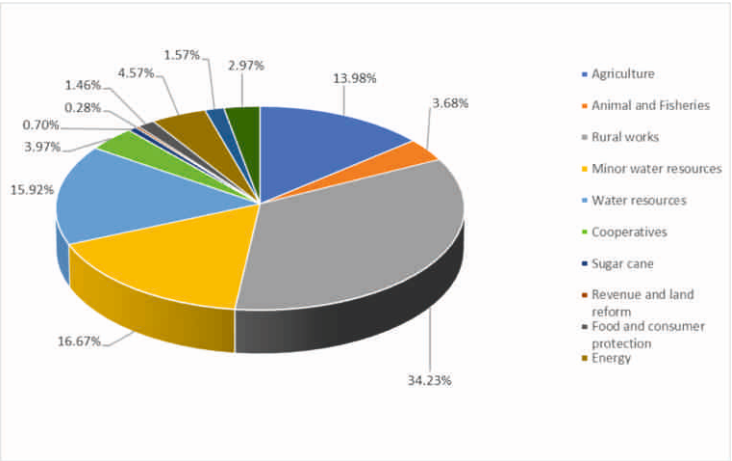


Recent budgetary investments to improve livestock production in Bihar

From 2012-17, the state of Bihar had been following its second agricultural road map or ARM. This road map to 2017 included a vision for the agriculture sector as a whole, as well as strategy, production targets and investment program. Another ARM was then developed for the period 2017–22 which identified the challenges of achieving the targets of the 2012–17 road map and outlined new measures to increase investment impact in the agriculture sector. In both instances, a detailed road map for the livestock sub-sector was lacking. These road maps did not capture the details of the varied livestock production systems of the state or measure their potential for future development and modernization. This may have led to a limited budget allocation to the livestock sector during the 2017-22 ARM (Figure 4).

Figure 4: Current allocation of budget in Bihar state (compiled from the Bihar Agricultural Road Map 2017–22).

The ARM is relatively general and the allocated budget is not based on quantitative analysis of returns to



alternative investments. The budget requested for the livestock sector is only 3.7% of the total agricultural budget. The contribution of livestock to the agriculture state gross product (ASGP) is about 20%. Proposed targets for livestock production need to be based on detailed quantitative analysis of the potential of the livestock sector o contribute to economic development in the state of Bihar, to increase ivestment in the sector. This is the main purpose of the livestock sector analysis (LSA) and livestock master plan (LMP).

3 Livestock systems and production zones in Bihar state

This section summarizes the distinguishing characteristics of the livestock systems in each of the three production zones in Bihar which include livestock population and the geographic distribution for major species, livestock product and output contribution of each species, and their major characteristics of productive and reproductive performance. It also elucidates the major gender and social inclusion considerations in these livestock production systems since this is critical to further modernizing these systems in Bihar.

The development of the LSA was supported by the continual involvement of state livestock experts and consultation with a wide range of key sector stakeholders. The systems and zones presented here were identified and their classification discussed and agreed upon in a series of meetings and workshops with the livestock experts of Bihar and other key sector stakeholders involved in trying to further modernize the livestock sector of Bihar. These consultations included: Gov't of Bihar technical staff and policy makers, including those from the new livestock university and government instituites, as well as veterinary clinic staff, NGO staff and livestock project staff from donor-supported development projects, private sector investors and technical staff, etc.

3.1 Livestock systems classification in Bihar

Livestock production systems can be classified using many criteria. In this study, the Bihar livestock production systems are classified based on the Seré and Steinfeld (1996) approach, which uses a combination of criteria and the concept of the farming system. It classifies livestock systems into four types: 1) landless livestock production systems (LL, which may be monogastric or ruminant), 2) grassland or grazingbased systems (LG, in which crop-based agriculture is minimal), 3) mixed-rainfed systems (MR, mostly rainfed cropping combined with livestock keeping), and 4) mixed irrigated systems (MI, in which a significant proportion of cropping uses irrigation and is interspersed with livestock). According to the Dixon et al (2001), a farming system is defined as a group of farms with a similar structure, such that individual farms are likely to share similar production functions. Studying and classifying similar livestock production systems into production zones based on agroecological criteria and farming systems characteristics provides the opportunity to group production systems with similar challenges and opportunities and can thus simplify the planning of development options/interventions.

The Bihar livestock production system has been classified into three livestock production zones, namely, Northern, Central and Southern (Table 2 and Figure 5). In addition to the three production zones, there is a commercial/specialized livestock production system which extends across the production zones. The commercial/specialized production systems include urban and peri-urban dairy, piggeries, and chicken layer and broiler systems.

Table 2 : Indicators for classification of traditional ruminant production systems in Bihar by production zone

Criteria	Northern	Central	Southern
Livestock species	• Buffalos, cattle, goats and poultry	• Cattle, buffalos, goats, poultry and sheep	• Cattle, buffalos, goats, sheep and poultry
Livestock feeding pattern	• Semi-intensive (grazing and stall feeding)	• Semi-intensive (grazing and stall feeding) • Extensive (sheep and goat)	• Semi-intensive (grazing and stall feeding) • Extensive (sheep and goat)
Challenges	• Flood prone	• Densely populated	• Drought prone
Opportunities	• Suitable for indigenous and 50% Jersey • Significant population of goats • Sutiable for chicken and piggery	• More suitable for higher grade Holstein-Friesian and Jersey crossbreeds • Sutiable for chicken and piggery	• Suitable for indigenous and 50% Jersey • Sutiable for chicken and piggery

Figure 5: Bihar livestock production zones.

3.2 Livestock systems in Bihar

The three livestock production zones and the commercial production systems are each subdivided into different species and flock/herd size groups (Figure 6). The species are cattle, buffalos, sheep and goats while the flock/herd size categories are small and medium. For backyard chicken and pigs, a uniform production system is assumed to exist throughout the country.

Table 3: List of districts by production zone

Northern	Central	Southern
W. Champaran	Siwan	Aurangabad
E. Champaran	Kaimur	Arwal
Gopalganj	Saran	Gaya
Sitamarhi	Rohtas	Nawada
Sheohar	Muzaffarpur	Sheikhpura
Madhubani	Bhojpur	Lakhisarai
Supaul	Vaishali	Jamui
Saharsa	Jehanabad	Banka
Madhepura	Samastipur	
Araria	Nalanda	
Kishanganj	Begusarai	
Purnia	Munger	
Katihar	Bhagalpur	
Darbhanga	Buxar	
Khagaria	Patna	

4 Crossbreeding of cattle was analyzed following the Bihar Breeding Policy recommendation.

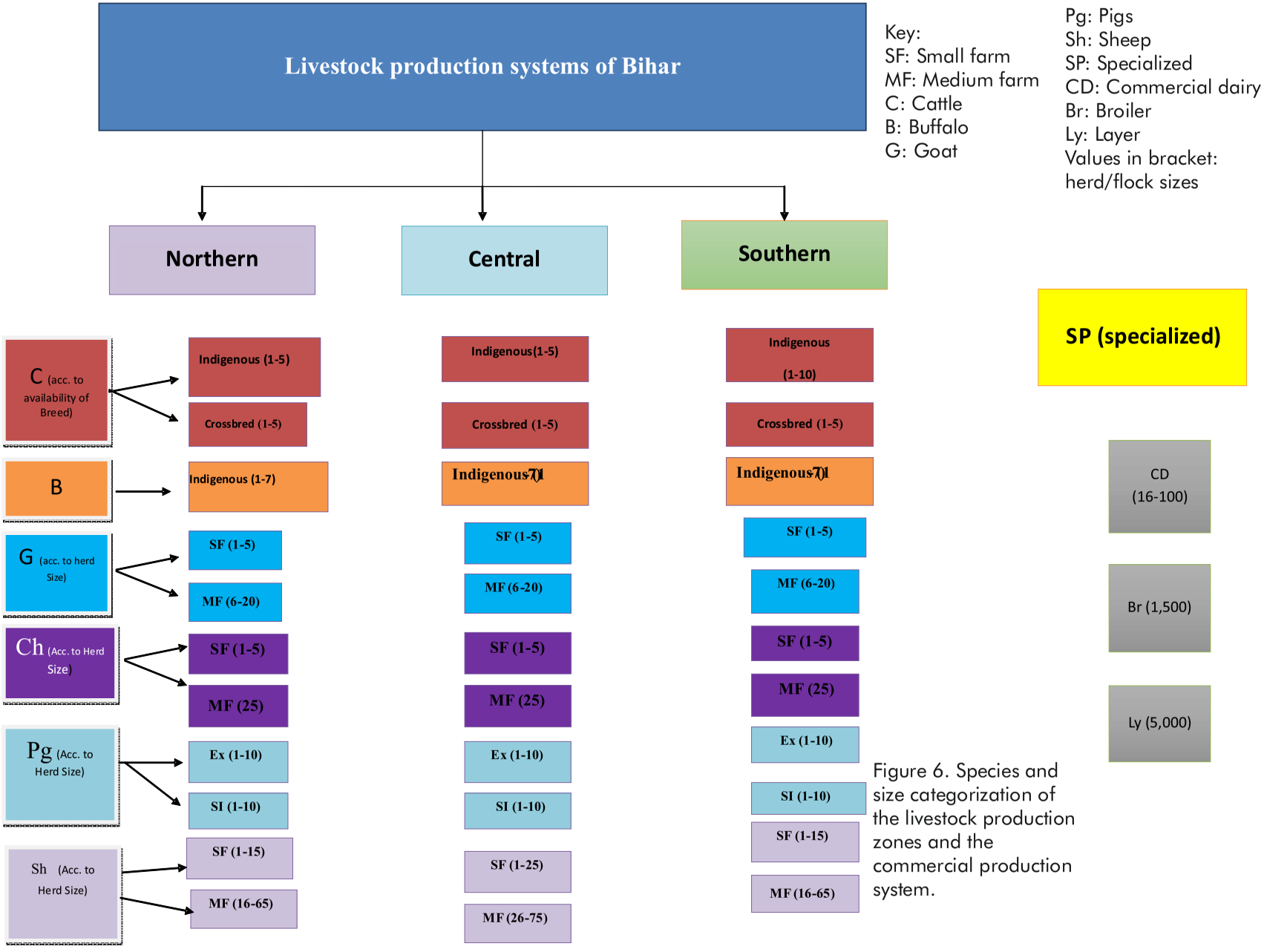


Figure 6. Species and size categorization of the livestock production zones and the commercial production system.

3.3 Livestock output distribution over the main production zones

Table 4: Red meat production in metric tonnes (MT) by production zone (2017–18)

Livestock production zones	Buffalos	Sheep	Goats	Total meat production	% red meat
Northern	32,850	92	16,199	49,141	46%
Central	33,770	321	9,633	43,724	41%
Southern	9,682	186	4,086	13,954	13%
Total red meat	76,302	599	29,918	106,819	

(LSA results)

The Northern and Central production zone contributes 87% of the total ruminant meat; sheep make very little contribution in all zones. Buffalos contribute 71% of the total meat red coming from the three relevant red meat producing species in Bihar (buffalos, sheep and goats).

Table 5: Annual milk production (in lakh MT) by production zone (2017–18)

Livestock production zones	Cattle	Buffalo	Goat	Total	% of milk production
Northern	12.8	14.8	1.0	28.5	32%
Central	35.9	15.6	0.6	52.0	58%
Southern	5.0	3.7	0.2	9.0	10%
Commercial dairy	0.1	0.0	0.0	0.1	0%
Total milk	53.7	34.1	1.9	89.6	100%

(LSA results)

Annual milk production at present amounts to 89.6 lakh MT. While one-third of this is produced in the Northern production zone, the Central zone contributes 58% of the milk produced. The Southern livestock production zone contribution to the total milk output is very low (10%) at present. Bihar is one of India's largest milk-producing states, and according to a study by Kumar (2010), Bihar accounts for 8.9% of national milk production. However, milk availability and milk productivity (3.7 kilograms (kg)/day/milking animal) in Bihar was reported in the same study to be one of the lowest in India.

3.4 Livestock species distribution over the different production zones

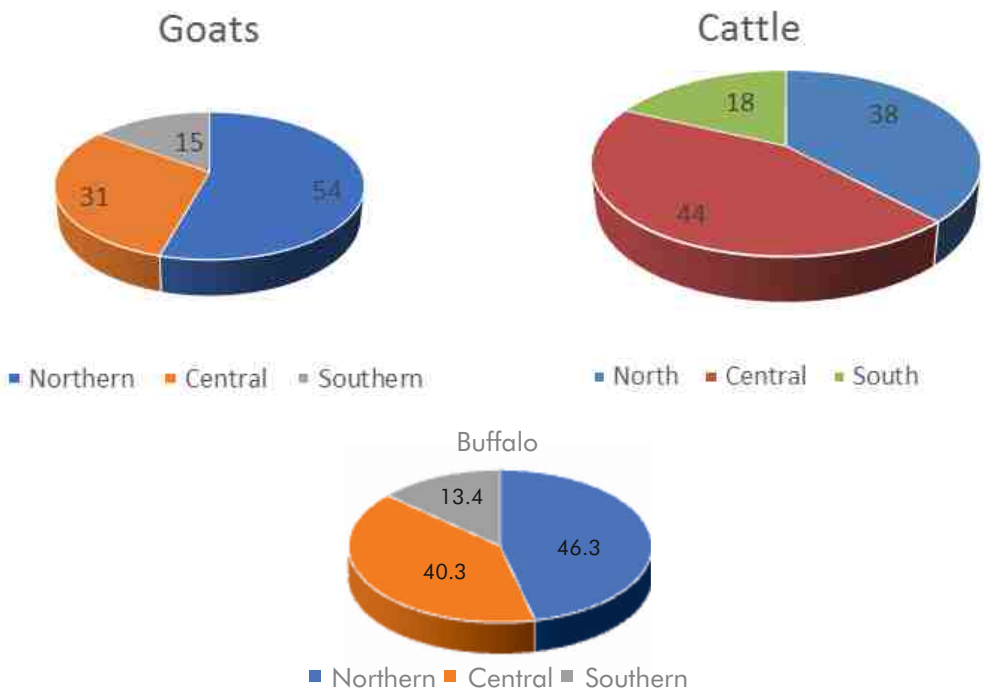
The common livestock species in Bihar are cattle, buffalo, sheep, goat, pig and chicken. According to projections for 2017–18, Bihar has 132.7 lakh cattle, 87.8 lakh buffalos, 145.3 lakh goats, 111.7 lakh chickens; and 6.9 lakh pigs. (Table 6). Of the 132.7 lakh cattle, 38% are found in the Northern zone while 44% and 18% are in the Central and Southern zones, respectively. The buffalo population is mostly in the Northern (46%) and Central (41%) zones, with 13% in the Southern production zone. Goats are concentrated in the Northern zone (54%), with 30% in the Central and 26% in the Southern zones (Figure 7). The Northern and Central zones thus contribute the largest share of the Bihar state livestock population.

Table 6: National livestock numbers (in lakhs) and distribution over livestock production zones in 2017/18

Livestock production zones	Cattle		Buffalos	Goats	
	Indigenous breed	Crossbred	Indigenous	Small size	Medium size
Northern	39.02	11.60	40.69	63.12	15.78
Central	14.08	43.69	35.37	31.30	13.41
Southern	18.30	5.95	11.75	17.31	4.33
Commercial		0.08			
Total	71.40	61.32	87.81	111.73	33.52
	Chicken			Pig	
In all three production zones	Traditional	Broilers	Layers	Traditional and semi-intensive	Commercial
	30.07	68.76	12.90	6.63	0.22

(LSA results)

Figure 7: Buffalos, cattle and goats per cent distribution over the different production zones.



3.5 Technical parameters for livestock productivity

The different livestock production and reproduction parameters are summarized for different species under each livestock production zone. The values of these parameters were obtained through review of the literature

(research and national survey reports) and a panel of experts. Using the parameters listed here and in the Annex, the baseline situation of the Bihar livestock system is established.

Cow dairy production parameters in the different production zones

The production parameters of cow dairy in the different production zones is listed in Table 7. Parameters like parturition rate in cow dairy in the three production zones ranges from 40-45% Northern, 45-55% Central and 40%-45% Southern. Mortality figures show 6-10% for juvenile male, as opposed to 18-35% for juvenile female. Subadult males and females show mortality of 20-35% and 5-8%, respectively. The annual mortality for adults ranged between 5-20% for males and 4-8% for females. Daily milk production of indigenous cattle ranges between 2.5-3.5 litres per day with a lactation length ranging between 220-230 days. For crossbred cows, the daily milk production ranges between 5-7 litres per day with a lactation length of 300 days.

Table 7: Average productivity parameters in cow dairy production systems by zones

Parameters	(Northern zone) Indigenous breed family dairy	(Northern zone) Crossbred family dairy	(Central zone) Indigenous breed family dairy	(Central Zone) Crossbred family dairy	(Southern zone) Indigenous breed family dairy	(Southern zone) Crossbred family dairy
Herd size	2.0	2.0	2.0	2.5	4.0	2.0
Parturition rate	0.40	0.45	0.45	0.55	0.40	0.45
Mortality rate (female juveniles)	10	7	9	7	6	10
Mortality rate (male juveniles)	25	35	28	35	18	35
Mortality rate (female subadults)	8	6	8	5	5	8
Mortality rate (male subadults)	20	35	30	35	25	35
Mortality rate (female adult)	5	5	5	4	5	8
Mortality rate (male adult)	15	20	15	20	5	20
Lactation length (days)	225	300	230	300	220	300
Daily milk production	3.0	6.2	3.5	7.0	2.5	5.0

Table 8: Average productivity parameters in commercial cow dairy production systems

Parameters	Commercial cow dairy[6]
Herd size	30
Parturition rate	0.60
Mortality rate (female juveniles)	8
Mortality rate (male juveniles)	35
Mortality rate (female subadults)	4
Mortality rate (male subadults)	35
Mortality rate (female adult)	4
Mortality rate (male adult)	18
Daily milk production (litres)	12
Lactation length (days)	300

Buffalo production and productive parameters

The buffalo breeds widely available in Bihar state are indigenous to India. Despite the development of the livestock breeding policy for the state of Bihar, little attention is given to improving the existing breeds. There are opportunities for improving the indigenous breed using other breeds of Indian buffalo. Currently, milk production from buffalo indigenous breeds is higher than from the indigenous cow dairy. In addition, the relatively high fat content in buffalo milk, compared to cow, fetches a good price for buffalo milk.

Table 9. Buffalo production system average productivity parameters

Parameters	(Northern zone) Indigenous breed small	(Central zone) Indigenous breed small	(Southern zone) Indigenous breed small
Herd size	2	2	2
Parturition rate	0.40	0.45	0.40
Mortality rate (female juveniles)	10	8	3
Mortality rate (male juveniles)	40	35	35
Mortality rate (female subadults)	8	5	5
Mortality rate (male subadults)	30	30	30
Mortality rate (female adult)	3	3	3

6 Herd size ranges between 16-100

Parameters	(Northern zone) Indigenous breed small	(Central zone) Indigenous breed small	(Southern zone) Indigenous breed small
Mortality rate (male adult)	25	25	25
Off-take rate	35	35	35
Dressing percentage	54	54	54
Lactation length (days)	300	300	290
Daily milk production	5.0	5.5	4.5

Goat production and productivity parameters

Like traditional cattle, production parameters of indigenous goats show the potential for further improvement of the system. In the indigenous goats traditional production system, the parturition rate is 1.3 and the mortality rate of juveniles is 25-30% (Table 10).

Table 10: Goats average productivity parameters

Parameters	(Northern zone) small-size flock	(Northern zone) medium-size flock	(Central zone) small- size flock	(Central zone) medium-size flock	(Southern zone) small-size flock	(Southern zone) medium-size flock
Flock size	3	13	3	13	3	13
Parturition rate	1.25	1.25	1.25	1.25	1.25	1.25
Mortality (%) (female juveniles)	30	25	30	25	25	25
Mortality (%) (male juveniles)	35	25	35	25	30	25
Mortality (%) (female subadults)	20	20	20	18	20	18
Mortality (%) (male subadults)	25	20	25	18	25	18
Mortality (%) (female adult)	20	12	15	12	15	12
Mortality (%) (male adult)	20	10	15	12	15	12
Dressing percentage	50	50	50	50	50	50
Live weight, kg (female juvenile)	4	5	4	5	4	4
Live weight, kg (male juvenile)	5	6	5	5	4	5

Parameters	(Northern zone) small-size flock	(Northern zone) medium-size flock	(Central zone) small- size flock	(Central zone) medium-size flock	(Southern zone) small-size flock	(Southern zone) medium-size flock
Live weight, kg (female subadult)	8	9	7	8	7	7
Live weight, kg (male subadult)	9	10	8	9	8	9
Live weight, kg (female adult)	15	18	14	17	13	16
Live weight, kg (male adult)	17	20	16	19	15	18

Chicken production and productivity parameters

The chicken production system is mainly divided into traditional (village chicken) and commercial. The commercial chicken production encompasses layer and broiler systems. The average number of eggs laid/hen/year in the village chicken production is 70 with a laying period of 12 months. The average slaughter weight is 1 kg and dressing weight is 65% of village chicken.

Village chickens produce low total income per hen compared to total income per bird produced by commercial chickens (Table 11). Due to the brooding behaviour of hens, the flock size in village chicken is counted by using the number of hens. A hen in a village chicken system has around eight followers (chicks, cockerels and pullets). The high number of followers per hen and the very small input cost in the village chickens produces an unexpectedly high net income per hen compared to commercial chicken. Layers and broilers, on the other hand, have high productivity but also high input cost. Layers produce 327 eggs per year and start laying when they reach five months old. Broilers also have a very high growth rate and usually reach a slaughter weight of 1.3 kg by 35 days.

Table 11: Chicken production average productivity parameters

Parameters	Backyard village chicken	Crossbred backyard chicken	Layers	Broilers
Average number of chicks and hens (for village system)	1.5	12	5,000	1,500
Age of hens at the start of the laying period (months)	6	5	5	N/A
Duration of the laying period (months)	12	12	12	N/A
Adult mortality (% per year)	10	10	10	5
Number of eggs laid (hen per year)	70	127	327	N/A
Age of males when sold (months)	6	missing	N/A	35 days
Proportion of commercial feed for layers (%)	NA	20	100	100

Parameters	Backyard village chicken	Crossbred backyard chicken	Layers	Broilers
Average live weight of chickens (growers) sold (kg)	1	1.5	1.4	1.3
Average dressing percentage (%)	65	65	65	65
Net income per bird or per hen (for village chicken) in rupees	77	611	130	49

N/A - not available

Pig production parameters

The main pig production system in Bihar state is village based. The village piggery is divided further into two types of management systems, extensive and semi-intensive, resulting in differences in productivity. The number of sows in both systems is the same. The extensive village piggery has the lower productivity performance. The litter size per sow in the extensive village piggery is about five while the litter size per sow is about seven for semi-intensive village piggeries. The mortality rate of young pigs is 20% in the extensive and 12.5 % in the semi-intensive village system (Table 12).

Table 12: Swine production average productivity parameters

	Village pig (extensive)	Village pig (semi-intensive)
Number of sows	1	1
Parameters of reproduction		
Age at first service (days)	260	250
Litter size (live births) per sow	5	7.2
Delay weaning-successful service (days)	60	14
Mortality and culling		
Mortality rate of young animals before weaning (%)	20	12.5
Mortality rate weaning—marketing	5	4
Adult mortality rate	3	3
Feeding parameters		
Proportion of purchased feed included in the ration (%)	0	20
Production parameters		
Age at weaning (days)	56	60
Weight at weaning (kg)	4.5	10
Weight at marketing (kg)	5.0	10
Dressing percentage (%)	70	70

3.6 Gender and social inclusion considerations in livestock production systems

Across the world, agriculture is undertaken by men and women. Time studies show that 32% of agricultural labour is provided by women in India (FAO 2011). In Bihar, as elsewhere, women are intrinsically involved in livestock management; women's activities range widely from care of animals, grazing, fodder collection, cleaning of animal sheds, processing milk and livestock products (ILRI FDGs 2018). Indoor jobs like milking, feeding and cleaning are dominated by women. Due to the recent out migration of men from Bihar (18%) (Rodgers et al. 2013), the burden of women is increasing. Despite women's considerable involvement and contribution in livestock, there are significant gender differences when accessing technologies, credit, information, inputs and services. This has resulted in a gender gap, contributing to inefficiencies in the livestock sector. Concomitantly, when women do not benefit or engage in increased productivity and income from livestock, they may disengage, which has a negative effect on livestock productivity.

Similar issues arise with Scheduled Tribes (ST) and Scheduled Castes (SC) who are not able to exploit the opportunities offered by livestock or able to engage effectively to improve livestock production. Bihar has approximately 12 lakh tribal people and 160 lakh SC people (Directorate of Economics and Statistics 2016) whose voice is unheard due to limited bargaining power (Nathan and Xaxa 2012). Many do not have land for their housing and farming, forcing them to live in forest or communal land areas. SC and especially ST main livelihoods are livestock keeping (Mazumder et al. 2014), especially indigenous dairy animals, small ruminants, pigs and chicken.

Dairy production systems

Data from Bihar indicate that women play an important role, with women providing 71% of labour in the dairy sector (ILRI 2014). Women in rural areas contribute four to five hours of labour for activities including collecting fodder, grazing, feeding, watering, cleaning sheds, dung collection for fuel, milking, bathing animals and taking care of sick animals (ILRI FDGs 2018). Control of dairy income by women in Bihar is different among out migrated (60-70%) and nonmigrating (20-30%) households. Women also control more income when there is informal marketing (80%) than formal co-operatives (30%) (ILRI FDGs 2018). The benefit from dairy income is multifaceted and includes nutrition for household, education of children, care of sick persons, social status for women and as a store of wealth.

In Bihar, 91% of marginal farmers live on less than 2 hectares (ha) of land; both ST and SC are the poorest within these communities (Rodgers et al. 2013) . In these categories of households, dependence on crop cultivation is decreasing whereas off-farm income and dairy income share have increased (Singh and Datta 2013). Dairy farming is more common with SC than ST that have very small pieces of land, with an average of 0.08 ha of land in Bihar (Rodgers et al. 2013; ILRI FD Gs 2018). Involvement of youth in dairy farming is limited as they migrate to cities for nonfarm income (ILRI FDGs 2018).

Goat farming/small ruminants

In terms of small ruminants, goat farming provides a significant contribution to the livelihoods of women, SC and ST. Women's labour contribution in goat production is two to four hours daily for grazing, cleaning sheds, care of kids and feeding (ILRI FDGs 2018) and control of income from goat is 50% (nonmigrating) and 80% (out-migrated households) (ILRI FDGs 2018). Goat is preferred by the poorest and women because of low investment, ease to handle, highly prolific in nature and low religious taboos. The goat population in Bihar has increased in the last decade due to increased land fragmentation. Goats are an asset that can be easily converted to cash by women for household emergencies, health services, paying school fees and for household

food security (ILRI FDGs 2018). Due to lack of capital, feed scarcity, lack of veterinary services and technical knowledge available to women, goat herd size is not increasing even though the number of goat farmers is increasing.

Backyard poultry (BYP)

Most BYP in Bihar are kept traditionally by landless, marginal communities and women; they are often reared by Muslim and tribal communities. BYP is considered important for household nutrition and as a good source of income with low input and high return (ILRI FDGs 2018). Women use household leftovers and agricultural by-products to decrease the feed costs. Women contribute 20-30 minutes of labour for feeding, cleaning and taking care of these birds. Women control 40-70% of the income produced by BYP (ILRI FDGs 2018). Women and marginalized communities are unable to access veterinary care and input supply due to mobility issues and social barriers. Women sell poultry within their village and in nearby local markets.

Pig production

Pigs are being reared in tribal belts of Bihar, especially south and north Bihar, by ST communities. Pig rearing is done on a small scale in backyards and pigs are fed with household waste and agricultural crop residues. Pig rearing is considered a low-input and high-return activity and does not require a lot of skill. Most of the management practices and labour for pig rearing is done by women in tribal regions; one to two hours are spent on care of pigs by women and women control 50-100% of the income generated by pigs, dependent upon whether the household is non-migrated or out-migrating (ILRI FDGs 2018).

The average herd size in these tribal communities is two to three pigs per household. There is high demand in the local market and a common practice in tribal regions is community sharing of pig meat within the village (ILRI FDGs 2018). Women sell pigs when cash is needed for emergencies. Due to the lower political bargaining power of the tribal communities, they are unable to access veterinary services and input supply for better pig production.

Broiler and layer production

There are very few commercial broiler and layer farms with 3,000-10,000 birds in all regions of Bihar except around urban areas. Due to high demand for egg and meat because of increased income in urban areas, government programs and the National Bank for Agriculture and Rural Development have promoted commercial farms. The poorest, marginalized people and women are not involved in commercial farming due to lack of capital for investment and lack of management skills. It was observed that in a few farms that keep 86% of the poultry population of the state (Table 13), there is a high-labour contribution from women for cleaning sheds, feeding, watering and caring for chicks, about one to two hours, but the income is mostly controlled by men.

Table 13: Distribution of livestock according to land-size category in Bihar (number per 1,000 households)

	Number per thousand households						%					
Land size category	Adult cattle	Adult buffalo	Sheep	Goat	Pig	Poultry	Adult cattle	Adult buffalo	Sheep	Goat	Pig	poultry
Marginal / landless	2,224	913	12	908	59	1,407	31	15	6	35	100	7
Small	714	543	1	229	0	420	10	9	1	9	0	2
Small-medium	1,487	888	3	256	0	838	21	15	2	10	0	4
Medium	2,260	1,600	174	186	0	412	32	27	91	7	0	2
Large	409	2,002	0	1000	0	1,8377	6	34	0	39	0	85
Total	7,094	5,946	190	2579	59	2,1454	100	100	100	100		100

Source: calculated from unit data of National Sample Survey (NSS) report 572, Livestock ownership in India

Table 14: Composition and distribution of livestock across social groups (%) across India

Social group	Composition of livestock in each social group					
	Cattle	Buffalos	Small ruminants	Pigs	Poultry	Total
ST	22	5	15	4	55	100
SC	28	9	18	1	46	100
OBC	23	15	19	0	42	100
Others	30	17	17	0	35	100
	Distribution of livestock across social groups					
ST	17	8	13	73	26	
SC	15	10	12	10	15	
OBC	43	54	53	11	43	
Others	25	28	22	6	16	
Total	100	100	100	100	100	

Source: calculated from unit data of NSS report 572, Livestock ownership in India

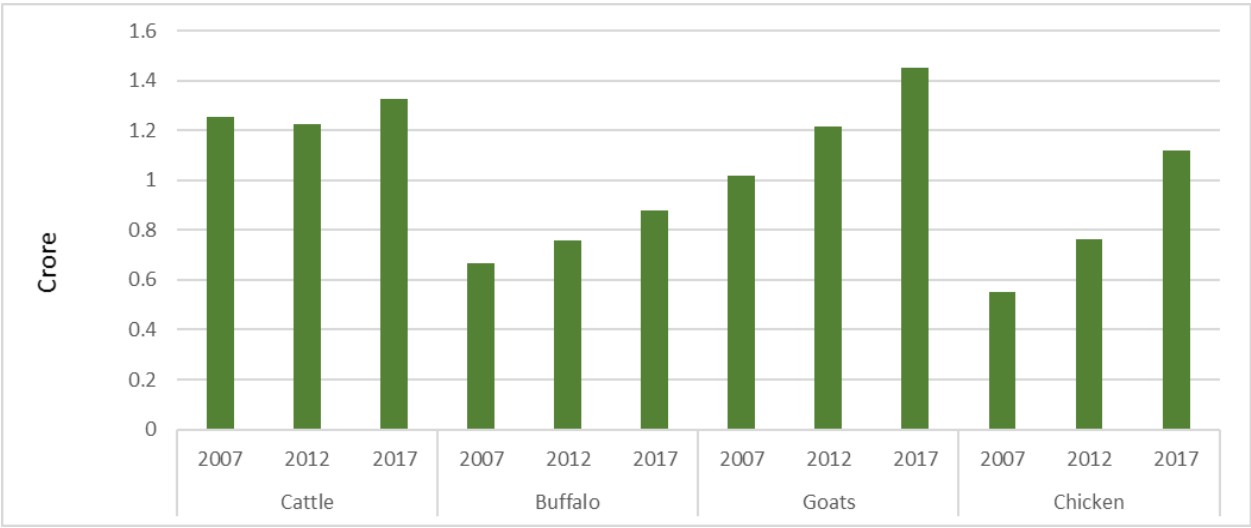
OBC – other economically backward classes

4 Livestock contribution to Bihar state

4.1 Past livestock trends—population and production

The state of Bihar has a huge population of different livestock species. Figures 8 and 9 present the livestock population recorded during the livestock census years 2007 and 2012 and projected for the year 2017. The projected population for the year 2017–18 shows that there are about 132.7 lakh cattle, 87.8 lakh buffalos, 2.5 lakh sheep, 145.3 lakh goats, 6.9 lakh pigs and 111.7 lakh chickens.

Figure 8: Cattle, buffalo, goat and chicken population trends in Bihar (2007–17).

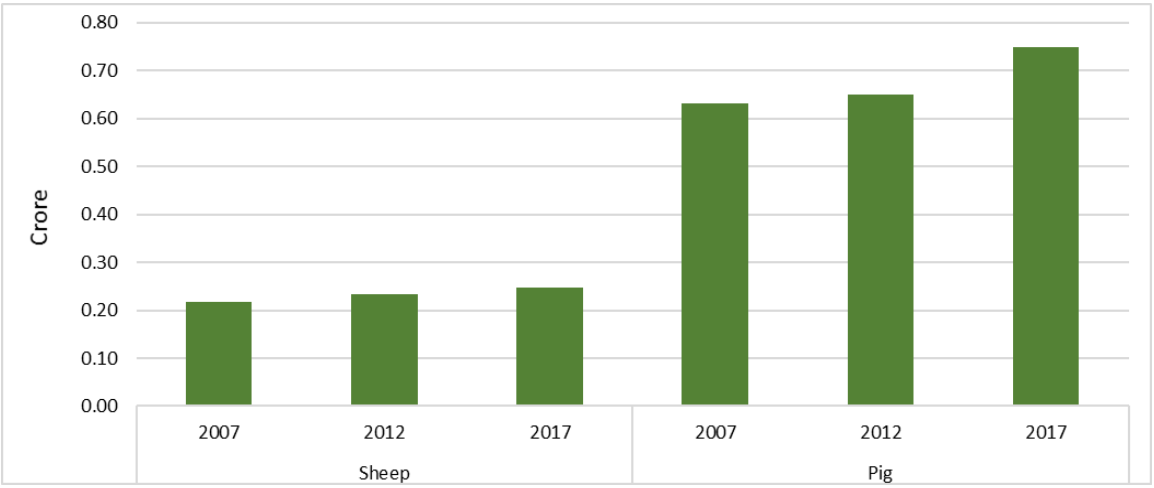


Source: 2007 and 2012 population data from the 18th and 19th Livestock Census; 2017 population based on own projection

During the last 10 years, the population of buffalos, goats and chickens has increased steadily while the population of cattle, sheep and pigs has only increased marginally. Bihar is one of the states with higher proportion of buffalos and goats than in the total livestock population of India (Singh et al. 2010). The increase in buffalo population was greater (16%) than the corresponding increase in cattle population (8%) during 2012–17. This indicates the growing importance of buffalo for milk production. According to Singh et al. (2010), Bihar farmers' preference towards buffalo for milk production is increasing because it efficiently converts coarse fodder to milk. In addition, buffalos are more disease resistant and survive well under adverse water-logged conditions and can more easly be sold for the meat market.

Poultry has grown at the fastest rate compared to other livestock in Bihar, due to the robust expansion of poultry farms and hatcheries. As shown in Figure 8, the chicken population increased by 102% during 2012–17, from 55.3 lakh to 111.7 lakh.

Figure 9: Sheep and pig population trends in Bihar (2007–17).

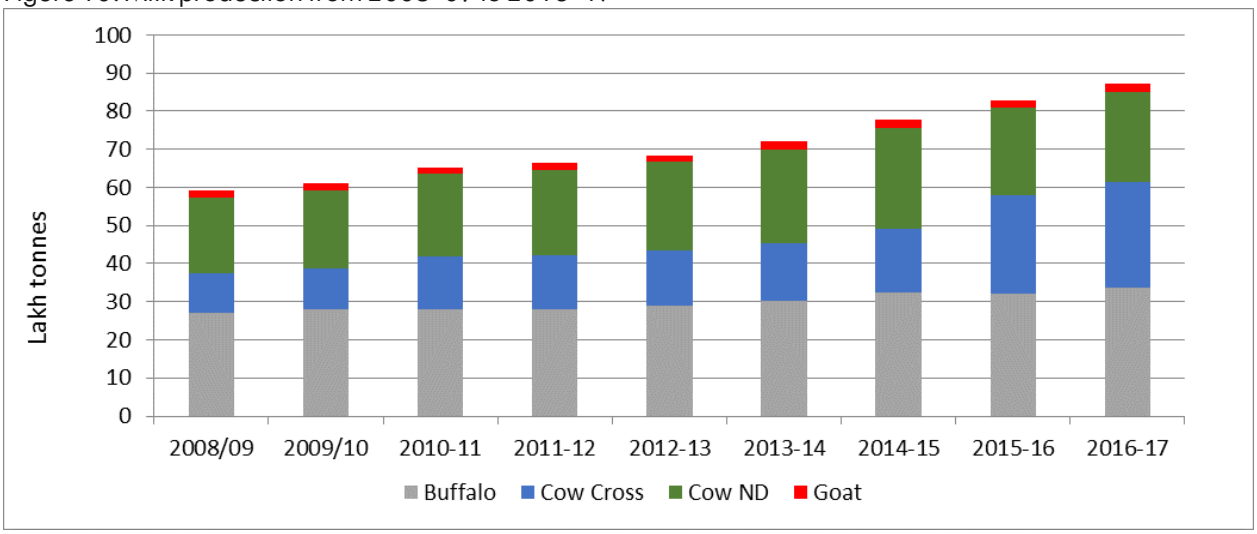


Source: 2007 and 2012 population data from 18th and 19th Livestock Census; 2017 population based on own projection

The goat population in Bihar grew by 20% from 120 lakh in 2012 to 145.3 lakh in 2017-18 (Figure 8). The sheep population in Bihar has marginally grown by 7% from 2.3 lakh in 2012 to 2.5 lakh in 2017-18 (Figure 9). The slow growth in the sheep population in Bihar is attributed to the lack of institutional efforts to promote wool production, among other reasons.

The total milk production in Bihar has increased steadily in the last decade, from 2008–09 to 2016–17. Most of the increase in milk production is attributed to the significant increase of crossbreed cows, which has increased by 78% in the last five years, from 2012–13 to 2016–17. Likewise, the share of milk produced from crossbreed cows has increased from 17% in 2008–09 to 32% in 2016–17. The share of buffalo milk as a part of total milk production, however, gradually decreased in the last 10 years from 46% in 2008–09 to 39% in 2016–17.

Figure 10: Milk production from 2008–09 to 2016–17



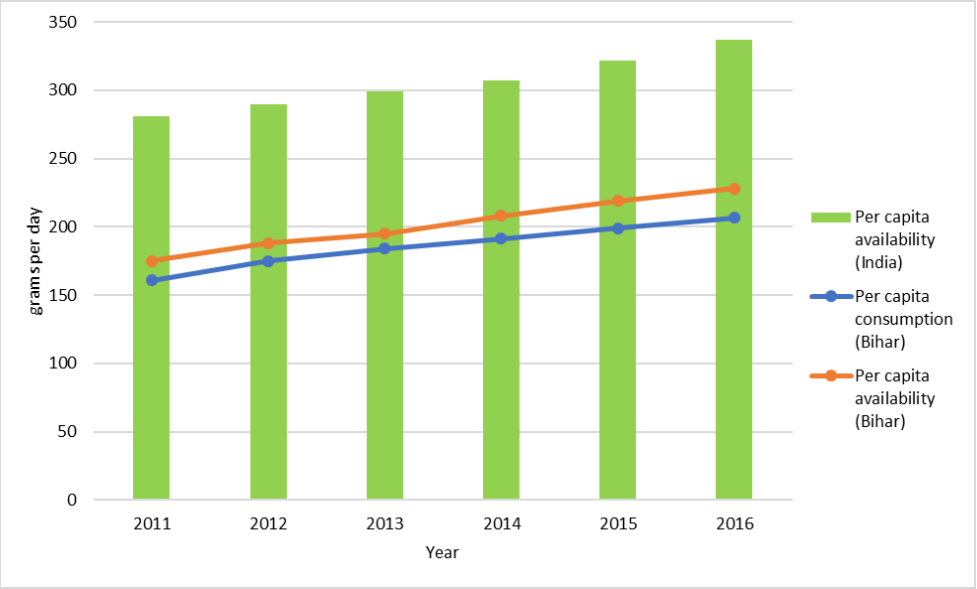
Source: Department of Animal and Fisheries Resources (DAFR) (2016)

The state of Bihar was ranked the ninth-top milk producer in India during the year 2016–17 (DAFR 2016). During the same year, the top five milk-producing states were Uttar Pradesh, Rajasthan, Gujarat, Madhya

Pradesh and Andhra Pradesh.

Figure 11 shows the average per capita milk consumption and availability in Bihar and the national average per capita milk availability from 2011–12 to 2016–17. During this period, the per capita milk availability in Bihar was lower than that of the national average. However, it steadily increased from 175 grams (gm) per day in 2011–12 to 228 gm per day in 2016–17. The per capita consumption of milk and milk products was lower than the per capita milk availability during the whole period of 2011–12 to 2016–17.

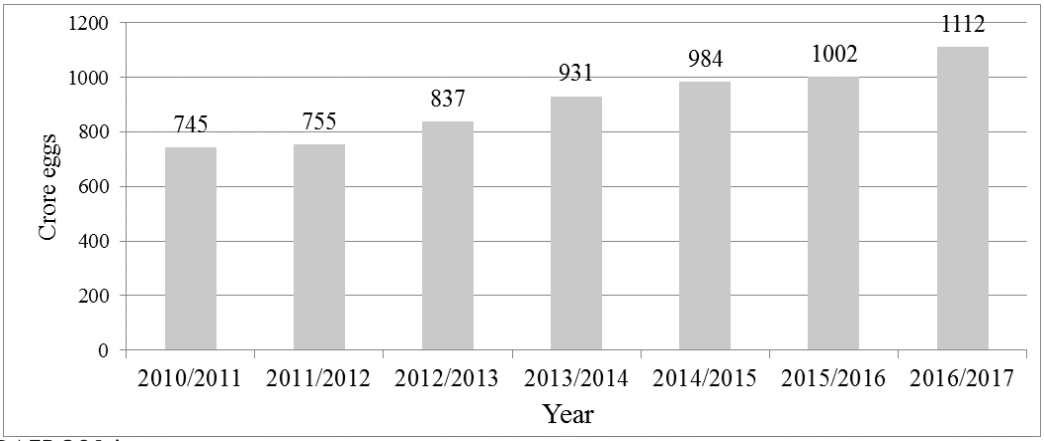
Figure 11: Average per capita milk consumption and availability in Bihar and the national average per capita milk availability (gm per day).



Source: DAFR 2016 and own calculation

Annual egg production in the state of Bihar from 2010–2011 to 2016–2017 is shown in Figure 12. In line with the drastic poultry population increase in Bihar, egg production in the state has steadily grown in the last seven years. The production of eggs has increased from 745 crore eggs in 2010–11 to 1,112 crore eggs in 2016–17, a growth of about 33% (Figure 12).

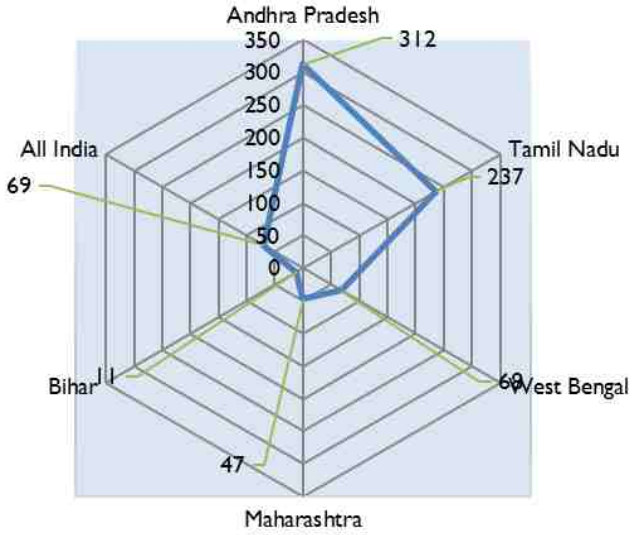
Figure 12: Annual egg production in Bihar state (2010–2011 to 2016–2017).



Source: DAFR 2016

Figure 13 shows the 2016–17 per capita egg availability in selected Indian states. Despite the steady increase of egg production in Bihar during the last seven years, per capita egg availability in the state is only 11 eggs per annum, which is far lower than the Indian average per capita egg availability of 69 eggs per annum. The state has a long way to reach the production level of major egg producing states such Tamil Nadu, Andhra Pradesh, Telangana, West Bengal and Maharashtra.

Figure 13: Per capita egg availability in selected Indian states during 2016–2017 (Source: DAFR 2016).



4.2 Current (2017–18) livestock population, production and GSDP

Current livestock population

The Bihar LMP team used the 2007 and 2012 India Livestock Census data[7] to project the 2017–18 Bihar state livestock population. Using the five-years growth rate (2007–2012), first, the team calculated an annual growth rate for each livestock species. The annual growth rates were then used to project and establish the baseline livestock population values for the targeted species for baseline year 2017–18.

The 2017 and 2012 livestock population (from India Livestock Census) and LMP projected values for 2017–18 are given in Table 14 below. The 2017–18 LMP projected figures are used as baseline livestock population values in the whole Bihar livestock sector analysis. The baseline year or 2017–18 cattle population in Bihar includes about 61 lakh or 46% crosses or exotic breeds and 71 lakh or 54% local/indigenous breeds. The total population of buffalos, sheep and goat have been increasing since 2007, reaching 87.8, 2.5, 145.3 lakhs in the baseline year, 2017–18. The populations of pig and chicken is projected to grow to 6.9 lakh and 1,117 lakhs by 2017-18.

As shown in Table 15, the population of layers and broilers continuously increased since 2007 and it is projected to constitute 73% of the chicken population in the baseline year 2017–18. The local/indigenous and crossbred chicken which are managed under the family/village backyard system has been decreasing steadily since 2007 and it only constitutes about 23% and 4%, respectively, of the total chicken population in 2017–18. For pig farming, the traditional backyard family system is predominant. Despite the huge potential in rural areas, commercial piggery and specialized pig fattening are almost non-existent in the baseline year 2017–18. In the last decade, the total pig population has grown by only 8%.

7 A livestock census in India is generally conducted once every five years; the in the series is the 19th Livestock Census with reference date of 15th October 2012, released June 2014.

Table 15: The distribution of Bihar livestock population over the three production zones and in specialized commercial systems (not zone specific)

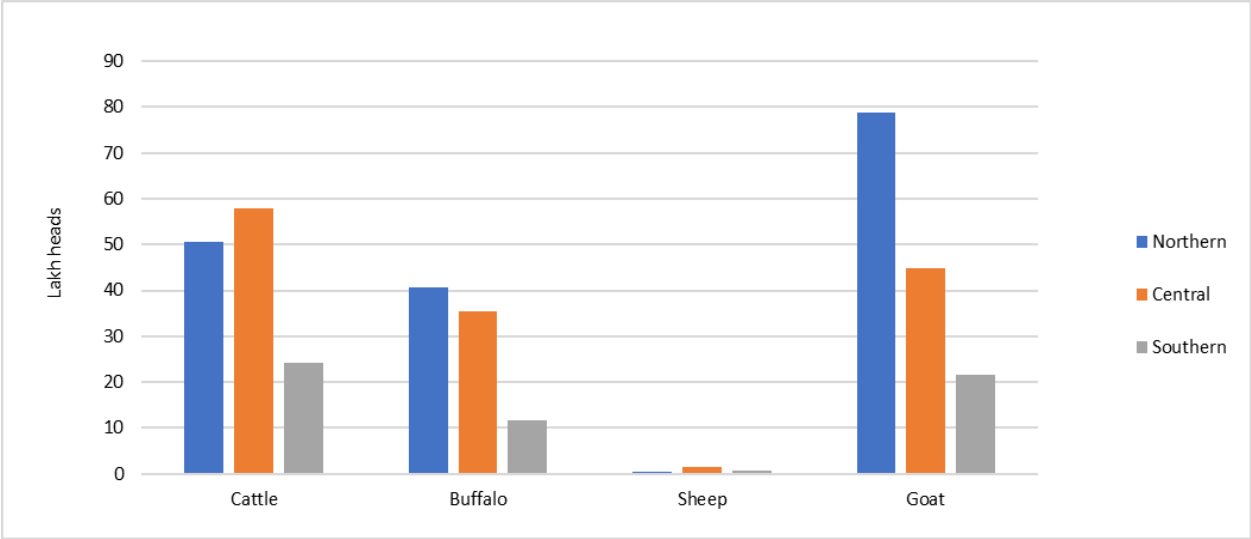
	Livestock population (lakhs)		
	2007 Census	2012 Census	LMP projected figures 2017–18
Indigenous breeds	1,05,827.6	87,564.0	71,397.3
Crossbreds	19,762.8	34,751.2	61,318.5
Total cattle	1,25,590.4	1,22,315.2	1,32,715.8
Buffalos	66,904.2	75,672.3	87,812.5
Sheep	2,182.4	2,324.7	2,480.4
Goats	1,01,670.1	1,21,535.2	1,45,254.5
Indigenous backyard (hens)	19,913.1	22,538.0	25,508.9
Crossbred backyard	3,135.2	3,782.2	4,562.7
Commercial chickens (layer and broiler)	32,248.6	50,116.7	81,661.8
Total chickens	55,296.9	76,436.9	1,11,733.3
Pigs	6,320.6	6,497.1	6,847.0

Source: DAFR (2016) and based on LSA simulation results

Figure 14 below shows the current population of cattle, buffalos, sheep and goats across the three Bihar state livestock production zones. There is a considerable number of cattle in all three production zones. The Northern and Central livestock production zones together support about 81.6% of the total cattle population, whereas the Southern production zone supports about 18.3 % of the total cattle population. The rest, about 0.17% of the cattle population, belongs to the commercial cattle system, which is at its initial development stage.

Most of the sheep, about 55%, are found in the Central livestock production zone. Overall, sheep production is less important in the other livestock production zones. The largest proportion of goats (54%) are found in the Northern livestock production zone followed by the Central (31%) and Southern (15%) production zones. Unlike sheep, goats remain important in all livestock production zones of Bihar. When the total distribution of ruminant livestock (cattle, buffalos, sheep and goats) population is considered, a less significant difference was observed across Central and Northern production zones, 46% in the Central and 38% in the Northern production zones.

Figure 14: Population of cattle, buffalos, sheep and goats across the three Bihar state livestock production zones in the base year 2017–18.



Current livestock production

Livestock in Bihar produce meat, milk, eggs and other products. Table 16 below presents the volume or quantity of these products produced from the five targeted livestock species during the projected base year, 2017–18. The computation was made based on the technical parameters and productivity indicators discussed in Section 3 above and the base year livestock population.

Table 16: Livestock production during the baseline year (2017–18)

Livestock products	Unit	Volume of production 2017–18
Indigenous breed cow milk	Lakh litres	11,894.9
Crossbreed cow milk	Lakh litres	41,730.6
Commercial dairy	Lakh litres	95.1
Buffalo milk	Lakh litres	34,066.4
Goat milk	Lakh litres	1,845.3
Total milk production	Lakh litres	89,632.2
Local chicken eggs(indigenous and crossbred backyard)	Lakh	1.5
Layers eggs	Lakh	2.6
Total egg production	Lakh	4.1
Hides and skins	MT	5,679
Wool	MT	260
Organic matter	MT	23,322,968
Draft power contribution	Lakh days	2.1

Source: Based on LSA simulation results * MT = metric tonne

As shown in Table 16, about 32% of the chicken meat and 37% of the eggs are coming from the local (indigenous and crossbred backyard) or village chicken system. Similarly, 66% of the chicken meat comes from broilers and layers and 63% of the eggs from specialized layers. The contribution of the local cattle breeds to the total milk production is only 13% (Table 16), although they represent 54% of the cattle population in Bihar (Table 15). The indigenous cattle breeds do not seem to have a future for milk production in land-scarce Bihar, as the yield per cow is too low. However, recently, the demand for organic milk and milk products (A2 milk)[8] is increasing. Thus, further improvement of the indigenous cattle through genomic selection needs to be encouraged.

Current livestock GSDP

Policy decisions on resource allocation to a sector are often based on the relative importance of that sector in the national or state economy. One of the most commonly used measures of importance of an economic sector or industry is the magnitude of its contribution to the GDP or GSDP. The contribution of livestock to GSDP is therefore the best way to measure the economic performance of the subsector and its relative importance in the state economy. Accordingly, the contribution of livestock to the Bihar GSDP or the livestock GSDP is defined as a monetary measure of the market value of all livestock final goods and services (milk, meat, eggs, manure and energy) produced annually, generated at the production stage and includes values added from the value chains by aggregating the margins from the various subchains.

Table 17 shows the trends in agriculture and livestock GSDP and GDP during 2011–12 to 2016–17. The GSDP estimates for that income from livestock and livestock products for the year 2016–17 is INR 17,400 crores which is approximately 2,700 crore United States dollars (USD) (India Central Statistics Office 2017).

The absolute value of the livestock GSDP has increased from INR 12,000 crore in 2011–12 to INR 17,400 crore in 2016–17. The 7.7% annual growth of livestock GSDP has led to a gradual increase of the contribution of livestock in the agricultural GSDP and state GSDP. The share of livestock and livestock products in the agricultural GSDP of Bihar has increased from 19.4% in 2011–12 to about 26.7 % in the year 2016–17, whereas nationally the share of livestock and livestock products in the agricultural GDP has decreased from 25% in 2011–12 to about 24% in the year 2016–17. As shown in Table 17, the livestock sector grew substantially more than the rest of the Bihar agriculture sector, which only grew 1.3%.

Similarly, the contribution of livestock and livestock products in the state economy (GSDP) has steadily increased from 4.9% in 2011–12 to 5.2% in 2016–17. The contribution of livestock and livestock products in the national economy (GDP) has increased only marginally from 9% in 2011–12 to 10% in 2016–17.

8 A2 milk is the milk that contains only the A2 type of beta-casein protein whereas A1 milk contains only A1 beta casein or A1 type variant. A1 protein variant is commonly found in milk from crossbred and European breeds of cattle. A2 milk is found in the indigenous cows and buffalos of India (and Asia as a whole) (Prasanta B. et.al. 2016).

Table 17: Trends in state, agriculture and livestock GSDP 2011–12 to 2016–17 in INR crore at constant 2011–12

	2011–12	2012–13	2013–14	2014–15	2015–16	2016–17	Average growth rate
GSDP	247,100	256,900	269,600	279,500	300,600	331,600	6.08%
Agriculture, forestry and fishing	62,100	68,000	59,500	59,300	60,900	65,100	1.3%
Livestock	12,000	12,500	14,000	15,400	16,300	17,400	7.7%
Livestock/agriculture GSDP	19.4%	18.4%	23.5%	25.9%	26.7%	26.7%	
Livestock/GSDP	4.9%	4.9%	5.2%	5.5%	5.4%	5.2%	
Livestock/national agriculture GDP	25%	26%	27%	24%	24%	24%	
Livestock/national GDP	4.1%	4.1%	4.3%	4.1%	4.0%	3.9%	

Source: India Central Statistics Office and LSA results

GSDP estimate of livestock at the production stage

In the sector model used for the Bihar LSA, the livestock GSDP is computed at the production stage by aggregating the gross value of the livestock output (milk, meat, eggs and manure[9]) and subtracting the intermediate consumption or costs to obtain the total value added (VA).

GSDP or total VA = gross value of output – value of intermediate consumption/costs.

The added value from each livestock species in each system and production zone is calculated and aggregated to generate the GSDP for the state herd. In the GSDP formula below, Q is total production of all livestock products generated by each livestock systems (S), p is the average producer price of each product and %CI is the percentage of the intermediate costs.

$$Total\ AV = \sum_{S,A} Q * p * (1 - \%CI)$$

Table 18 provides the VA at the production stage of the various livestock commodities. The total VA from the livestock sector during the base year, 2017–18, amounts to INR 20,318 crore or about USD 317 crore. This is, about 17% higher than the 2016–17 estimate reported by the India Central Statistics Office (Table 17 above).

9 The average weight of manure produced per animal and per day is calculated and used to estimate the value of manure, which only takes into account the quantity used at the farm and sold, if any.

Table 18: Summary of the composition of the subsector gross VA at the production stage 2017–18

Commodity	VA (in INR crores)	Share of VA
Meat		
Buffalo meat	1,676	8%
Sheep meat	14	0.07%
Goat meat	857	4%
Pork meat	193	1%
Poultry meat	340	2%
Milk	0	
Cattle	7,112	35%
Buffalo	6,541	32%
Eggs	97	0%
Hides and skins	85	0.4%
Wool	3	0.01%
Organic matter	3,484	17%
Energy	2	0.01%
Total	20,318	100%

Source: Based on LSA simulation results

Table 18 further shows that about 81% of the livestock GSDP comes from milk, followed by organic matter and meat which accounts for about 17% and 15%, respectively. Overall, cattle and buffalo account for about 91% of the current livestock VA or GSDP of Bihar, showing the importance of the cattle and buffalo production systems in the state. This includes organic matter VA which is predominantly cattle and buffalo output (about 99.7% of the organic matter VA). VA from buffalo meat amounts to about 8% and the remaining 7% comes from goat meat (4%), sheep meat (0.07%), chicken (2%) and pigs (1%).

Table 19 below shows the contribution of each production zone to the total livestock GSDP of the year 2017–18. The production performance of the specialized dairy farming system and monogastric animals (pigs and chickens) is assumed to be not zone specific, hence were not modelled by production zones. The results show

that more than half of the livestock GSDP (about 55.8%) comes from the Central livestock production zone followed by Northern which contributes about 31.8% of the livestock GSDP. The rest, 12.4% of the livestock GSDP, comes from the Southern livestock production system (about 9.5%), specialized dairy farming system (0.1%) and monogastric livestock (chickens 1.8% and pigs 1%).

Table 19: Share of livestock GSDP by livestock production zones and species 2017–18

	Cattle	Buffalos	Sheep	Goats	Chickens	Pigs
Northern	8.5%	20.7%	0.02%	2.6%	1.3%	0.9%
Central	34.4%	19.9%	0.1%	1.5%		
Southern	3.9%	4.8%	0.04%	0.8%		
Commercial	0.1%	0.5%	0.1%			
Total	46.8%	45.4%	0.1%	4.9%	1.8%	1.0%

Source: Based on LSA results

More than 90% of the cattle and buffalo VA during the base year originated from the Central and Northern livestock production systems whereas the goat VA is predominantly from the Northern production system (54%). The latter finding is in line with the fact that most of the goats in Bihar are reared by the marginal communities in the Northern part of the state. The Northern production system is home to about 54% of the goat population in Bihar.

4.3 Projection of livestock populations, production and GSDP to 2031–32 under business as usual (BAU))

Projected livestock population (to 2032–33 BAU)

The herd and sector model were used to project the livestock population, livestock products and livestock GSDP for 15 years. The 2032–33 projected livestock population figures for different livestock species are given in Table 20. These values are based on the BAU scenario, i.e. with no additional investment beyond that already occurring to improve the productivity of the sector for the coming 15 years. This scenario assumes that private and public investment continue at current rates.

Under the BAU scenario, in 2032–33 there is projected to be significant growth in the populations of all livestock, especially of chickens, goats and buffalos, at 374%, 71% and 45%, respectively. The numbers of chickens in all system typres is projected to grow very significantly. Meanwhile, the number of local cattle is projected to decrease by 43%. Pigs across all systems (extensive, semi-intensive and intensive or commercial) will increase by only 13% under BAU, and mostly due to the larger numbers and growth (16%) in the traditional extensive. While cattle overall in total are projected to increase only 5%, the growth rate for crossbred cows is projected to be higher (60%) than for local cattle which are projected to decrease by 43%. This trend of relative increase in the numbers and propostions of crossbred cattle to increase milk production has been an ongoing strategy in India, which has gradually replaced a sizeable number of local breed animals.

Table 20: Comparison of baseline current and projected livestock populations 2017–18 to 2032–33 under the BAU scenario

Livestock species	Livestock population (in lakh)		% change
	2017–18	2032–33	
Cattle	132.7	138.8	5%
Local	71.4	40.4	-43%
Cross	61.3	98.3	60%
Buffalos	87.8	127.0	45%
Sheep	2.5	3.0	21%
Small	2.2	2.7	21%
Medium	0.3	0.3	20%
Goats	145.3	248.0	71%
Small	111.7	191.0	71%
Medium	33.5	57.0	70%
Chickens	176.2	834.7	374%
Local/indigenous backyard	90.0	130.5	45%
Crossbred backyard	4.6	8.0	75%
Layer subsystem	12.9	469.8	3540%
Broiler subsystem	68.8	226.4	229%
Pigs	6.8	7.8	13%
Extensive backyard	6.6	7.7	16%
Semi-intensive backyard	0.02	0.01	-73%
Commercial piggery	0.2	0.1	-73%
Pig fattening	0.005	0.001	-80%

Source: Based on LSA results

The percentage of growth of goats and sheep populations in the year 2032–33 is almost the same across small and medium farms, however most of the goats and sheep are within the context of small farm systems. Under the BAU scenario, in 2032–33, the pig population in the state of Bihar is projected to decrease by about 34% overall. While taking into account the very small pig populations in all the pig systems, the populations of pigs under the semi-intensive, commercial and intensive pig fattening systems are projected to decrease by about 73%, 73%, and 80%, respectively, due to a lack of incentives and marketing opportunities faced by intensive and commercial pig farmers.

Overall as shown in Table 20, under the BAU situation in 2032–33, crossbreeds of cattle, all types of species of chicken, and buffalos and goats would be projected to dominate the livestock systems of Bihar state.

Projected livestock production (to 2032–33 under BAU)

To estimate the quantities of future productionof livestock products to 2031-32 under BAU, the baseline livestock productivity parameters were applied to the projected livestock population. The volume of the main livestock products, meat, milk, eggs, manure and skin and hides, are estimated and valued to approximate their contributions to the state economy or GSDP of Bihar.

The results of the production projection (BAU 2032–33) are presented in Table 21 below and compared with the 2017–18 baseline situation. Under the BAU scenario, milk production increases from 89,632 lakh litres to 1,26,228 lakh litres, a 41% increase.

Table 21: Comparison of the baseline 2017–18 and projected 2032–33 BAU livestock production in Bihar

Livestock products	Unit	Volume of production 2017–18	Volume of production 2032–33	Change
Milk (total)	Lakh litres	89,632.2	126,228.2	41%
Local cows	Lakh litres	11,894.9	6,736.0	-43%
Crossbreed cows	Lakh litres	41,730.6	66,934.5	60%
Specialized	Lakh litres	95.1	141.0	48%
Buffalos	Lakh litres	34,066.4	49,266.1	45%
Goats	Lakh litres	1,845.3	3,150.6	71%
Buffalo meat	MT	76,302.0	110,347.0	45%
Sheep meat (total)	MT	599.0	723.0	21%
Small farms	MT	533.0	644.0	21%
Medium farms	MT	66.0	79.0	20%
Goat meat (total)	MT	29,918.0	51,062.0	71%
Small farms	MT	21,041.0	35,973.0	71%

Livestock products	Unit	Volume of production 2017–18	Volume of production 2032–33	Change
Medium farms	MT	8,877.0	15,089.0	70%
Pork meat	MT	44,473.0	27,529.0	-38%
Poultry meat (total)	MT	61,975.0	190,228.0	207%
Local chickens	MT	20,136.0	29,438.0	46%
Layers	MT	695.0	25,291.0	3540%
Broilers	MT	41,145.0	135,499.0	229%
Eggs (total)	Lakh	4.1	95.8	2,234%
Local chickens	Lakh	1.5	2.3	52%
Layers	Lakh	2.6	93.4	3,540%
Hides and skins	MT	5,679.0	9,686.0	71%
Wool	MT	260.0	314.0	21%
Organic matter	MT	23,322,968.0	29,672,790.0	27%
Draft power contribution	Lakh days	2.1	0.2	-92%

Source: Based on LSA results

The additional milk production in 2032–33, about 69%, predominantly comes from the crossbreed cattle followed by buffalo which contribute about 42% of the additional milk. The milk production from local cattle breeds is projected to be about 43% lower in 2032–33 and contributes only about 5% of the total milk production in 2032–33.

The major red meat products are buffalo and goat meat. The production of the dressed buffalo carcass increases from 76.3 thousand MT in 2017–18 to 110.35 thousand MT in 2032–33, a 45% increase, whereas goat meat increases from 29.9 thousand MT in 2017–18 to 51.1 thousand MT in 2032–33, a 71% growth. Overall, sheep and pork meat production are very low in Bihar state. While the sheep meat production increases from 599 MT in 2017–18 to 723 MT in 2032–33, pig meat production is projected to decrease by 38% in the final year, 2032–33. Over the period of 2017–18 to 2032–33, poultry meat production increases by 207%, which is predominantly due to an increase in the population of layers as well as broilers. Similarly, egg production increases by 2,234% over the same period, largely due to a significant increase in the population of layers.

Table 22: Red meat production in MT by production zones, 2032–33 BAU

Livestock production zones	Buffalo	Sheep	Goat	Total	% red meat
Northern	47,507	111	27,651	75,269	46.4%
Central	48,837	387	16,436	65,661	40.5%
Southern	14,002	225	6,975	21,202	13.1%
Total red meat	1,10,347	723	51,062	1,62,132	

Source: Based on LSA results

Overall, based on the figures shown in Table 21, under BAU, livestock products from improved livestock species become dominant in 2032–33.

Table 22 shows the red meat contribution of each zone to the state red meat production in 2032–33 BAU. Central and Northern livestock production zones are almost equally important in terms of red meat production.

Despite ample forage feed availability, the Southern livestock production zone contributes only about 13% of the total red meat production in the year 2032–33.

Table 23: Milk production by production zones and species, 2032–33 under BAU

Livestock production zones	Species	Milk in crore litres	% of total
Northern	Cow	138.1	10.9%
	Buffalo	213.3	16.8%
	Goat	17.7	1.4%
	Subtotal	369.0	29.2%
Central	Cow	543.3	43.0%
	Buffalo	225.4	17.9%
	Goat	10.0	0.8%
	Subtotal	778.7	61.7%
Southern	Cow	55.3	4.4%
	Buffalo	54.0	4.3%
	Goat	3.8	0.30%
	Subtotal	113.1	8.9%
Commercial		1.4	0.11%
Total		1262.3	100%

Source: Based on LSA results

Similarly, the Central and Northern livestock production zones are projected to lead in milk production in 2032–33 BAU. Table 23 shows milk production by production zones and species. Under the BAU scenario, about 91% of the total milk production in 2032–33 comes from the Northern and Central livestock production zones.

Projected livestock GSDP (in 2032–33 under BAU)

The total livestock VA or livestock GSDP at production stage in 2032–33 is projected to reach 28,000 crore, which is a 46% growth over the 2017–18 value. Table 24 shows the distribution of the livestock GSDP across the 2different livestock commodities.

Like the 2017–18 situation, livestock wealth in Bihar state in 2032–33 BAU is accumulated in milk (both cow and buffalo). Cow and buffalo milk production contributes about 70% of the total livestock GSDP. If VA from organic matter are included, the contribution of cattle and buffalo to the livestock GSDP increases to about 86% of the total.

Table 24: Livestock GSDP in 2032–33 under BAU

Commodity	VA (in INR crore)	Per cent of total
Cow milk	10,229	36.4%
Buffalo milk	9,459	33.7%
Buffalo meat	722	2.6%
Sheep meat	17	0.1%
Goat meat	1,464	5.2%
Pork meat	122	0.4%
Poultry meat	915	3.3%
Eggs	557	2.0%
Hides and skins	145	0.5%
Wool	3	0.01%
Organic matter	4,437	15.8%
Draft power	1	0.004%
Total	28,071	100%

Source: Based on LSA results

The distribution of the gross VA or GSDP of the commodities that are generated from the different livestock species over the three main livestock production zones and specialized sector is provided in Table 25 below. For example, cattle and buffalo in the Central and Northern livestock production zones contribute to more than 80% of the value addition.

Compared to the 2017–18 baseline situation, the total contribution of goats and chicken increases 71% and 172%, respectively, while the contribution of pigs decreases by 37%. Overall, under the BAU scenario, the cattle and buffalo production systems remain dominant and important in the state of Bihar.

Table 25: Share of livestock GSDP by zone and species, in 2032–33 under BAU

Livestock production zones	Cattle	Buffalos	Sheep	Goats	Chickens	Pigs
Northern	5.9%	20.8%	0.01%	3.1%	1.4%	0.4%
Central	36%	20%	0.05%	1.7%		
Southern	2.6%	4.8%	0.03%	1.0%		
Commercial	0.1%				2.1%	0.01%
Total	44.5%	45.6%	0.1%	5.8%	3.5%	0.4%

Source: Based on LSA results

4.4 Projected consumption and consumption preferences

Projected consumption of livestock products

Projections of future production and consumption gaps for the major livestock products (meat and milk) without any additional policy or technology interventions beyond current trends (the BAU scenario) were made to assess the size of the future supply and demand gaps. This projection is critical to anticipate the magnitude of required future investment in livestock R&D interventions (policies and technologies), which will be required to close any production-consumption gaps.

The estimation of current and projected consumption requirements of livestock products requires the base year information on quantities of livestock products consumed by households, income elasticity of demand for different livestock products, the growth rates of real per capita GDP and human population.

Accordingly, given the income elasticity of demand (η) for a given livestock product, trend annual growth rates (γ) of real per capita GSDP, and baseline per capita consumption (LC0) of a given livestock product, the projected per capita livestock product consumption (LCt) for a given year t is based on the following formula:

$$(1) \quad LC_t = LC_0 * (1 + \eta * \gamma)^t$$

The projected total consumption (TLCt) of a given livestock product in time t is obtained by multiplying the projected per capita consumption with the projected population (POPt) for a given time t:

$$(2) \quad TLC_t = LC_t * (1 + \eta * \gamma)^t * POP_t$$

The following sections provide brief discussion of the steps used in the derivation of important variables used in estimating the current and the projected future consumption of livestock products in the state of Bihar.

First, the baseline per capita annual consumption (LC0) data for livestock products in the state of Bihar was not available for the base year 2017–18. The most recently available per capita annual consumption data are from the NSS 68th round conducted during 2011–12 and the results are summarized in Table 26. As shown in Table 26, during 2011-12, the average state per capita liquid milk and total milk and milk product consumption was about 48 and 58 litres/annum, respectivelly. The per capita milk and milk product[10] consumption was slightly higher for the urban areas than the rural areas of the state of Bihar. Similarly, the per capita consumption of

10 Total milk and milk products include liquid milk and other milk products such as ghee and curd.

eggs in urban areas, about 15 eggs/annum, was slightly higher than in rural areas, about 12 eggs/annum. The average state per capita goat meat/mutton and buffalo meat consumption was 0.6 kg/annum and 0.4 kg/annum, respectively; as such there was no clear difference between urban and rural areas.[11] The per capita consumption of pork in rural areas was 0.04 kg/annum and, in contrast to other livestock products, the per capita annual consumption of pork was higher for rural areas than urban areas.

Table 26: Per capita consumption of livestock products in the state of Bihar during the year 2011

Livestock products	Rural	Urban	Average
Liquid milk (litres)	47	49	48
Egg (numbers)	12	15	13
Goat meat/mutton (kg)	0.6	0.70	0.6
Buffalo meat (kg)	0.3	0.4	0.4
Pork (kg)	0.04	0.01	0.02
Chicken (kg)	2	2	2
Milk and milk products (litres)[12]	63	54	59

Source: NSS Report No. 562 (2015)

Second, the average per capita income computed by the Bihar directorate of economics and statistics (Table 27) is used as state average per capita income. Accordingly, the computed trend in annual growth rate in real per capita GSDP over the period from 2012–13 to 2015–16 is used; the computed annual growth rate in real per capita GSDP (γ) was 3.4% for this period (Table 27).

Third, the income elasticity (η) parameters used in the projections of consumptions of different livestock products are based on previously estimated national or state level income elasticities. There are several studies that estimated elasticities for livestock products to project the demand for livestock products at national or state levels. Most of the recent studies have used the household consumer expenditure data from NSS 67th round and NSS 68th round conducted during 2004–05 and 2011–12, respectively. The income elasticities used to project the consumption of livestock products in the state of Bihar were identified from studies that used the most recent data (NSS 68th round) and studies that derive elasticities that closely reflect the consumption patterns of livestock products in the state of Bihar. Among the many studies that estimated the income elasticities of livestock products in India, the study by Chengapa et al. (2016) is the only study that used the most recent household consumer expenditure data, NSS 68th round. Thus, the income elasticity estimates for milk, chicken, eggs and pork are based on the study by Chengapa et al. (2016). The income elasticities for beef/buffalo and goat/mutton from the same study, however, do not reflect the livestock product consumption pattern of the households in the state of Bihar. Hence income elasticities from the study by Gandhi and Zhou (2010), which used household consumer expenditure data from 2004–05 NSS 67th round, were used instead.

11 The available data for buffalo meat consumption did not distinguish local vesrsus export demand, while the majority of this product is likely to be exported. Thus the per capita consumption figures provided for urban and rural demand cannot be considered reliable.

12 Milk and milk product include liquid milk, curd and ghee. The amount of curd and ghee was converted to liquid milk equivalent based on sources available at https://www.quora.com/How-much-milk-is-required-to-produce-1-kg-of-ghee.

Table 27: Trends in annual population and GSDP growth rates for Bihar state (2011–2012 to 2015–2016)

Year	Total population (in lakh)	Annual population growth rate (%)	GSDP (INR crore)	Per capita GSDP (INR)	Growth rate in per capita GSDP (%)
2011–12	1,050		2,471	23,525	
2012–13	1,070	1.58%	2,569	24,068	2.3%
2013–14	1,080	1.58%	2,696	24,874	3.3%
2014–15	1,100	1.58%	2,795	25,379	2.0%
2015–16	1,120	1.58%	3,006	26,868	5.9%
Average	1,084	1.58%	2,707	24,943	3.4%

Source: Bihar directorate of economics and statistics (2016)

Accordingly, the rural and urban per capita consumption of the respective livestock products for the year 2011–2012 (Table 26), the average growth rate in per capita GSDP (%) (Table 27) and respective income elasticity (Table 28) were used in equation (1) to project the rural and urban per capita consumption of livestock products for the base year 2017–18. The total rural and urban consumption of each livestock product was calculated separately using equation (2). Finally, to arrive at the state level or aggregated per capita consumption of each livestock product, for the base year, the sum of total rural and total urban consumptions of each livestock product was divided by the 2017–18 total state population.

Table 28 shows the income elasticities of livestock products used in projecting the consumption of livestock products. For all livestock products except pig meat, the signs of income elasticities of demand are positive indicating that all the livestock products considered are normal goods—the demand for these products increase as income increases. In contrast, the sign of the income elasticity of demand for pig meat is negative, indicating pig meat is considered as inferior meat. Pig meat is mostly consumed by low-income communities in rural areas; its consumption in urban areas is very low (Table 26).

Table 28: Income elasticities of livestock products

Livestock products	Rural	Urban	All
Milk and milk products	1.2	1.3	1.3
Eggs	2.6	2.1	1.5
Goat meat/mutton	1.3	1.3	1.3
Buffalo meat	1.0	1.0	0.9
Pork	-0.3	-2.6	-1.1
Chicken	2.0	1.2	2.2

Source: Chengapa et al. (2016) for milk, chicken, eggs and pork; Gandhi and Zhou (2010) for beef/buffalo and goat/mutton

Second, the population of Bihar for the baseline year was not available. The last census in India was conducted in 2011. Therefore, the projected human population was based on the state level population data estimated for

the years 2011–2012 to 2015–2016 by the Bihar directorate of economics and statistics (Directorate of Economics and Statistics 2016). Table 27 shows the population data published by the Bihar directorate of economics and statistics for the years 2011–2012 to 2015–2016.

The total human population for the year 2011–2012 was about 1,050 lakh and is expected to grow annually by 1.58% to reach 1,150 lakh in 2017–2018 base year, and 1,460 lakh in the year 2032–2033 (Table 29). A separate urban and rural population was used to arrive at aggregated per capita consumption of livestock products for the baseline year 2017–2018. To do so, an annual urbanization rate, the proportion of total human population living in the urban areas, of 11.3%[13] was used to compute urban and rural populations from the aggregate population estimated by the Bihar directorate of economics and statistics (Table 27).

Table 29: Projected total population size (in lakhs) in Bihar state (2017 and 2032) used in obtaining the projected total consumption figures for different livestock products

Year	Rural population (lakhs)	Urban population (lakhs)	Total population (POPt) (lakhs)
2017	930	220	1,150
2032	370	1,090	1,460

Source: Bihar directorate of economics and statistics

Table 30 presents the baseline and projected per capita consumption of livestock products in Bihar state, 2017–2018 to 2032–33. Except for pork, significant increase in per capita consumption is expected for all livestock products between 2017–2018 and 2032–33. However, it is important to note that the percentage change in per capita consumption between 2017–18 and 2032–33 is greater than 100% for eggs and chicken. At the state level, the highest growth per capita consumption of livestock products is projected for chicken, followed by eggs and goat meat/mutton. For milk and milk products and buffalo meat, the per capita consumption is projected to grow by 86% and 58%, respectively, between 2017–18 and 2032–33. To the contrary, the consumption of pig meat is expected to decrease by 42% between 2017–18 and 2032–33.

Table 30: Current and projected future annual per capita consumption of livestock products in Bihar 2017–18 to 2032–33

Livestock products	Annual per capita consumption		Growth in per capita consumption
	2017–18	2032–33	(%), 2017–18 to 2032–33
Milk and milk products (litres)	78	146	86%
Egg (numbers)	20	42	107%
Goat meat/mutton (kg)	0.8	1.6	95%
Buffalo meat (kg)	0.4	0.6	58%
Pork (kg)	0.03	0.02	-42%
Chicken (kg)	3	9	200%

Source: LSA calculations

13 In the absence of a strong nonagricultural sector, despite a large population, the urbanization rate in Bihar is just 11.3% as of 2011, vis-à-vis 31.2% for all-India (Kumar and Punia, 2014; International Growth Centre 2014).

Current and projected production and consumption of livestock products under business as usual (BAU)

Table 31 shows the current and projected state-level total production and total consumption of livestock products at current investment rates (BAU) for the base year 2017–18, and final year 2032–33. The estimation of the current and projected future livestock production was made using an Excel-based deterministic herd/flock growth model built in the LSIPT. The main data required in the herd/flock model are the size of livestock population for the reference (base) year and the herd/flock survival rates are derived based on technical parameters relating to births, deaths and offtake rates. In turn, the baseline technical parameters for different production systems by herd/flock size classes are based on the review of grey literature and expert opinions.

The results for projections of the production and consumption of meat and milk over the coming 15 years BAU are presented in Table 31. Over the next 15 years, the total consumption of goat meat/mutton is projected to grow by 147% from 93,000 to 2,31,000 MT. While this projected change in consumption seems high, by 2032–33, the estimated population will have increased to 1,460 lakh. This accounts for an average annual meat consumption of 1.6 kg per year. Similarly, despite very low per capita consumption of buffalo meat, 0.6 kg per annum, the total buffalo meat consumption is projected to grow by 100% from 44,000 to 88,000 MT.

Considering differential growth rates from the different production systems, the production of goat meat/mutton and buffalo meat is projected to grow by about 71% and 45%, respectively. Thus, in 2032, domestic production of goat meat/mutton is expected to cover only 22% of the required consumption. It is estimated that there will be about an 1,80,000 t goat meat/mutton gap between production and consumer demand. The low consumption in buffalo meat allows the domestic production to cover 125% of the total demand in 2032–33, an excess of 22,000 MT which could be exported to international markets. The buffalo meat exports from Bihar (22,000 t) is approximately 2% of the total 2017-18 Indian buffalo meat export, which is 13.50 lakh MT (DGCIS, 2018). According to the 2017-18 report of the Indian Directorate General of Commercial Intelligence and Statistics (DGCIS), the top five Indian buffalo meat export destinations are Vietnam, Malaysia, Egypt, Iraq and Saudi Arabia.

Table 31: Current and projected production and consumption of livestock products BAU 2017–18 to 2032–33

Livestock product	Production		Consumption		Per cent (%) change (2011 to 2016)		Production as a percentage (%) of consumption	
	2017	2032	2017	2032	Production	Consumption	2017	2032
Milk and milk products (lakh litres)	89,630	126,230	90,480	213,920	41%	136%	99%	59%
Egg (lakhs)	4,100	95,760	23,640	62,200	2,234%	163%	17%	154%
Goat and mutton (thousand MT)	30	51	93	231	71%	147%	32%	22%
Buffalo (thousand MT)	76	110	44	88	45%	100%	173%	125%

Livestock product	Production		Consumption		Per cent (%) change (2011 to 2016)		Production as a percentage (%) of consumption	
	2017	2032	2017	2032	Production	Consumption	2017	2032
Pork (thousand MT)	44	28	3	2	-38%	-26%	1,334%	1,120%
Chicken (thousand MT)	62	190	353	1,340	207%	280%	18%	14%

Source: Own calculation

A similar pattern is also observed for the projected future consumption of milk. The consumption of milk and milk products is projected to grow by 136% from about 905 crore litres in 2017–18 to 2,139 crore litres in 2032–33. Similarly, the domestic production is projected to grow by 41% from 896 crore litres in 2017–18 to 1,262 crore litres in 2032–33. The domestic milk production is thus expected to cover only about 59% of the total consumption requirements representing a milk production-consumption gap of 877 crore litres.

While the total consumption of eggs is projected to grow by 163% from 236 crore eggs in 2017–18 to 622 crore eggs in 2032–33, the total domestic production of eggs in Bihar is projected to increase by 2,234% from 41 crore eggs in 2017–18 to 958 crore eggs in 2032–33, which is projected to cover 154% of the domestic requirement. The egg production excess is expected to be 3,36 crore eggs in the year 2032–33.

Chicken consumption is projected to grow rapidly in the state of Bihar. The total consumption of chicken in the state is projected to reach 13 lakh MT in the year 2032–33, an increase of 280% from the year 2017–18. Although the domestic production increased in a similar pattern, by 207%, the total quantity of chicken meat production projected in the year 2032–33, 1.9 lakh MT, is expected to meet only about 14% of total consumption requirements of the state, 13 lakh MT. Thus, it is expected that there will be a gap of about 12 lakh MT of chicken meat in the year 2032–33.

Total pig meat consumption and production is projected to decrease by 26% and 38%, respectively, in the year 2032–33. Despite the decline in total pig production in the year 2032–33, total pig meat production is expected to exceed the total consumption requirement by 1,119%. There may be opportunites for exports to other states, such as in the Northeast.

In general, the 15-years production and consumption projections under BAU indicate significant production gaps in milk, goat meat/mutton and chicken meat.

Effects of gender and cultural patterns on consumption behaviour

Traditionally, people in India, including in Bihar, have a diet based on grains and vegetables, and consume limited amounts of meats and meat products (Devi et al. 2014). The recent economic growth and introduction of western culture have changed the food consumption habits. There are wide variations in the consumption of different livestock products. Cultural differences and religious belief are mainly responsible for variation in meat consumption patterns in Bihar. Dietary habits of Indians are significantly influenced and controlled by traditions, customs and taboos. This is a strong factor of influence especially in rural societies.

Regarding consumption of milk and milk products, almost one-third of Indians especially in the northern states follow lacto-vegetarianism where milk and milk products are an important source of protein. Increased

production of milk through the White Revolution facilitated this consumption pattern. There are no taboos attached to milk consumption and it is accepted by all classes of people.

There are variations in the consumption of meat products which include beef, chicken, goat meat, mutton and buffalo. This is due to cultural and religious differences within society. In Bihar, 82.7% of the population are Hindu and 16.8% belong to the Muslim community. Hinduism bars beef consumption and Islam bars pork consumption. The Hindu community considers the cow a sacred animal so killing of cow is banned in Bihar. Buffalo meat is only consumed by the lower caste communities, specifically the SC and ST.

Chicken meat is consumed at a higher level than other meat products because it is accepted by both Hindu and Muslim communities. Presently, poultry production is growing rapidly in India, making it a cheap source of protei. Chicken meat is considered an important dish during festivals for all classes of people.

Pork is considered an important source of protein among tribal communities. There is a traditional practice of cooking pork during festivals and marriages in these communities. They have a system of distributing pork among the villagers. This meat is considered the cheapest among tribal communities. Pork is not preferred by Muslims and the majority of most Hindu communities, except the lower caste such as ST and SC within these communities.

Even though goat meat is acceptable by some members of both Hindu and Muslim communities, the consumption of goat meat is low in Bihar due to high cost. Goat meat is consumed by the better-off households or those who rear these animals. Lower caste SC and ST households rear goat to sell in the market rather than for their own consumption (ILRI FGDs 2018).

About 48% of children under the age of five are stunted or too short for their age, which indicates that they have been undernourished for some time. Undernutrition is particularly common in the younger age groups, in rural areas and among scheduled caste women (Government of India 2016). The malnutrition in Bihar is higher than in any country in the world (von Grebmer et al. 2011). Poor growth and anaemic conditions are very common given that the diet is deficient in micronutrients of vitamin A, vitamin B-12, riboflavin, calcium, iron and zinc. ASFs are rich in these micronutrients; small amounts in a daily diet would provide adequate nutrition (Murphy and Allen 2013).

Women's role in livestock care and animal husbandry affects household food security. A recent study by Jumrani and Birthal (2015) indicates that livestock ownership by household does not automatically improve household nutrition. There is need for intrahousehold distribution of income. This study also reports that income control by women from livestock production significantly reduces malnutrition among children. Households where women oversee animal production, especially dairy animals, have better household nutrition (Jumrani and Birthal 2015). There is strong evidence that the consumption of dairy products has a strong marginal effect on child nutrition. These effects are particularly stronger for children between 6 and 24 months of age who are no longer exclusively breastfed and have high physical growth potential (Bhutta et al. 2013). Traditionally in Bihar, women and female children eat last after the male members have finished the meal (Desai and Vanneman 2012). This leads to undernutrition for female children and women. This is practised among the higher caste households even more than in ST/SC households.

Gender and social implications of the projected production and consumption of livestock products

When we see the projection of milk and milk products, only 59% of consumption requirements will be met through state production in 2032 under the BAU scenario (Table 31). This may have negative implications for the poorest, as products will have to be imported with a possible increase in consumer price. Therefore, the

poorest, especially lower caste communities, SC and ST communities are likely to be most affected.

There may also be negative social implications as chicken and goat meat demand will also be higher than the production, with only 14% and 22% of consumption requirements met by state production under the BAU scenario. On the other hand, the other livestock products may be more available and affordable, as the production from Bihar of buffalo meat (125%) and pork (1,120%) is expected to be higher than projected consumption requirements. This is of relevance to the poorest and lower caste communities like SC/ST who consume more of such meats, compared to other communities. Eggs are also projected to be more available, given the large increase in supply compared to the expected demand.

In each case where there is higher demand than projected supply, i.e. as projected for milk, goat meat/mutton and chicken meat, communities will have an opportunity to fulfil the supply through increased production. In these cases, because women often perform much of the labour in livestock production, it will be important to understand the demands on labour for women and to ensure that women will benefit from the labour they are providing. However, this could also open opportunities for women to start up small to medium businesses to supply the medium-sized towns and markets with products such as eggs and chicken meat.

Even though there is an increased trend of diversification among the poorest due to increased income, levels of nutrition deficiency remain high in India (Kumar et al. 2016). This is obvious with households living below the poverty line where protein deficiency is 53%. Inequitable distribution of food among different segments of the population and lower income levels are the major factors for undernourishment in the poorest households. The consumption expenditure data from the NSS (Table 32) by land-holding size in Bihar show that consumption expenditures among the marginal households, especially lower caste households like SC and ST, are lower than the other caste groups. Moreover, the smallholders in the SC/ST communities have lower consumption expenditures compared to marginal farmers of other caste groups.

Table 32: Consumption expenditures by land holding and social class in Bihar (INR)

Size class of land	SC/ST	OBC	Others
Landless<0.02	4,287	4,412	4,569
Marginal<1 ha	3,832	5,127	5,837
Small 1-2 ha	4,291	6,098	6,753
Medium 2-4 ha	6,938	8,111	7,750
Large>4 ha	9,578	12,281	12,287

Source: NSS Report No. 576: Income, Expenditure, Productive Assets and Indebtedness of Agricultural Households in India 2012-13

5 Livestock sector improvement strategies

The animal husbandry sector plays an important role in the economic development of the state of Bihar. Livestock production, however, confronts several constraints including poor quality of animal germplasm, frequent occurrence of diseases and acute feed and fodder scarcity. Moreover, many socio-economic and institutional factors such as underdeveloped veterinary and breeding infrastructure, shrinking common lands and lack of farmers' access to markets, credit and information, restrict farmers from realizing the production potential of their animals. Overcoming these challenges requires evolving suitable development strategies and targeting thereof to the regions and species that have potential to generate significant economic and social gains without causing any damage to the environment and natural resources (Singh 2013).[14]

In the second animal and fisheries sector of the agricultural road map (2017–22), efforts were made to identify problems faced in achieving the targets set for the period 2012–17, as well as the type of measures that need to be taken. In the following section prior to addressing the measures/interventions by production zone, the challenges and opportunities as well as the complementary success requirements are presented by a) major commodity value chains, b) species of livestock and c) category: feed, animal health and genetics.

Section 5 consists of five sections on commodity value chains: dairy (5.1), buffalos (5.2), goats (5.3), chickens (5.4) and pigs/pork (5.5). Section 5.6 is specifically focused on the post-production investment strategies for each of the commodities i.e. dairy, buffalos, goats and chickens. Section 5.7 addresses some of the strategies and challenges from the perspective of gender and social inclusion in Bihar. Under each commodity value chain, the challenges, opportunities and strategies are outlined. Where appropriate, the challenges and opportunities as well as complementary success requirements are contextualized to the livestock production zones, i.e. Northern, Central and Southern.

The contents of this chapter, particularly the strategies/interventions proposed to address the challenges are further detailed in Section 6 of this report. The interventions are quantified and incorporated to develop intervention scenarios for the quantitative analysis. The interventions identified were also aligned with the outlined measures for livestock improvement in the agricultural road map of 2017–2022.

5.1 Cattle value chain improvement strategies

The development of the livestock and the dairy sector is important to enhance the rural economy and to further decrease poverty (Hardenberg 2016). The low animal productivity in Bihar is due to several different factors, including poor animal health and insufficient feed and fodder (Singh 2013). Research and improvement of these constraints are crucial to obtain better productivity in the dairy sector (Hardenberg 2016).

14 Singh, R. K. 2013. Livestock Research and Development Priorities for Bihar and Odisha. Available at SSRN: https://ssrn.com/abstract=2391607 or http://dx.doi.org/10.2139/ssrn.2391607

The state has made significant strides in milk production, however, the milk productivity level in the state is still very low. This may be attributed to the low percentage of crossbred and other improved varieties within the bovine population even with increased introduction of more crossbred varieties for increasing milk production as demand within the state is increasing rapidly with growing urbanization and increase in per capita income. Moreover, increased milk production generates additional income to the marginal and landless households, besides dairy farming providing additional employment to rural women (Government of India 2008).

Challenges: cattle

Challenges to cattle production exhibit differences by production zones and systems (Table 33). The challenges of cattle production from specialized farms, i.e. those more commercially oriented with improved breeds and higher blood level of exotics, especially in terms of feed and animal health, are linked to concentrate availability, and mastitis and protozoal diseases (Tables 33 and 34).

Table 33: Challenges of cattle production by production zones

Category	Northern zone	Central zone	Southern zone
Feed	Scarcity of feed and fodder during two to three months of flood time March to June lack of availability of green fodder, lack of quality fodder seeds	High density of cattle population and limited grazing land, lack of availability of quality feed Fluctuating prices of dry fodder (INR 4-12/kg).	Low milk production Scarcity of green fodder[15] Insufficient rainfall impacting feed and low-quality feed
Animal health	Mortality, high parasite infestation, alkali disease due to toxicity of selenium e.g. paddy straw, low mineral contents in feed and fodder	Insufficient animal health services (disease control, treatment), high incidence of protozoan disease, no timely deworming and vaccination	Young mortality, disease affecting cows, villages are scattered and low veterinary services coverage
Genetics/ breeding	Low productivity, repeat breeding and anoestrus	Low productivity	Lack of improved types of cattle

Challenges: cattle in specialized commercial dairy

The herd size of the commercial dairy operations in Bihar ranges between 16-100. The average herd size is about 30 heads. Although smallholder dairy farms is the dominant source of milk in Bihar, the increasing growth in bigger dairy operations is a welcome trend in dairy development from the perspective of productivity gains. The increase in milk production is mainly from the increase in the number of crossbred cattle, and there is a steady increase in artificial insemination (AI) service delivery over the years. The major challenge for commercial dairy is access to credit. Other challenges are covered in Table 34 and opportunities are included in table 35:

15 South and southwest Bihar are more vulnerable and often experience severe drought situations (source. http://bsdma.org/Know-Your-Risk.aspx?id=4).

Table 34: Challenges to commercial dairy in Bihar state

Category	Challenges: cattle specialised
Feed	Low quality of the concentrate feed (>100 feed plants, but feed produced does not meet requirement of cows)
Animal health	Mastitis (clinical and subclinical), heavy protozoan infestation (trypanosomiasis, Babesios, theileriosis, anaplasmosis etc.)
Genetics/ breeding	Lack of quality animals for herd replacement and establishing new farms, anoestrous and repeat breeding are key reproductive performance problems

Table 35: Opportunities for cattle dairying in Bihar state

Species	Northern zone	Central zone	Southern zone
Cattle dairy	Due to availability of water and hedge areas there is potential for growing green fodder, labour is available, milk bulk chilling infrastructure development in progress in certain places	Availability of green and dry fodder (paddy and wheat straw), good milk yield from cows, good market for milk and products, well-developed infrastructure of COMFED, farmers more commercially oriented	Large area of land available for grazing, labour is available, high demand for milk and milk products

Key strategies to address cattle production challenges

The strategies to address the key challenges (Table 36) vary from the flood-prone north Bihar villagesto the drought-prone south Bihar villages. Although conservation of forages is key in the Northern and Southern production zones, there is a need to improve the quality of existing feed resources. Availability of veterinary services and timely vaccination as well as calf management are areas needing attention. Addressing calf mortality remains a vital step forward.

Table 36: Key strategies to address challenges: cattle (by zone)

Category	Northern zone	Central zone	Southern zone
Feed	Conservation of forage to address feed shortage during the 2-3 months of flooding, establishment of fodder banks, complete feed block development (green fodder, concentrate, dry fodder and mineral mixture), cultivate perennial grasses–Napier cross, import fodder seed from other states e.g. Berseem, sorghum etc., improve productivity/ha of land, where possible increase land area under fodder, supply of improved seeds	Availability of green fodder during lean period (April–June), conservation of green fodder in form of hay and silage, buffer stock of feed for scarcity period, ensure availability of concentrates in market year-round, improve the nutritional value (treatment using chemicals) of less utilizable dry fodders e.g. maize Stover, Kadbi etc.	Production of fodder (Napier, sugarcane grass, hybrid Napier, sorghum, Moringa Olerifera), establish cattle feed plants for provision of concentrates and rations for milking cows required, develop complete feed block (brick) total mixed ration, improve the poor-quality forages through treatments

Category	Northern zone	Central zone	Southern zone
Animal health	Improve management at farmers' level (all), sufficient quantity of colostrum feeding at the right time (calf), control of roundworm infestation (calf), control of all worm infestation (all), vaccination against highly infectious disease (haemorrhagic septicaemia (HS), black quarter (BQ), FMD etc.) at proper age and time, equipment for proper drainage of water from paddy fields and less use of paddy straw from water logged fields, supplementation of area specific minerals	Increase availability of vet services through seasonal health camp at village level, strengthen and operationalize the existing sub-divisional level diagnostic facilities, establishment of referral diagnostic lab at district level, make round the year calendar on deworming, vaccination (HS, BQ, FMD and Brucellosis) activities	Improve calf management (see Northern), more veterinary services required (see Northern)
Genetics/ breeding	Grading up of local breeds, crossbreeding-AI facility with good quality semen, increase the number of semen production centres and AI centres, reproductive management interventions	Selection among the local breeds, crossbreeding	Up grading by using better-milk producing Indian cattle breeds, crossbreeding program

5.2 Buffalo value chain improvement strategies

Although the local cattle population in the state of Bihar has been declining, the buffalo population has been growing but only marginally; this is attributed to slow increase in productivity, and inadequate attention to making the bulls and semen available (National Dairy Development Board 2008).

Table 37: Challenges to buffalo production in Bihar state

Category	Northern zone	Central zone	Southern zone
Feed/fodder	Diet not nutritionally balanced	Feed shortage due to reduced access to grazing because of rise in water level during rainy season	Diet nutritionally low
Animal health	High calf mortality due to high roundworm infestation, negligence by owners, lack of awareness of veterinary services available, lack of adequate information/knowledge on buffalo diseases by producers	Mortality in juveniles	Like Northern
Genetics/ breeding	Occurrence of silent heat and inability to detect heat cases, buffalos are majorly nondescript breeds, high dependence on natural service, little knowledge on AI	Milk yield is low, local breeds need improvement, farmers sticking to natural service/mating	Local breeds of buffalo with low milk yield, population is also low, infertility is high

Table 38: Opportunities for buffalo production in Bihar state

Species	Northern zone	Central zone	Southern zone
Buffalo meat and milk	Availability of grazing land, natural habitat for people rearing buffalos, more buffalo milk in the area compared to cattle, buffalo milk fetches good price	Either side of Ganges river is suitable for buffalo, buffalo stay close to the banks (dairy area), where the market for buffalo milk is available (demand is more and so is population)	Large open area for grazing

Table 39: Key strategies to address buffalo production challenges

Category	Buffalo
Feed	Supplementation of concentrate according to milk production, provision of mineral mixture
Animal health	Strengthen vaccination programs, improve housing and management, provision of veterinary service at village level, strengthen the animal husbandry extension facility
Genetics/ breeding	Develop technique to detect silent heat timely, upgrade using Murrah[16] and Nili-ravi[17] breeds, provide one breeding bull at every panchayat level whose dam line is producing 3,000 litres milk/lactation, develop further methods of processing and extending buffalo semen
Extension	Train farmers on housing, management and record keeping, strengthen the animal husbandry extension facility, raise awareness on the value of AI efficiency and cost effectiveness

5.3 Goat value chain improvement strategies

Bihar contributes about 7.6% to India's total goat population, however, goat rearing is mostly confined to marginal groups and landless labourers who are unable to rear large animals. There is a considerable scope for developing goat rearing into an industry. Generally, the current herd size is one to three goats per family depending on availability of surplus labour. The village goat is mostly the Bengal breed. However, crosses with other breeds like Jamunapari, Barbari, Sirohi and Jakharana are also available (Dey et al. 2007). The study indicated the need to conserve native breeds, change management practices, address health care, marketing, credit and insurance access, and foster awareness and provide training for scientific goat farming.

Table 40: Challenges to small-size goat production in Bihar state

Category	Northern zone	Central zone	Southern zone
Feed	Complete grazing-based goat rearing, no supplementation of concentrates, scarcity of feed resources during flooding	Scarcity of community grazing land	Low biomass, inability to supplement concentrate due to affordability
Animal health	Extremely high mortality rates (30-40%), high incidence of internal and external parasites, lack of awareness on economic loss due to (PPR), goat pox, enterotoxaemia etc.	Lack of awareness and unavailability of facilities for deworming and vaccination	Very limited availability of vet services

16 The Murrah buffalo is a breed of domestic buffalo which originated from India. It is a popular dairy buffalo breed and kept mainly for milk production. For more information see: http://www.roysfarm.com/murrah-buffalo/.

17 The Nili-Ravi buffalo is a breed of domestic buffalo similar to the Murrah buffalo. It is concentrated in the Punjab. It is mainly a dairy buffalo breed used principally for milk production. The Nili-Ravi buffalo breed dates back to the Indus River Valley civilizations when they were two different buffalo, Nili and Ravi. However, due to coincidental standards, both buffalo breeds looked very similar and it became hard to distinguish the two. The two breeds became one, Nili-Ravi in 1950. For more information see: http://www.roysfarm.com/nili-ravi-buffalo/.

Category	Northern zone	Central zone	Southern zone
	Absence of timely/adequate veterinary services (access to preventive health care), diagnostic facility not fully functional, goat rearers either landless or small landholders (~0.38 ha)		
Genetics/ breeding	Small size and body weight of the nondescript local breeds, limited research on local breeds improvement, Black Bengal has good quality meat but size is small, lack of quality bucks	Small size and body weight of the nondescript local breeds, limited research on local breeds improvement, Black Bengal has good quality meat but size is small, lack of quality bucks	Population of unimproved local nondescript goats is higher in this zone

Table 41: Challenges to medium-size goat production in Bihar state

Category	Northern zone	Central zone	Southern zone
Feed	No scientific feeding practices are followed, little concentrate is given to goats	Feed shortage, scarcity of community grazing land	Low biomass and limitation on access to land, inability to supplement concentrate due to affordability and goat rearing is a zero input
Animal health	Lack of awareness about preventive goat health care and its management, lack of timely deworming and vaccination which increase the risk of mortality	High load of parasites/, lack of awareness on economic loss due to PPR, goat pox, enterotoxaemia etc., lack of timely and complete vaccination, diagnostic facility not fully functional	Very limited availability of vet services
Genetics/ breeding	Lack of good quality Black Bengal bucks, indiscriminate breeding leading to inbreeding, natural breeding is followed with available bucks in most villages	Like Northern zone	Population of local nondescript goats is higher in this zone

Table 42: Opportunities for goat production in Bihar state

Species	Northern zone	Central zone	Southern zone
Goat meat (small)	Abundant grazing resources, growing demand for goat meat likely to outstrip supply, availability of labour, need to diversify incomes, income generation potential for scheduled castes, northwestern Bihar people are engaged in goat marketing including bulk sales to other states and Nepal	More urbanization and literacy, more awareness on the value of concentrate as supplement, availability of market, higher population of improved goats, low incidence of external and internal parasites	Favourable topography and conducive environment, a high proportion of landless wanting to keep goats, more open land is available
Goat meat (medium)	Women play a major role in goat rearing and management, medium and large producers have the capacity to contribute more to production of goats and possess the potential to become entrepreneurs in goat rearing Demand will outstrip supply, thus creating new opportunities for productivity increasing technologies and increasing incomes		

Table 43: Key strategies to address challenges in goat production

Category	Goats medium size
Feed	Grow good green biomass-producing trees on a small portion of land, practice stall feeding, follow scientific lopping practices, increase amount of concentrate in goat feed, explore use of nonconventional feeds e.g. Azolla
Animal health	Awareness generation on vaccination, deworming and other preventive care of goat diseases through *Pashu Sakhi*, timely deworming and vaccination of goats, use og right solution for deworming goats i.e. faecal sample testing, development of separate, simple and scientific goat house/Machan
Genetics/ breeding	Black Bengal breed of goat needs to be conserved, selection of Black Bengal type bucks from within the herd from same area, inbreeding needs to be checked (discourage service with unwanted available bucks), castration of scrub bucks to discourage inbreeding

Table 44: Complementary success requirements for production of goats

Category	Complementary success requirements
Feed	Educating farmers about scientific ration (feed) formation
Animal health	Maintenance of health record
Extension	Organizing field level training program cum demonstration of modern technology
Genetics	Emphasize dual purpose breed of goat since goat milk has immense medicinal value

5.4 Chicken value chain improvement strategies

The chicken value chain focuses on the backyard chicken, and the specialized broilers and layers. In the following section, the major challenges across the value chain are specified along with the opportunities and suggested strategies to overcome the challenges.

Table 45: Challenges to backyard chicken production in Bihar state

Category	Northern zone	Central zone	Southern zone
Feed	No serious challenge on feed for backyard units	Less availability of maize	Unavailability of minimum balanced feed
Animal health	High mortality rate (20%) (including predators), lack of awareness of proper management, unavailability of veterinary expertise	Mortality rate (20%)	Poor health care and management
Genetics/ breeding	Lack of good quality breeds, limited research in improving local breeds of chicken	Like Northern zone	Egg laying capacity is low (60-80/year)

Table 46: Opportunities for backyard chicken production in Bihar state

Species	Northern zone	Central zone	Southern zone
Chicken backyard	Availability of maize, disease-resistant local birds, people are natural rearers (northeast), large number of landless farmers with the potential to rear chickens, readiness of women to diversify income	Availability of feed plants, suitable climatic condition as compared to Northern and Southern, easily available market (demand is growing), large area for open feeding/scavenging	The tribal community is more adaptable to BYP compared to Northern and Central zones, coloured birds preferred for ceremonial and cultural purposes of tribal families

Table 47: Key strategies to address challenges in backyard chicken production in Bihar state

Category	Northern zone	Central zone	Southern zone
Feed and breeds	Increase availability of veterinary expertise, encourage landless farmers and women with training, increase access to better breeds	Increase the availability of maize from Northern zone, land availability for maize and soybean production, increase access to better breeds	Increase availability of different vegetable oil cakes, explore the use of nonconventional feeds such as Azolla as a protein supplement in semi-scavenging feeding
Animal health	Timely vaccination, immediate response to diseases, proper housing system, strengthening of poultry, diagnostic lab at district level, training facility at district level, weekly visit by poultry expert at block level	Like Northern zone	Awareness raising on animal health and management

Table 48: Challenges to broiler production in Bihar state

Category	
Feed	High and fluctuating price of chicken feed, inadequate feed processing plants, unregistered feed processing plants, quality control of processed feeds lacking at processing plants, land access limited for producing feed ingredients like maize and soybeans
Animal health	Hygiene and sanitary codes not adhered to, poor management (light, ventilation etc.), chicken diseases e.g. avian influenza, chronic respiratory disease, inflammatory bowel disease etc.
Genetics	Limited choice of broiler breeds

Table 49: Opportunities for broiler production in Bihar state

Species	Northern zone	Central zone	Southern zone
Broiler	Chicken meat is now an acceptable commodity by many, demand is growing, provides opportunity for employment (skilled and unskilled people), labour is easily available, chicken meat a priority in government development scheme, feed ingredients for chicken-feed processing are available		

Table 50: Key strategies to address challenges to broiler and layer production in Bihar state

Category	
Animal health	Establishment of poultry health care centres and provision of poultry experts/field vets in every district of Bihar, mass awareness regarding high-threat diseases among poultry farmers, regular vaccination and proper management, maintenance of high-grade biosecurity, provision of appropriate vaccines as required, timely identification of exposure to diseases
Genetics/ breeding	Use tested breeds of broiler chicken, set up a research institute for chicken breeding at state level
Extension	Skilled manpower required—training on management and MThnical support, awareness, control and regulations need to be established, MThnical knowledge provision to farmers, establish training institutes at regional directorate level

Table 51: Complementary success requirements for broiler and layer production

Category	
Feed	No private layer feed manufacturing plant, COMFED is the layer feed provider
Animal health	Increased construction of layer farms but no poultry animal health facilities in line with the expanding layer farms, avian influenza is a big threat for all poultry
Genetics/breeding	Limited choice of layers

Table 52: Challenges to layer production in Bihar state

Category	Complementary success requirements
Feed	Check indiscriminate use of antibiotics and growth promoter in poultry feed for healthier consumption qualities
Animal health	Awareness of farmers about strict biosecurity measures and ensure implementation
Extension	Establishment of government/co-operative /public and private mode poultry farms at block level for education, demonstration and for distribution of chicken amongst BPL farmers
Genetics	Advance the use of Ross and Cobb varieties of broiler chicken

Table 53: Opportunities for production of layers in Bihar State

Species	Northern zone	Central zone	Southern zone
Layer	Potential for increasing production—growing number of restaurants, cafés and pastry shops, government promotion 'one egg a day—keep the doctor away', 90% of eggs presently come from out of state—boosting egg production means making Bihar self-sufficient		

Table 54: Key strategies to address challenges to broiler and layer production in Bihar state

Category	
Animal health	Establishment of poultry health care centres and provision of poultry experts/field vets in every district of Bihar, mass awareness of high-threat diseases among poultry farmers, regular vaccination and proper management, maintenance of high grade biosecurity, provision of appropriate vaccines as required, timely identification of exposure to diseases
Genetics/ breeding	Use tested breeds of broiler chicken, set up a research institute for chicken breeding at state level

5.5 Pig and pork meat value chains improvement strategies

In India, the eastern and northeastern regions of the country comprise around 63% of the pig population (Pig330.com, 2016).[18] According to the same study, the highest pig population is in the state of Assam (16.3 lakh) followed by Uttar Pradesh (13.3 lakh), Jharkhand (9.6 lakh), Bihar (6.5 lakh) and West Bengal (6.5 lakh). Pork production is concentrated mainly in the states of Uttar Pradesh (30%), followed by northeastern states (25%), Bihar (15%), West Bengal (6%), Karnataka (4%), Jharkhand (4%) and Kerala (3%).

According to an all India study by the Global Agricultural Information Network (USDA, FAS, 2016),[19] the sector is also constrained as most of the pig farmers belong to the lower socio-economic strata (Seth et al, 2014)[20] and undertake pig farming as a livelihood rather than scientific pig farming with improved foundation stock, proper housing, feeding and management. Pig husbandry in India is an occupation for ST and OBC; status regarding livestock ownership at the national level suggests that pig production is an economic activity dominated by marginal and smallholders (NSSO 2003)[21]

Table 55: Challenges to pig production in Bihar State

Category	
Feed	The corn feed needed to raise quality pork is not grown cost efficiently to sustain domestic pig herds
Animal health	The health status of pigs is poor; disease outbreaks often devastate local pig populations
Genetics/ breeding	Low productivity of local breed, lack of suitable pig breeds for commercial meat production according to the Bihar weather and climate

Table 56: Opportunities for pig production in Bihar state

Species	Northern zone	Central zone	Southern zone
Pig/pork	-Prolific breeders, income opportunities for small and landless farmers, unemployed educated or uneducated young people and for rural women -Growing level of awareness about the economic value of pigs like other domestic livestock animals -Livestock keeping—especially pig keeping is integral to the majority of tribal people's way of life -Increasing per capita income, urbanization and changes in lifestyle and food habits might contribute to demand for pork		

18 https://www.pig333.com/latest_swine_news/pork-production-in-india_11587

19 https://gain.fas.usda.gov/Recent%20GAIN%20Publications/Pork%20-%202016_New%20Delhi_India_7-21-2016.pdf

20 See also http://www.rseeudaipur.org/wp-content/uploads/2014/08/14-Pankaj_Se.pdf

21 The National Sample Survey Organization (NSSO), since its inception in 1950, has played a major role in providing the socio-economic data needed—from all spheres of life—to formulate a vibrant plan for social and economic development.

Table 57: Key strategies to address challenges in pig production in Bihar state

Category	
Feed	Raise awareness of proper feeding and management, establish feeding methods
Animal health	Establish state level department on piggery, technical support, awareness, and training directed at producers and vet service providers, strengthen the preparedness of relevant government health institutions
Genetics/ breeding	Upgrade the current breed of pigs and pursue crossbreeding, import suitable breeds and encourage commercial piggeries
Marketing and processing	Promote preparation and consumption of pork, establish abattoirs and processing plants
Extension	Establish a model farm with training facility

5.6 Post-production improvement strategies

Table 58: Post-production opportunities, challenges and intervention strategies for dairying

	Northern zone	Central zone	Southern zone
Opportunities	Condensing plants for ease of transport of milk to Central zone, explore food ingredient business for baking and confectionary, access to markets of Bangladesh, Nepal and northeast India which are milk deficit and are in close proximity to Bihar	More urbanization and educational hub	Use of the tourism circuit to promote ultra-high temperature pasteurization (UHT)/cheese/yoghurt through specialized retail stores
	New trends in food for the younger generation, cheese, UHT milk, yoghurt, introduction of new and consumer-friendly retail packs and probiotics		
Challenges	Low urbanization	Monopoly of COMFED	Low productivity, poor milk collection system
	Access to finance, availability of uninterrupted power supply, chilling at source to improve the quality of milk, lack of cold chain infrastructure		
Intervention strategies			
Collection system	Bulk milk chilling units (BMCU) and automation of milk collection at the village level with SMS- based mobile payment system Creation of new milk- producer societies and district unions	Separate collection of milk by species to convert to VA products—additional costs only for separate transportation to dairy plants	Improve the milk transportation from collection points through refrigerated/insulated tankers
Processing	Establish milk condensing plants for ease of transport and cheese plants for production of mozzarella and feta cheese	Establish processed cheese plant	Additional processing facilities to improve procurement and processing, 100,000 Litres per day plant and additionally enhance capacity
Sales and retailing	Establish customs and formalities agents for milk products in northeast states and seek export permissions from the National Dairy Development Board to access Nepal and Bangladesh markets Creation of seamless cold chain for product movement Improvement of quality standards of products Promotion of local products helps local farmers and adds to state GSDP Introduction of new packs and products		

Table 59: Post-production opportunities, challenges and intervention strategies for buffalo meat and skins

	Northern zone	Central zone	Southern zone
Opportunities	Natural habitat for people rearing buffalo hence high buffalo population, farmers more commercially oriented due to green fodder, dry fodder and labour availability Market for buffalo meat exists in Middle East and Far East and buffalo hides are in demand due to its hard surface texture for use in upholstery and footwear		
Challenges	Lack of awareness on alternative feed resources and hence limited organized system for animal pooling and block-level model for fattening Limited market access due to lack of transportation and market information from village to abattoirs Lack of advisory services at local level No organized local market for buffalo due to religious beliefs Lack of collection and pre-processing facility for hides and skins		
Intervention strategies			
Collection system	Formation of feedlot co-operative societies and work in partnership with COMFED for awareness regarding better upkeep of animals Establish transport system for large ruminant movement to avoid middlepersons in the value chain of the supply chain Establish a market information system to provide timely price/market information and implement a live weight meat pricing system with minimum support price (MSP) Strengthen private sector engagement in the buffalo value chain and in boosting export of buffalo meat Revitalize the livestock extension centres in Bihar to train producers on small-scale technology in value addition for hides and skins		
Processing	Invite private investments into small and medium abattoirs to support already established large meat processing plants in the Forbesganj area Additional hide and skin processing tanneries to be established		
Sales and retailing	Participate in the Agricultural and Processed Food Products Export Development Authority sponsored food trade shows to create interest Departments of Industry and DAFR to develop/establish export market for buffalo meat Create optional retail/catering system for consuming buffalo meat or carabeef especially in the tourist circuits in association with the Department of Tourism		
Complementary success factors	Modernization of existing abattoirs Strengthening of livestock markets and market information systems Incentivise private investments that work on value chain development on the supply side Develop a state-wide market intelligence system for the livestock sector to assist in realistic planning at the micro and macro levels going forward without disturbing the current scenario		

Table 60: Post-production opportunities, challenges and intervention strategies for goat meat

	Northern zone	Central zone	Southern zone
Opportunities	Big demand for goat meat, northwestern Bihar people engage in goat trade including bulk purchase from other states and Nepal, need to diversify for income generation, labour availability	More urbanization and literacy, more awareness on the value of concentrate as supplement, availability of market	Favourable topography and conducive environment, a high proportion of landless interested in goat rearing
Opportunities	Women play a major role in goat rearing and management, medium and large producers can contribute more in production of goats and they can become entrepreneurs in the field of goat rearing		

	Northern zone	Central zone	Southern zone
Challenges	Unorganized goat market (inappropriate engagement by middleperson), lack of timely price/demand information, price of goat on visual determination rather than weight Lack of modern abattoir facilities Poor funding and insurance facilities Lack of package of practices for goat rearing Limited access to animal health centres and vets due to longer distance Lack of strategic planning to produce large number of marketable goats in peak season Lack of infrastructure for processed meat market		
Intervention strategies			
Collection system	Create live animal market infrastructure at each block level and encourage goat co-operative/self-help group (SHG) models at the village level Existing infrastructure of agricultural markets could be used by allotting space on rental basis Development of community animal extension workers (Pashu Sakhi) and working with JEEViKA to create SHGs for market linkage of producers with processors Link farmers with big buyers and reduce engagement of middlepersons Introduce weighing system in pricing		
Processing	Modern abattoirs for export of meat Farmer entrepreneurship development for processing of goat meat Use of by-products of goats (milk and manure) which give better income to the goat rearers Develop community owned processing unit or cluster approach of processing units to support the export houses		
Sales and retailing	Organized marketing facilities, digital marketing platform Cold chain Halal certification to fulfil religious beliefs Meat cuts/product packs and promotion Ready to eat meats and sausages/shawarma concepts		
Complementary success factors	Support of goat-rearing groups and provide support to strengthen the community institutions through public-private partnership (PPP) as well as NGOs Development of short-term training programs on goat entrepreneurship development and scientific goat rearing practices Promotion of goat meat in trade shows Increase the coverage of goat animal health and management related services 24/7 via use of community-based animal health workers Government support in infrastructure development Encourage community institutions Private sector to play key role in the goat processing value chain		

Table 61: Post-production opportunities, challenges and intervention strategies for chicken meat and eggs

	Northern zone	Central zone	Southern zone
Opportunities Backyard	Not much commercial farming Access to markets Labour availability Availability of maize for feed, disease resistant local birds, natural rearers (northeast), large number of landless farmers with potential to rear chickens, readiness of women to diversify for additional income	More urbanized Some commercial operations in both multiplication and out growing Availability of feed plants, suitable climatic conditions as compared to Northern and Southern, easily available market (demand is growing)	Suitable for commercial farming Feed plants available Tourist destination The tribal community people in the south are more adaptable to BYP compared to Northern and Central, coloured birds preferred for ceremonial and cultural purposes of tribal families

	Northern zone	Central zone	Southern zone
Broiler	Chicken meat is an acceptable commodity by all, considerable demand exists, provides opportunity for employment (skilled and unskilled people), labour easily available, chicken meat a priority in government development scheme, feed ingredients for chicken feed processing are available		
Layer	Potential for increasing production—growing number of restaurants, cafés and pastry shops, government promotion 'one egg a day—keep the doctor away', 90% of eggs come from out of state—boosting egg production means making Bihar self-sufficient		
Challenges	Flood prone Unorganized marketing system MSP not fixed Lack of processing facilities Limited number of training centres at district level (only 3 out of 38), lack of adequate knowledge of housing to prevent flood damage	Interference by middlepersons, lack of processing facilities Limited number of training centres at district level (only 3 out of 38), lack of adequate knowledge of housing	Drought prone Unorganized marketing system MSP not fixed Lack of processing facilities Unavailability of training centres at district level (only 3 out of 38), lack of adequate knowledge of housing
Broiler/layer commercial model	Unorganized market and dominance of middlepersons, demand fluctuation by season (wedding and festival), very poor commercial poultry production, unorganized market and dominance of middlepersons, demand fluctuation by season (wedding and festival), few training institutions in Bihar (Patna, Bhagalpur and Muzaffarpur), lack of skilled labour and management force		
Intervention strategies			
	Organized marketing system, organizing producers into co-operatives, establish market information system, establishment of poultry processing plants (three in each zone), farmers work in SHGs and form a co-operative for proper marketing Training facility at district level, weekly visit by poultry expert at block level, establish training centre at district level, awareness about appropriate housing during flood period		
Collection system	Establish a government-regulated chicken marketing system for the entire supply chain for eggs as well as chicken Provide necessary support on Day Old Chicks (DOC) as well as feed and feed ingredients Coordinate with National Egg Coordination Committee		
Processing	Establish modern abattoirs with processing facilities for VA chicken products Advance hygienic meat processing practices in the retail trade with cold chain facilities Explore option of egg processing to ensure availability for food processing industry development as well as meet the needs in times of shortages (floods/drought etc.)		
Sales and retailing	Promotion of processed chicken meat, promotion for awareness, control and regulations to prohibit unhygienic practices in chicken shops		
Complementary success factors	Skilled manpower required—training on management and technical support Create training institutes at zonal/district level for providing technical knowledge to farmers Encourage private participation by allotting lands and ensuring access to finance Feed and feed additive availability		

Table 62: Post-production opportunities, challenges and intervention strategies for pork

	Northern zone	Central zone	Southern zone
Opportunities	Prolific breeders Income opportunities for the small and landless farmers, unemployed educated or uneducated young people and for rural women Growing level of awareness about the economic value of pigs like other domestic livestock animals Majority tribal population, livestock keeping—especially pig keeping—is integral to their way of life. Increasing per capita income, urbanization and changes in lifestyle and food habits might contribute to demand for pork		
Challenges	Limited information on national investment on pig production, limited availability, poor quality and high price, low consumption of pork because of religious prohibitions, the movement of frozen, chilled swine meat is limited by poor infrastructure, transportation and cold storage		
Intervention strategies			
Collection system	Create live animal market infrastructure at each block level and develop swine co-operative/SHG models at the village level Existing infrastructure of agricultural markets could be used by allotting space on rental basis		
Sales and retailing	Create cold chain facilities for transport and retailing, promote pork products such as ham, bacon and sausage among the hotel/restaurant/café chain		
Complementary success factors	Investment attractions to go into commercial pig production Boosting the consumption of pork and other processed products Ensure remunerative price to pig producers by establishing bacon and pork processing plants through private- and public-sector investment Support private small-scale meat processing plants which are mainly processing pork and pork products like sausage, bacon and ham Establish pig producers co-operative Develop infrastructure, transportation and cold storage in the state of Bihar for moving frozen, chilled swine meat to states in the northeast and Nepal in addition to urban markets in Bihar		

6 Priority institutions and policy constraints and opportunities

This section provides a review of current major policy and institutional constraints, evidence and recommended actions for selected areas of livestock production in Bihar. The review covers: animal health, animal breeding, animal nutrition, milk (dairy), poultry (chicken), buffalos, goats, pigs, hides and skins, livestock and livestock product marketing and processing, policy requirement for social and gender inclusion, livestock research and livestock extension services. Many studies including major policy documents, government directives, regulations, acts, laws, strategies and road maps and research papers have been reviewed, and the salient issues are summarized in the subsequent paragraphs and presented in tabular form in the Annex.

6.1 Animal health

Growth in livestock production depends upon livestock protection against diseases. Despite the considerable progress in animal health service delivery during the last two decades, there exists a high incidence of livestock diseases, such as mastitis, vector-borne diseases, infectious diseases and emerging diseases (such as FMD, BQ, Hidradenitis suppurativa, theileriosis and surra etc.). Inadequate doorstep services and insufficient medicines at veterinary institutions present a big challenge to the development of the livestock industry.

Animal health service delivery is constrained by inadequate infrastructure such as diagnostic facilities in the veterinary dispensaries and manpower, inadequate PPPs, low adoption of technologies and Good Management Practices (GMP) and prevalence of uncertified practitioners, lack of adherence to the prevention of contagious diseases act and lack of proper compliance with vaccination protocols. Additional constraints include lack of a system of quality control and regulation of services and an inadequate disease reporting system. The National Animal Disease Reporting System that links the state headquarters to the Central Disease Reporting and Monitoring Unit at New Delhi is currently operating but it needs improvement and proper monitoring.

The main approaches to the further development of the commercial livestock sector include providing an enabling environment to encourage the private sector to operate in rural areas through provision of incentive packages, preparation of a policy statement providing for cost sharing for prevention and control of diseases of economic importance, support and strengthen PPP in delivery of animal health services, resolve the administrative constraints that inhibit the launch of mobile clinics, establish a system that ensures quality control and regulation of services and properly train and equip the field staff to directly communicate livestock disease data to a central (state headquarters) monitoring unit.

6.2 Animal breeding

Much like the animal health services, breeding services are predominantly a public service provided through the Bihar Livestock Development Agency and COMFED. Apart from the government, some NGOs and private service providers also provide limited breeding services. More engagement of the NGOs in breeding services is restricted due to stringent government guidelines and privatization of AI services lacks proper monitoring and assessment.

The state has a breeding policy that covers all geographic regions, focuses on specific breeding issues, recognizes the importance of research institutes and includes a uniform curriculum on AI training. However, the policy doesn't encompass a regulatory authority to govern the use of germplasm and an institutional framework for implementation of a regulatory framework, including a strategy on monitoring AI, nor does it establish an animal identification authority or mention climate change adaptation strategies.

Key breeding concerns include a lack of adherance to breeding policies as well as inbreeding due to inappropriate semen allocation and monitoring. Poor heat detection and insemination skills as well as poor infrastructure are other constraints that lead to a high incidence of repeat breeding, an irregular supply of liquid nitrogen and ultimately poor semen quality.

The recommended policy action includes revisiting the breeding policy, privatization of AI services, reinforcing the genetic improvement, encourage PPPs, develop a breed standard and initiate herd/flock books for existing local breeds, provide extension services and training to farmers, establish an identification, registration and performance testing system for purebred animals, and ensure adequate expertise and infrastructure and establishment of livestock breeders' associations and societies.

6.3 Animal nutrition

Adequate and balanced availability of feed and fodder is a prerequisite for increasing livestock production in Bihar. Crop residue and by-product of crops are the main sources of fodder for most livestock, however goats are generally maintained on tree leaves and grazing. There exists a huge gap between demand and supply of both dry and green fodder. Although the feed constraints in terms of quantity and quality are critical constraints, there is also insufficient land to produce the required quantity of cultivated feeds. Additional constraints include inadequate technical support services, inadequate fodder storage facilities, unorganized and informal fodder markets and an inefficient fodder transport system.

The government has an active role to play in making land available for feed production, establishing feed quality standards and monitoring, regulating forage seed markets and supplying high yielding multi-cut forage varieties, and establishing policies, regulations and incentives to support private-sector investment in animal feeding. The government's role also includes the improvement of feed marketing and supply channels by strengthening animal feed factories and distribution selling points, the support of community fodder banks and technologies, and the provision of training, extension and professional education to farmers.

6.4 Dairy

The dairy industry in Bihar has been growing and steady growth in milk production has been registered in the past years. However, to meet the growing milk demand for the growing population of the state, the dairy industry needs to enlarge considerably and produce more milk. The development of the dairy industry still requires strong support services, providing better breeding, improving animal health and feeding inputs to milk producers. This necessitates encouraging investment by private sector dairy processors and strengthening of institutions that provide necessary support; PPPs also need to be strengthened.

Efforts also need to be geared towards ensuring quality and monitoring of AI operations, building skills of milk producers, expanding the co-operative networks and conducting milk production and demand surveys. Better organization of the milk collection, distribution and processing facilities, and input into building the organizational and institutional capacity of dairy co-operative societies (DCS) remain priorities.

The policy actions will consist of strict enforcement of the breeding policy, enhanced capacities for policy implementation, strengthen monitoring of the AI operations, improve the capacity of the AI service delivery through capacity building programs and PPP, strengthen quality control and carry out education campaigns for all intervening parties on improvement of the quality of milk and dairy products, increase the capacity to process milk and reinforce the marketing chain for the output and, lastly, reinforce and strengthen DCS.

6.5 Poultry

The poultry development program envisages to strengthen poultry, meat and egg production in the state. It is imperative to establish more layer and broiler poultry farms to enhance the availability of eggs and meat in the state. The poultry industry in Bihar has a promising future, but currently it is constrained by inadequate availability of feed resources, poor quality of feeds, limited research in improving local breeds of chicken, inefficient marketing system, inadequate processing facilities, inadequate technical support services, lack of basic infrastructure such as storage and transportation, lack of proper assessment of investment options and inadequate access to credit.

Recommended policy measures include strengthen quality audit and compliance of commercial feeds, encourage private investments, reinforce the strategic plan for developing commercial chicken, strengthen the capacity of research scientists (chicken nutrition and health) and support staff, and improve credit access to farmers and other actors in the value chain. Additional policy actions include strengthen facilities for hygienic meat processing and preservation of eggs, develop reliable and stable market chains year-round for marketing of poultry products and support formation of producer co-operatives/associations and rural market yards.

6.6 Buffalo

The buffalo industry is one of the fastest-growing livestock industries in Bihar. It contributes to about 38% of the milk and 36% of the meat production of the state. The development of the buffalo industry is constrained by insufficient supply of dairy buffalo stock, inadequate buffalo breeding services, inadequate feed supply and inadequate support services. Other constraints include inadequate financial and credit facilities, inadequate milk collection and distribution centres and inadequate abattoir and processing plants. The poor sanitary and phyto-sanitary conditions are also considered to be one of the major constrains in realizing the export potential.

The policy recommendations consist of strengthening support services, providing better breeding, health and feeding services, encouraging the private sector, building skills of milk producers and expanding the co-operative networks. In addition, enhancing the organization of the milk collection, distribution and processing facilities and building the organizational and institutional capacity of DCS and improving credit access by farmers is crucial.

6.7 Goats

In Bihar, goats are mainly reared by women, and landless and marginal farmers (in smaller flocks). The goat sector is largely neglected in policy terms. There is no formal institutional mechanism for providing services to this sector. Currently, the sector is constrained by poor health service coverage, lack of effective common

property resource (CPR) policies, lack of regulation for vaccine quality control, inadequate extension, no formal mechanism for credit and inadequate marketing of goats at farmer level, village level and urban areas.

Proposed policy actions include develop a policy for the small ruminant sector focusing on critical issues such as health services, breeding issues, common property resources, and producer associations for marketing linkages. Additionally, establish institutional mechanisms for providing services and regulating quality control and improve access to credit by goat farmers.

6.8 Pigs

Despite Bihar's potential in pork production, pigs are managed by small and marginal livestock keepers with very low inputs. The development of the pig industry is limited by low genetic potential of existing stock, inadequate breeding services, prevalence of animal diseases, poor nutrition and inadequate support services. Other constraints include low sanitary inspection at all stages of the value chain, inadequate infrastructure, poor marketing system, low consumption of pig meat, lack of extension and lack of information materials.

The policy response will need to consist of establishment of a breeding improvement program to improve the genetic potential of local pigs, enhancing health care and nutritional management, strengthening livestock market price and related information, strengthening sanitary inspection regulations, encouraging farmer organizations, increasing extension services delivery through farmers associations and supporting existing farmer organizations in the establishment of farmer field schools (FFS), farmer to farmer extension and study tours.

6.9 Hides and skins

Hides and skins are important by-products of livestock that provide major input to the industrial sector and can contribute significantly to farmer incomes and foreign exchange earnings. Despite the large population of Black Bengal goats and other livestock species in Bihar, hide and skin production is very low. Few private tanneries are presently operational in Bihar. These tanneries suffer from lack of modern effluent treatment plants and irregular power supply. Additionally, the quality of hides and skins retrieved from abattoirs is usually poor due to improper skinning, preservation and skin processing.

The recommendation, therefore, is to encourage the private sector to build leather processing plants to take advantage of the large population of Black Bengal goats in the state, give necessary attention to updating and reinforcing the processing regulations on hides and skins, encourage proper branding, flaying, preservation and storage of hides and skins, encourage trading of hides and skins according to grades, strengthen marketing information and support services, boost investment in processing facilities, provide credit facilities, set standards for upgrading abattoir facilities and strengthen guidelines for skin processing, effluent treatment, and environmental standards.

6.10 Livestock and livestock products marketing and processing

Demand for livestock products, both in terms of quantity and quality, is expected to increase in the future. However, the marketing and processing systems of the livestock sector remain relatively unorganized, possibly leading to high transaction costs for the smaller players. Investment in gaining access to growing urban markets and processing of dairy and meat products will be critical. Given the very small marketable surplus of individual households, it is necessary to build institutions that vertically integrate small and scattered producers with dairy and other product processors. Co-operatives, self-help groups and other forms of collective action need considerable support to improve efficiency and facilitate commercialization of smallholder dairy.

Public sector encouragement of private investments in meat processing and marketing will support and ensure fair competition in the market. Subsequently, standards need to be established to improve the quality of livestock products and hygienic practices that meet the sanitary and phytosanitary specifications for export.

It is also imperative to increase farmer awareness about the importance of quality and hygiene standards through extension and communication campaigns. Identification of real marketing bottlenecks and critical areas of market development through a good livestock market information and research system would be very helpful in encouraging market competition. Finally, setting, monitoring and certification of standards by a competent authority will become increasingly important as retailing of poultry and other meat products starts to consolidate and modernize into managed outlets and retail chains.

6.11 Policy requirements for social and gender inclusion

To achieve a livestock sector in Bihar, to which both men and women, and ST and SC, contribute and benefit an equitably will require a more thorough policy review, analysis and documentation. As has been mentioned in Section 3, both women and ST/SC are integral players in the livestock sector and will be for some time to come. This makes it paramount that policies align to ensure effective opportunities and rewards for both women and men, including from ST/SC, their households, communities and the state.

An initial and important policy entry point[22] will be to ensure the access and control by women and ST/SC of resources for livestock production. This includes appropriate policies to give access to credit to utilize animal health care, feed and good genetic stock, information to support more modern production, land tenure policies to be able to expand production, and markets for attractive returns. These issues are often within a wider context and will affect the livestock sector for most producers; however, if we are to engage women and ST/SC more, these issues will need to be addressed.

At the public institution level, general recommendations on gender inclusion include ensuring that gender and social inclusion are mainstreamed in all departments related to animal husbandry and production. To support this there are four main areas of work: 1) developing a gender and inclusion strategy to guide the departments and partners to address gender and inclusion issues, 2) raising awareness and training field staff on gender-inclusive interventions based on evidence, 3) developing the capacity to perform gender and social inclusion research to provide an evidence base and 4) developing the appropriate interventions and setting up a monitoring system to understand how proposed interventions differentially impact women and men, ST/SC and others, in terms of labour, income and livelihoods options.

To realize this will require institutional support in the form of dedicated approaches and resources from a variety of partners (government, NGOs, women's groups, research and private sector) to be developed in a gender/social inclusion action plan. Areas that need to be considered include: 1) a dedicated gender budget for staff, research and activities, 2) leadership and engagement at state level to support this type of work through policy and public support, 3) recruitment of capable gender experts to support the development of the strategy and the action plan, 4) development of the appropriate gender indicators to ensure accountability and progress, and 5) grants to pilot and showcase innovation for gender-appropriate approaches.

Linking the development of the livestock sector with gender-policy tools already available in Bihar, specifically the women's development co-operation, would also be a good entry point. This would require a dedicated

22 Information for this section was based on secondary literature and key informant interviews with the following organizations: Professional Assistance for Development Action, Aga Khan Development Network, BAIF, National Bank For Agriculture And Rural Development (NABARD), and Bihar Agriculture & Extension Training Institute.

effort as they are now in different sectors. Bihar already supports certain reservation policies, including 35% women for public distribution system food shops, 35% for women-only dairy co-operatives (although only 22% of women are registered as members from both mixed- and women-only dairy co-operatives), 50% for women in Panchayat Raj institutions and 35% reservation for women in state government jobs.

Policies are also needed to support nutrition sensitive agriculture, along with nutritional or health institutions and the livestock development department to work together for nutrition improvement of marginal communities. Introduction of a mid-day milk and egg program will boost protein consumption for marginalized community children, which will reduce malnutrition.

Dairy (cows and buffalos)

Within the dairy sector, pursuing policies and entry points to ensure increased engagement of women in co-operatives, preferably women only co-operatives, could provide women with better control of the income from milk sales. Overall, women need to be supported to become more effective leaders of farmers' groups, besides village-level groups. This could be achieved by supporting training for women on handling accounts and milk quality standards, supporting gender inclusive by-laws, and members' education. Setting targets will facilitate progress assessment, for example: an increase from 22% to 60% women members and a goal of 50% women leaders.

Other activities to support gender and socially inclusive development are for more women extension workers to be employed in COMFED co-operatives and other programs for enhanced communication to women farmers, as there are communication barriers between men and women due to cultural and gender norms. Special training or extension work for marginal or SC/ST communities are also required as there are social and cultural barriers preventing women from all castes working together. Credit systems for women and SC/ST without collateral assets could be made available, including a group-based credit system for women-producer groups.

Small animals (goats/BYP/pigs)

Like small ruminants, poultry and pigs are important assets for developing social inclusion, which therefore require different policy support mechanisms. Women and marginal communities lack capital for investment and feed purchases as well as political capital for policy lobbying. Establishment of a feed security bill could enable land owners to sell feed to landless livestock keepers for intensive production where labour is abundant enough.

Other aspects to focus on include support of women producer groups and federations for inputs and service for goats, BYP and pigs for marginal communities. Training and extension work in marginal or SC/ST communities to address social and cultural barriers could encourage women of all castes to work together. Credit systems for women and SC/ST without collateral assets could be made available (for example, a group-based credit system for women producer groups). Given that most small animals are cared for by women at least partially due to high migration by men, women could be supported as community-based animal health workers, especially for small animals. Weather-based small animal insurance in flood-prone areas is needed, targeting women. Small animal development (pro-poor) policies especially for goats, BYP and pigs could encourage gender and social inclusion. A forum for sharing of knowledge between NGOs and government agencies could also aid in fostering inclusionary policy development.

6.12 Livestock Research

The development of the livestock sector requires adequate investment in research, education and training to generate and disseminate new technology, inputs, services and institutional options. Presently, there is inadequate operational resources and the share of animal sciences in total agricultural research staff and expenditure remains low. Most of the livestock research is skewed towards milk production and is disciplinary oriented, while most problems are multidimensional. The research-extension link has rarely absorbed feedback from farmers and extension staff and the link between research and extension remains weak which results in inadequate packaging and dissemination of research outputs. Moreover, there is a lack of adequate coordination among various agencies collecting statistics, which creates unnecessary overlaps and gaps.

Some of the policy actions required are development of multidisciplinary systems-oriented livestock research that must include all stakeholders, encourage research, training and extension linkage and platforms, capacity building for research scientists including animal scientists and promote PPP for infrastructure investments.

6.13 Livestock extension services

Most of the livestock extension is conducted by the Bihar Animal Husbandry Department, which has neither the resources or the expertise to adequately conceive and operate technology transfer packages. There are attempts to provide livestock extension services through co-operatives, NGOs and research institution-affiliated programs like Krishi Vigyan Kendra, however the coverage of, and access to, these agencies is limited, both in area and content. The Agricultural Technology Management Agency (ATMA) approach has attempted to coordinate agricultural extension, yet very few of the ATMAs have embraced livestock extension activity. Within livestock extension, services are primarily focused on milk production, neglecting other roles of livestock, and concentrated in higher potential areas.

The main constraints in extension service delivery include low allocation of public or private funding to livestock extension services, low private sector involvement, lack of appropriate livestock extension systems and inadequate access to information on animal husbandry, weak research-extension linkages and insufficient extension expertise.

To improve livestock extension, service delivery needs to be expanded to include all livestock species and support utilization of the fund allocated to Bihar under the centrally sponsored program, including Rashtriya Krishi Vikas Yojana. There is also a need for strong partnerships between the public sector, private sector, local and international NGOs, farmer organizations and research and education agricultural institutions. Besides sufficient expertise both in quantity and quality, research-training-extension-farmer linkages and adequate infrastructure and facilities are important for efficient livestock extension service delivery.

7 Foresight assessment of intervention options

7.1 Cow dairy improvement

The investment context

Cow dairy is the most important commodity value chain of the livestock sector of Bihar. It contributes 35% of the GSDP and 11% of the agricultural GSDP (LSIPT results and Bihar, Directorate of Economics and Statistics, 2016). Fifty-seven lakh households own cattle and directly depend on the dairy sector for their livelihoods (MAFW, 2017) and many more households make their leaving along the dairy value chain. Cow dairy production (including both indigenous and crossbred cattle) is found in all areas of the state. As such, the proposed cow dairy improvement interventions will target the whole state for both indigenous and crossbred cattle. The cow dairy improvement interventions include improvements in the genetics and feeding of animals, health and extension service delivery, marketing and processing of milk and milk products and research. The foresight assessment for these improvement interventions is done in three scenarios.

- Business as Usual (BAU) scenario - Represents the base case scenario (no additional investment or any change in the types of investment) with the analysis showing the impacts of continuing the current type and level of investment and recurrent spending on milk production and contribution to GSDP throughout the LSA analysis period of 15 years.

- With Intervention-1 (WI-1) scenario – Crossbreeding of cattle and buffalos are both emphasized, but cattle given priority, along with improving the productivity of all cattle and buffalos (including indigenous ones). Crossing of local cows increases the number of crossbred cattle, thus enabling the population of crossbred cattle to increase while the number of indigenous cattle decreases. The population of buffalos, both locals and crosses also increases. This scenario is aimed at meeting the milk consumption requirements of the state in the 15-year LSA period.

- With Intervention-2 (WI-2) scenario – Crossbreeding of cattle with exotics is de-emphasized, while crossbreeding of local cows with improved local cows (i.e., Sahiwal and Gyr) is given priority and improving the productivity of both through complementary feed and health interventions. Crossbreeding with improved local cows enables the local cattle population to increase while the number of crossbreds remains constant. This scenario is aimed at exploiting the resistance traits of indigenous cattle breeds to disease, inadequalte feed and heat stress and satisfying growing demand for A2 milk.[23]

23 A2 milk is the milk that contains only the A2 type of beta-casein protein whereas A1 milk contains only A1 beta casein or A1 type variant. A1 protein variant is commonly found in milk from crossbreds and European breeds of cattle. A2 milk is found in the indigenous cows and buffalos of India (and Asia as a whole) (Prasanta B. et. al., 2016).

WI-1 scenario

Cow dairy improvement interventions and targets

Genetics

- The number of AI performed during 2017–18 (27.96 lakh) is targeted to increase to 50 lakh per annum by 2022–23, 85 lakh by 2027–28 and 110 lakh[24] by 2032–33. The AI will use semen of both crossbred and improved indigenous cattle breeds.
- Currently, Bihar has one semen production centre (under the Department of Animal Husbandry (AH)).[25] The target is to add three new semen production centres with a capacity of about 50 lakh straws per year every five years until 2032–33, providing four semen production centres at the end of 15 years.
- Nine liquid nitrogen cryovessel storage plants are found in Bihar out of which four are currently functional. In the coming five years, it is targeted to rehabilitate the existing plants by 2022–23 and then build three additional cryovessel storage plants by 2032–33.
- There are three liquid nitrogen production plants in Bihar of which none are functional. In the coming five years, the targeted goal is to rehabilitate the existing plants and by 2032–33 build three additional new liquid nitrogen production plants, each with a capacity of 1,000 litre/hour.[26]
- Currently, two cattle breeding farms exist (managed by AH; of which one is not functional). The goal is to strengthen the existing farms and establish two new ones by 2022–23 and four more new facilities by 2032–33.
- In Bihar, there are 1,476 AI centres which are managed by AH of which 800 are functional and another 3,280 private/NGO AI centres. The goal is to restore existing centres and establish 500 new ones by 2022–23, another 1,000 or more by 2027–28 and an additional 1,000 by 2032–33. These AI centres will cater to both cattle and buffalo and serve as 'aid' and extension service delivery centres.[27]
- Currently, there are three frozen semen banks of which two are not functional. The targeted goal is to make the inoperative semen banks functional and increase the banks to five (two additional by 2032–33).
- The per cent of sexed semen/sex fixer use compared to total insemination in Bihar will reach 20% by 2022–23, 30% by 2027–28 and 35% by 2032–33.
- To speed up genetic gains, the use of embryo transfer will be supported.
- Due to the improvement in the AI service, the population of crossbred cattle is expected to increase while the indigenous cattle population is expected to decrease.
- The annual population growth rate of crossbred cattle for the coming 15 years of the LSA (2018–19 to 2032–33) is expected to be lower than the growth trend observed between the 2007 (18th) and 2012

24 Assumptions include: per cent of adult females=58% for cattle and 48% for buffalo; the parturition rate=50% for cattle and 45% for buffalo; and number of repetitions=2.
25 This semen production centre is already under construction.
26 Liquid nitrogen tank with capacity of 21 litres handles 1,000 straws, used for 100 days, with an evaporation rate of liquid nitrogen=100 millilitres per day
27 Assumptions include: one AI centre serves 1,500 breedable cattle

(19th) Livestock Censuses. The annual crossbred cattle population growth rate observed between the 2007 (18th) and 2012 (19th) Livestock Censuses is about 12% (Tables 64 and 65).

- The crossbred cattle population growth rate used to project the 15-years (2032–33) population is about 4.5%, which is much lower than the 12% crossbred cattle growth rate observed between the 2007 and 2012 censuses. A lower growth rate is used in the WI scenario to limit the growth rate of the total cattle population due to the serious feed shortage observed in the state.
- The annual population growth rate of indigenous cattle for the coming 15 years of the LSA (2018–19 to 2032—33) is expected to take the growth trend observed between the 2007 (18th) and 2012 (19th) Livestock Censuses; i.e. a decrease of about 3.7% (Tables 64 and 65).

Table 63: Cattle population of Bihar over different periods of years

	Past censuses		WI-1 scenario projected figures	
	2007 Census	2012 Census	Base year (2017–18)	2032—33
Idigenous breeds	1,05,82,760	87,56,401	71,39,731	40,43,180
Crossbreds	19,76,279	34,75,122	61,31,852	1,18,64,434
Total cattle	1,25,59,039	1,22,31,523	1,32,71,583	1,59,07,614

Table 64: Cattle population growth rate and trends of Bihar over periods of years

	Livestock population annual growth rate (%)	
	Over the 2007—12 Censuses[28]	Future projection (over 2017–18 - 2032–33) for WI-1 scenario
Indigenous breeds	-3.72%	-3.72%
Crossbreds	11.95%	4.50%
Total cattle	-0.53%	1.22%

Feed

Feed is the major constraint to improving the livestock sector in Bihar. The feed balance study undertaken by the Bihar LMP team reveals a huge gap between the needs and the available feed resources. The study indicated that, in the base year (2017–18), the feed balance (available supply/demand) for Northern, Central and Southern livestock production zones was about 47%, 50% and 41% of metabolizable energy need, respectively (see Annex 3 for deatils). In 15 years, the metabolizable energy deficit is projected to worsen to 32% at state level from 48% in the base year (see Annex). Therefore, to achieve improvements in the production of livestock products, the following feed improvement interventions need to be given priority:

28 The latest censuses available are the 2007 (18th) and 2012 (19th) Livestock Censuses

- In the higher irrigated areas, implementing year-round forage production through the combination of perennial and annual forages by overlapping perennial and annual forage crops in the different seasons. This has been found to result in up to a threefold increase from the current productivity of forages (ICAR 2011).
- Mixed cropping of graminaceous and leguminous forages, when managed properly using modern soil and crop management techniques, are able to yield 180-300 t of green fodder (30-55 MT of dry fodder) per ha/year.
- Strengthening research related to grasslands/grazing lands/rangelands improvement and identification of improved forage types that suit each of the agro-ecological zones.
- Including forage crops in crop sequences. Cropping leguminous forages after harvest of the main crops/cereals will improve soil nitrogen and cereal and forage yields.
- Introducing short-duration forages in gap periods of main season crops, grown on residual moisture.
- Introducing intercrops in widely spaced row crops. Cotton, sugarcane and grain crops like maize and sorghum offer scope for adding short-statured forage crops. Inclusion of these forage crops does not affect row-crop production and will benefit the main crop in several ways.
- Dual-purpose crops give fodder as a by-product. Farmers growing these crops (vegetables, maize, sugarcane, etc.) get substantial amounts of fodder along with the main product.
- Cultivar releasing criteria of maize, rice, wheat, coarse grains, cereals and pulses need to give due emphasis to the improvement of the crop residue biomass and nutritive value for animals.
- Mixed intercropping system with forage production consists of growing two or more plant species together with different growth habits, canopy structures and rooting patterns while offering little competition. Common mixes of crops are cereals/grasses and cereals/legumes.
- Mixed cropping of cereals/grasses with leguminous forages also have significant impact on increasing crude protein content of forages.
- Introducing the integration of perennial forages on bunds and boundaries. Bunds around fields are a common feature on cultivated lands and occupy 2-10% of the cultivated area. Perennial forages like Sesbania, hybrid Napier + Stylo, fruit trees like amla (Indian gooseberry), ber (Ziziphus spp.) and karonda growing on the bunds and boundaries recorded maximum forage yields (ICAR 2011).
- Improving management of communal grazing land.[29]
- Replacing low-yielding annual grasses with high-yielding perennial grasses that are adaptable to the prevailing conditions of each of the production zones.
- Careful preservation of the surplus production from rangelands during the rainy season will contribute to meeting the forage requirements of the lean periods.

29 Marginal farmers—accounting for 92.35% of the total in Bihar state—on average possess approximately 0.25 ha (0–1), while small farmers—accounting for 5.48% of the total—on average possess 1.25 ha (http://agcensus.nic.in/document/agcensus2010/completereport.pdf, Ministry of Agriculture 2014).

- The adoption of targeted fodder production area is planned to be 50% by 2022–23 and 80% by 2027–28 and remain at 80% in 2032–33.27,28
- The area of land under permanent pasture/grazing during 2013–14 was about 15,000 ha. The plan to improve productivity is to oversow with improved grass and leguminous forage seeds and use of fertilizer, where applicable. The targeted goal is to increase rehabilitated permanent pasture/grazing land to be 50% of the total permanent pasture land by 2022–23, 80% by 2027–28 and remain at 80% by 2032–33.
- Improving production, marketing and quality control of forage seeds, forages and concentrates through strengthening existing regulatory bodies.
- The number of fodder seed production farms (now zero under AH and zero under private) is targeted to grow from the current zero enterprises to three private enterprises in five years.

Animal health

- Currently, there are 39 veterinary hospitals and polyclinics in Bihar. In the first five years, it is proposed to strengthen the existing hospitals with various clinical experts and with diagnostic laboratories. By 2027–28, the targeted goal is to put one veterinary hospital in each subdivision and by 2032–33 one hospital in each block.
- The number of veterinary dispensaries is proposed to increase from the current 1,083 (MAFW, 2017) to 1,400 by 2022–23, 1,700 by 2027–28 and 2,000 by 2032–33. [30]
- The number of veterinary aid centres (livestock centres/mobile dispensaries) is currently about 1,595.[31] Veterinary aid centres will also serve as AI centres.
- Cattle currently receive vaccinations for critical diseases at the following percentages: FMD 80% (started from 2015), brucellosis 90% (from 2017), HS and BQ 80% (historically implemented). The targeted goal is to maintain a vaccination rate of 80% by 2022–23. The major intervention thus is to make the vaccination campaigns more timely and improve deworming, sanitation, housing, and controlflooding and drought.
- The percent of farmers who adopt the recommended rate of external and internal parasite control treatments will reach 80% in the coming 15 years.
- Support for private veterinary service providers.
- Implementation of mastitis control and prevention technologies.

Extension

Current livestock development training centres include three: one functional in the veterinary college, one non-functional under the training school Buxar (Bihar AH), one functional under COMFED in Patna. Training centres with different levels of capacity will be established at different administrative levels. Regional directorate and district level training centres may focus on training of trainers while block-level training centres will provide education to farmers and other input suppliers.

30 Calculated based on the livestock number and assumption of one veterinary dispensary serving 5,000 animals.
31 Veterinary aid centres will also serve as extension (education, input and marketing service) and AI centres and vice-versa.

- Increasing the number of training centres to eight (8 or one training centre in each regional directorate) by 2022–23, 20 by 2027–28 and 38 by 2032–33. These training centres will be engines for the production of livestock extension agents (Pashu Sakhi, agri-clinics and agro-business operators, para-vets/community animal health workers, input suppliers, other private extension service providers and extension service providers at co-operatives, farmer-based organizations, farmer self-help groups, telecommunication extension service providers/operators etc.).

- By 2032–33, all of the AI centres/veterinary aid centres will also serve as extension service centres (training, input and marketing).

- Extension service providers need to be supported through improved oversight, regulation and incentives (input, advisory and marketing services) provided by extension departments at different levels.

- Necessary parliamentary acts, regulations, guidelines and manuals will be developed/improved in the first two years of this plan to help the extension services provide better outreach to farmers.

- Bureaucracy that hinders service providers' success will be identified and addressed while supporting the ethical and responsible provision of services. Control of unregistered input, advisory and marketing service providers is also critical for survival of the legal service providers.

- Coverage of ongoing dairy improvement training will reach 15% by 2022–23, 40% by 2027–28 and 80%[32] by 2032–33. Farmers will receive more intensive and continuous training in dairy cattle management (feeding, breeding, deworming, tick control, hygiene and milk handling and transport).

- Percentage of MCCs and milk producer associations providing dairy input supply, animal health, extension and financial services will increase to 80% by 2032–33.

Research

- In Bihar, the Indian Council of Agricultural Research Research Centre for Eastern Region (ICAR-RCER) is the only central government research centre. It will be requested to increase and diversify research in the livestock sector in Bihar.

- Three new state research centres (one in each production zone) will be established to perform research in all of the livestock sub-sectors of Bihar.

Processing and marketing

Currently, 22,018 registered milk producer co-operative societies (MPCS) are found, of which 2,653 are women's milk producer co-operative societies (WMPCS). The total membership of these MPCS is 11,39,000 and under WMPCS, the membership is 1,27,000. Milk collection capacity of the state for processing will increase from the current 13%[33] of the total milk produced to 20% in 2022–23, 25% in 2027–28 and 32% in 2032–33.

- Increasing the functional capacity and utilization of existing MCC.

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32 According to Glendenning et.al. 2010 (http://www.ifpri.org/publication/review-agricultural-extension-india) agri-clinic operators get two months training; out of the trainees, 47% did not succeed in the business in the past and served only about 500 households. We assume that a training centre will give two months training for 200 trainees/year and currently there are about 57 lakh households that own cattle.

33 Milk collection/processing capacity of COMFED and private processors is about 28.55 and 4 lakh litres/day, respectively; the total milk collection/processing capacity in Bihar is about 32.55 lakh litres/day or 3,255,000 *365=1,18,80,75,000 litres/year.

- Currently, there is a capacity to process 13% of the total milk produced into various milk products (pasteurized milk, UHT, powdered milk, ice cream, butter, ghee etc.). It is targeted that the per cent of milk processed will reach 20% [34] by 2022–23, 25% by 2027–28 and 32% by 2032–33.
- Establish 21 new pasteurized milk and other milk products plants (ghee, yoghurt etc.), 11 UHT milk plants, 11 powdered milk plants and 3 ice cream production and processing plants in the next 15 years (Table 65).
- Establish new bulk milk chilling units with 5,000-litre capacity for areas more than 50 km away from milk processing plants.
- Strengthen the capacity of milk quality and safety control laboratories.
- Provide incentives to the private sector to take part in the marketing and processing of milk.
- Strengthen existing dairy co-operative societies and establish 15,000 new MPCS in each of the first, second and third five years.
- Enhance the capacity of MCCs to test milk quality (fat, protein, total solid non-fat and antibiotic residues).
- Create enabling environment to establish functional linkage between private milk traders, MCCs, co-operatives and processing plants.
- Train farmers and cottage-scale processors on the use of small-scale technologies to create value addition from raw milk (e.g. curd, ghee, paneer, khoa etc.).

Table 65: Targets for 15-years and 5-years breakdown of milk processing facilities

Milk processing facility	15-years targets (# of plants)	Targets—breakdown for 5 years (# of plants)		
		2018–19 to 2022–23	2022–23 to 2027–28	2027–28 to 2032–33
Pasteurized milk and other milk products (ghee, yoghurt) processing plants	21	5	6	9
UHT milk processing plants	11	3	3	5
Powdered milk processing plants	11	3	3	5
Ice cream production plants	3	1	1	1

Animal and herd-level targets and assumptions for farmers adopting cow dairy improvement interventions (to 2033)

- Parturition rate to increase from the current 45% to 50% annually.
- The sex ratio at birth of female to male will be around 80% annually for cows that receive sexed semen and sex fixer treatments (Mohteshamuddin, 2017).
- The mortality rate will decrease by 50% annually.

34 This includes milk processing plants currently under construction (ITC – 2 lakh litres/day, Mother Dairy – 2 lakh litres/day, four other private processors – 1.5 lakh litres/day and COMFED – 3.5 lakh litres/day milk processing capacity).

- The current daily milk production of crossbred cattle is 6, 7, and 5.5 litres/day in the Northern, Central and Southern zones, respectively. It will increase by an additional four litres/day in each of the production zones. MAFW (2017) and Vaidya (2017) reported that for every litre of milk, 0.4 kg of concentrate is required (keeping genetics in mind).
- The amount of land allocated for crossbred cattle farmers to produce forage will increase to 0.04 ha from the current level of about 0.008 ha. The additional land allocated will be achieved through extension education to encourage farmers' use of all available areas around houses, hedges, fences etc.
- The amount of purchased concentrate/processed feed is targeted to increase by 1.5 kg/day per lactating cow (Vaidya 2017) over the 5 years to 2028.
- Cattle will be provided with 40-50 gm/day mineral supplement and 30 gm/day of common salt.
- Expenditure for veterinary service is targeted to increase by an additional INR 500 per animal/year.
- The cost of using sex fixer/sexed semen will incur on average an additional INR 2,000 per cow/year.

Animal and herd-level interventions for indigenous cattle and productivity improvement targets for farmers adopting the above cow dairy improvement interventions (to 2033)

- Parturition rate increases from the current 40 to 45% anually.
- Mortality rate will decrease by 50% annually.
- Lactation length (in days) of indigenous cattle increases from the current 225, 230 and 220 days in the Northern, Central and Southern zones to 230, 240 and 230 days, respectively.
- Indigenous cattle milk production increases from the current 3, 3.5 and 2.5 litres/day in the Northern, Central and Southern zones to 5, 5.5 and 4.5 litres/day, respectively (MAFW 2017; Vaidya 2017).
- The amount of purchased concentrate/processed feed increases by 0.8 kg/day/lactating cows (Vaidya 2017).
- Cattle will be provided with 40–50 gm/day mineral supplementation and 30 gm/day common salt.
- Expenditure for veterinary services is targeted to increase by an additional INR 500 per animal/year.

WI-1 Scenario—Impact of interventions

Projected population in 15 years

According to the 16th and 19th Livestock Census, at the national level, the indigenous cattle number decreased by 15% over 15 years (during the period of 1997 to 2012) while the crossbred (indigenous X exotic dairy) cattle population increased by 98%. Moreover, the rate of decrease in the number of indigenous and increase in the crossbred cattle number became more pronounced during the period of 2007 to 2012. During this five-years period, the number of indigenous cattle in Bihar decreased by 17% while the number of crossbred cattle increased by 76%. The table below (Table 66) conveys a similar future trend as in the past five years. In the coming 15 years (2018–19 to 2032–33), the indigenous cattle population is expected to decrease by 43% and the crossbred population to increase by 93%. The total cattle population is projected to increase by 20%.

Table 66: Cow dairy population at production subsystem level for baseline, BAU and WI scenarios (in lakhs and percentages)

Production zone	Breed	Livestock population				
		Baseline 2017–18	BAU 2032–33	% change baseline to BAU	WI-1 scenario 2032–33	% change baseline to WI-1 scenario
Northern	Indigenous breed	39.0	22.1	-43%	22.1	-43%
	Crossbred	11.6	18.6	60%	22.5	94%
	Total	50.6	40.7	-20%	44.6	-12%
Central	Indigenous breed	14.1	8.0	-43%	8.0	-43%
	Crossbred	43.7	70.1	60%	84.6	94%
	Total	57.8	78.1	35%	92.5	60%
Southern	Indigenous breed	18.3	10.4	-43%	10.4	-43%
	Crossbred	6.0	9.6	60%	11.5	94%
	Total	24.3	19.9	-18%	21.9	-10%
Commercial dairy		0.1	0.1	48%	0.1	60%
Total population	Indigenous breed	71.4	40.4	-43%	40.4	-43%
	Crossbred	61.3	98.3	60%	118.6	93%
Grand total population		132.8	138.9	5%	159.2	20%

Source: LSA results

Projected production in 15 years

Compared to the base year (2017–18), under the "with intervention" scenario (WI-1) milk production from cow dairy grows by 182% to 2032-33 (Table 67). This increase comes mainly from the milk production of the crossbred family dairy system. The increase in milk production from crossbred family dairy is about 237% by 2032-33. This big increase in milk production is both due to the increase in the number and productivity of crossbred cows. Meanwhile, milk production from indigenous cattle shows a 7% increase, although the decrease in the indigenous cattle population is about 43%. The improvement in the productivity of indigenous cattle in 2032–33 under the WI-1 scenario results in a positive percentage increase in milk production.

The decline in traction power is the other significant finding. By 2032–33 under both the BAU and WI-1 scenarios, the use of cattle for traction power shows a 43% decrease. This is due to the fact that the dairy cattle production system favours crossbreds more for milk production than indigenous which are commonly used for traction power.

Table 67: Production in the base year, and BAU and WI-1 scenarios

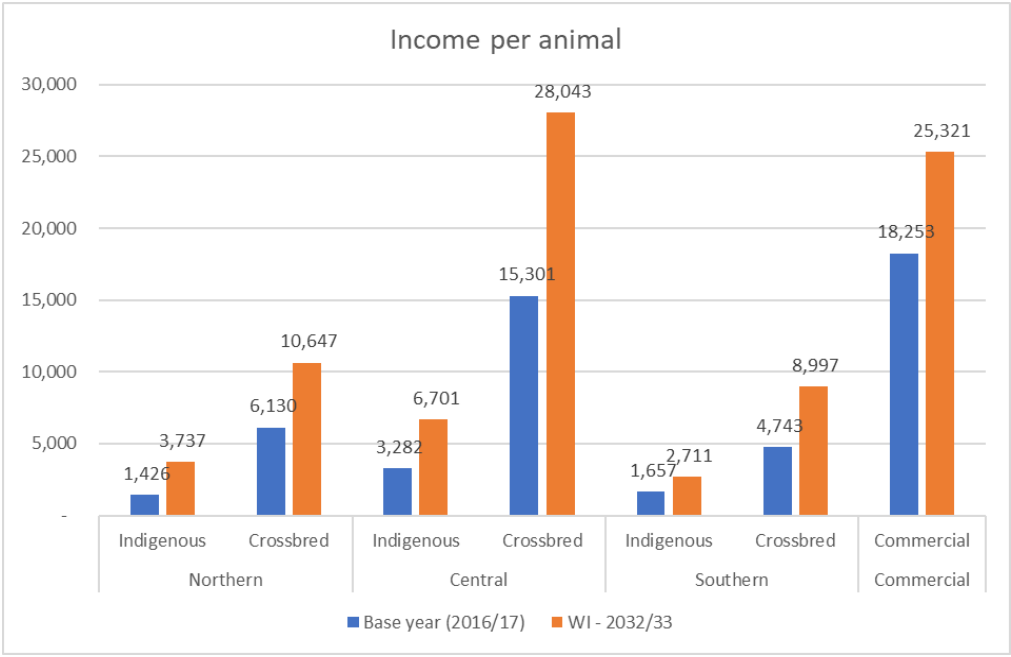
Products	Base year 2017–18	Production in 2032–33 under BAU scenario	% change under BAU	Production in 2032–33 under WI-1 scenario	% change under WI-1
Milk in indigenous breed family dairy (crore litres)	118.9	67.4	-43%	127.8	7%
Milk in crossbred family dairy (crore litres)	417.3	669.3	60%	1,386.5	232%
Milk in commercial dairy (crore litres)	1.0	1.4	48%	2.0	114%
Total milk (crore litres)	537.2	738.1	37%	1,516.3	182%
Organic matter (lakh MT)	122.0	135.1	11%	156.2	28%
Traction power (lakh days)	1.7	0.9	-43%	0.9	-43%

Source: LSA results

Projected income per animal in 15 years (2032-33)

Figure 15 shows the income per animal in the indigenous family dairy, crossbred family dairy and commercial dairy under BAU and WI-1 scenarios. The results indicate that the increase in income per animal by 2032-33 is significantly higher for crossbred family dairy and commercial dairy. The highest income per animal under the WI-1 scenario is achieved for crossbred family dairy in the Central production zone and commercial dairy production, INR 24,043 and INR 25,321, respectively.

Figure 15: Annual income per animal for BAU and WI-1 scenarios in 15 years (by 2032-33).



Returns on investment

As shown in Table 68 below, the net present value (NPV) and equivalent annual net present value (EANPV) for dairy improvement in the indigenous breed family dairy in all livestock production zones are positive, which indicate the potential of the investments. The investments result in 15-years NPVs of INR 2,700, INR 11,000 and INR 4,700 per herd in the indigenous breed family dairy system of the Northern, Central and Southern livestock production systems, respectively.

The results in Table 68 (and Figure 16) further show that the internal rate of return (IRR) in the indigenous breed family dairy in the Northern and Southern production zones is equal to the acceptable social discount rate, which is 10%, but much higher and more profitable in the Central livestock production zone, about 25%.

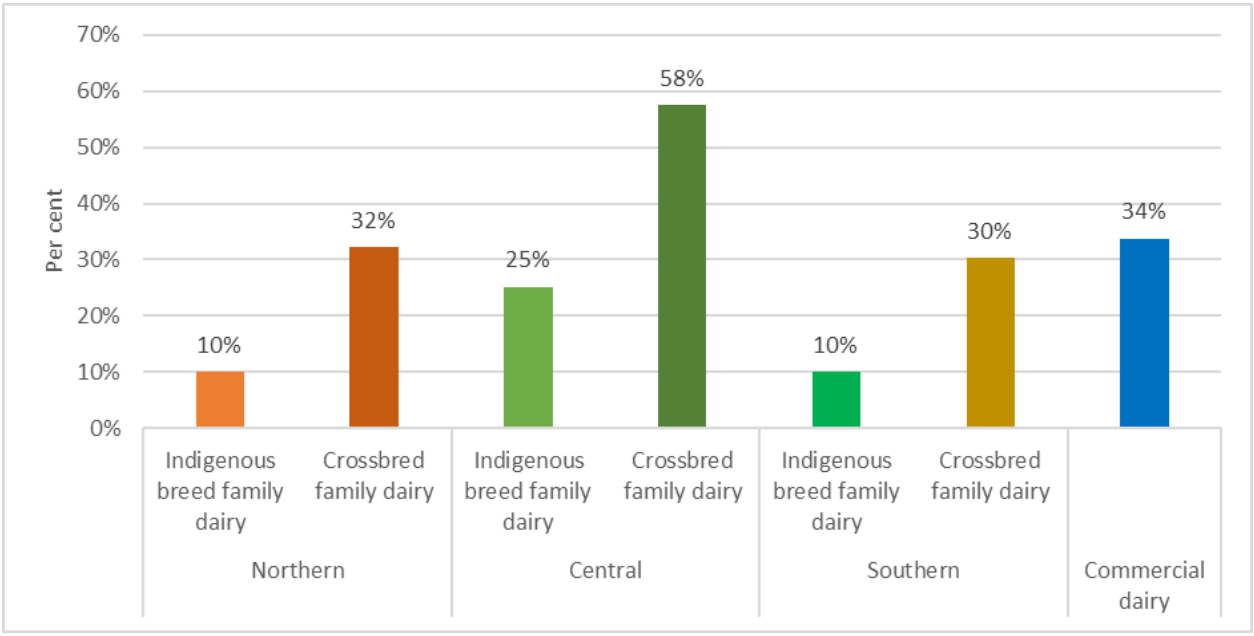
Table 68 also shows that investments in crossbred family dairy and commercial dairy show higher measures of NPV, IRR and BCR. The highest NPV and IRR for crossbred family dairy are observed in the Central livestock production zone where feed availability is much better than in the other livestock production zones. Overall, the crossbred family dairy system performs quite well in all production zones and its improvement promises to be quite rewarding. The investment resulted in economically viable 15-years NPVs of INR 67,000, 1,80,000 and 58,000 per herd in the Northern, Central and Southern livestock production zones, respectively. Similarly, as shown in Figure 16, the IRRs obtained for crossbred family dairy in all livestock production zones are greater than the acceptable minimum investment return of 10%.

The highest NPV over the 15-years time horizon is observed in the commercial dairy (Table 68). This shows the viability of the investment made in the sector and the potential of the commercial dairy business. However, it requires the state government to implement appropriate policy measures to make land available for the private sector to grow adequate forage to meet the feed requirements of the crossbreds. It also requires improvement in the marketing system and infrastructure to absorb the additional milk for value addition and distribution. Incentives to attract private sector investment in the industry include favourable loans.

Table 68: Results of financial analysis for both breed and livestock interventions in family and commercial cow dairy production in Bihar, 2017–18 to 2032–33 (at cow dairy production unit/thousand herd)

Production zone	Breed/size	Financial indictors based on 15-years discounted incremental cash flow analysis			
		NPV (INR Thousand)	IRR (%)	Benefit-cost ratio (BCR)	EANPV (INR Thousand)
Northern	Indigenous breed family dairy	2.7	10%	1.0	0.4
	Crossbred family dairy	67	32%	1.5	9
Central	Indigenous breed family dairy	11	25%	1.3	1.5
	Crossbred family dairy	180	58%	2.1	23.7
Southern	Indigenous breed family dairy	4.7	10%	1.0	0.6
	Crossbred family dairy	58	30%	1.5	7.7
Commercial dairy		1,196	34%	1.8	157

Figure 16: Impact of interventions: 15-years IRR for WI-1 scenario by production subsystems (at cow dairy production unit or herd level).



Overall, as shown in Figure 17 below, the IRR is greater than the acceptable minimum investment return of 10% and the BCR is greater or equal to one for all three systems: indigenous breed family dairy, crossbred family dairy and commercial family dairy. However, it is more viable in the crossbred family dairy and commercial family dairy systems.

Figure 17: Impacts of interventions: BCR and 15-years IRR for WI-1 scenario (at cow dairy production subsystem level).

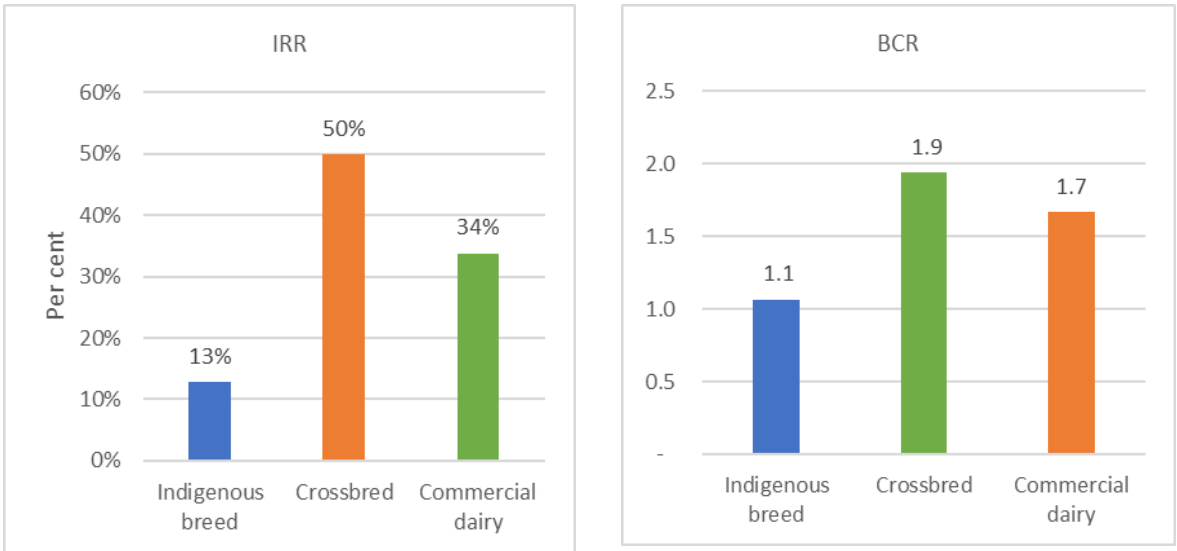
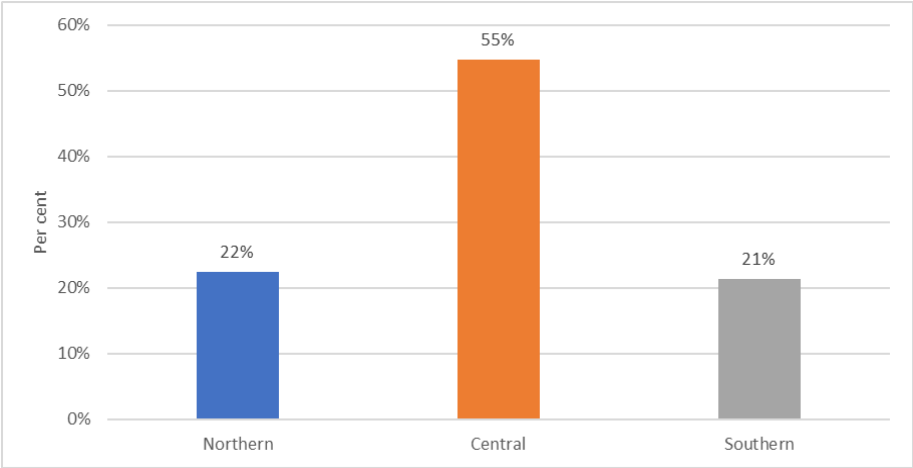


Figure 18 below shows the 15-years IRR for the three livestock production zones. Overall, the IRR is greater than the acceptable minimum investment return of 10% in all livestock production zones, but it is more viable in the Central livestock production zone.

Figure 18: Impacts of interventions: 15-years IRR for WI-1 scenario (at livestock production zone level).



GSDP contribution for all cow dairy products

As shown in table 69 below, The GSDP contribution of cow dairy in the WI-1 scenario in 2032–33 is more than twice (226%) the base year cow dairy GSDP contribution, while the increase is only 37% to the BAU scenario 2032–33. Milk provides the highest GSDP share in the cow dairy system. The GSDP contribution of milk under the WI-1 scenario in 2032–33 changes by 252% when compared with the base year (2017–18), increasing from INR 7,112 crores to INR 25,004 crores. In the BAU scenario, the GSDP contribution of milk increases by only 44% in 2032–33from the base year (2017–18). Similarly, the per cent change in GSDP contribution of milk under BAU (in 2032–33) from the base year for indigenous and crossbred dairy is 43% and 60%, respectively, while the per cent change in the WI-1 scenario (in 2032–33) is 50% and 290%, respectively.

Table 69: GSDP contribution for baseline, BAU and WI-1 scenarios (INR crores)

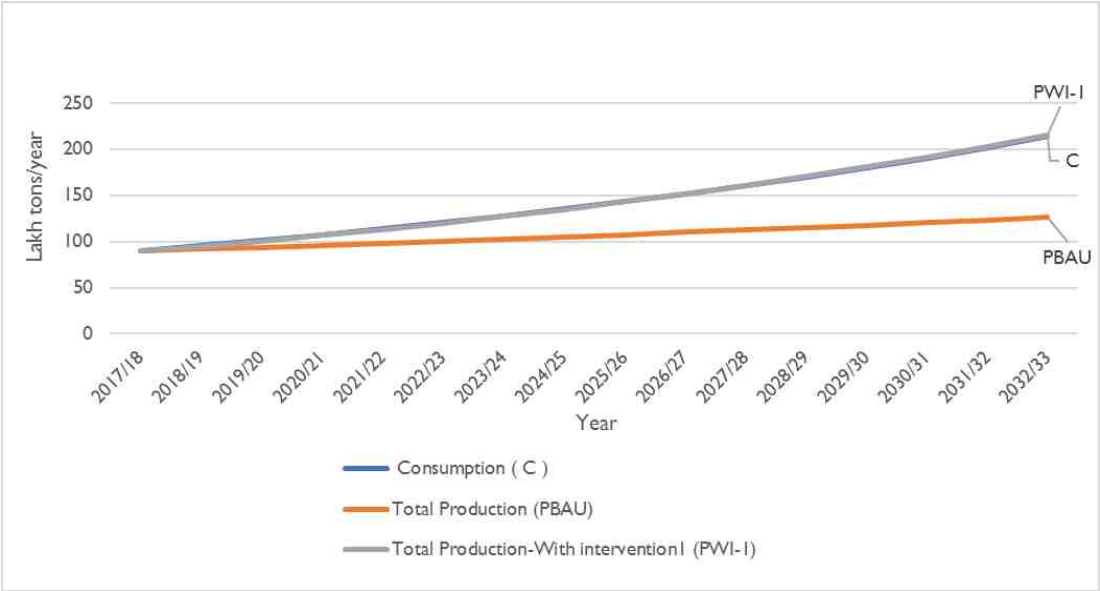
Products	Baseline (2017–18) (INR crores)	GSDP for BAU in 2032–33 (INR crores)	% change, baseline to BAU	GSDP for WI-1 in 2032–33 (INR crores)	% change, baseline to WI-1
Milk— family indigenous	1,134.7	642.6	-43%	1,697.9	50%
Milk—family crossbreds	5,966.7	9,570.3	60%	23,280.5	290%
Milk—commercial dairy	10.9	16.2	48%	26.1	138%
Total milk	7,112.3	10,229.1	44%	25,004.4	252%
Organic matter	1,830.5	2,026.1	11%	2,342.5	28%
Energy	1.3	0.8	-43%	0.8	-41%
Total	16,056.4	22,485.1	40%	52,352.2	226%

Milk production-consumption balance in 15 years under the WI-1 scenario

Figure 19 shows the projection of future production-consumption balance in milk and milk products under the BAU and WI-1 scenarios. Milk consumption is projected to grow linearly from 900 crore litres in 2017–18 to 21,300 crore litres in 2032–33 (a 136% increase), due to changes in human population, urbanization and incomes. Meanwhile, milk production under the BAU scenario or with the current level and type of investment is projected to increase by only 41%, from 896 crore litres in 2017–18 to 1,260 crore litres in 2032–33. With the current investment (BAU), the production-consumption gap for milk remains large in 2032-33, indicating the need for additional investment to close the gap. With additional investment (WI-1), milk production from cattle, buffalo and goats is projected to increase by 141% over the 15-years horizon, from 896 crore litres in 2017–18 to 2,159 crore litres in 2032–33.

Milk and milk product consumption in Bihar state is projected to increase progressively in the coming 15 years, hence the additional milk production from milk improvement interventions (WI-1) will only close the production-consumption gap by the year 2026–27.

Figure 19: Future production-consumption balance in milk and milk products under BAU and WI-1 scenarios



WI-2 scenario

Compared to crossbred cattle, indigenous breeds of India are known for their resistance to existing constraints: disease, inadequate feed and heat stress. They also produce A2 milk,[35] which has significantly higher market value than milk from crossbreds among urban consumers in India. Due to these potentially positive traits, an additional dairy foresight scenario analysis (WI-2) focusing on improvement of indigenous cattle breeds was conducted. In the WI-2 scenario, productivity of indigenous cattle is improved through crossbreeding with improved locals, and their numbers increase while the number of crossbreds is held constant. Indigenous cattle breeds are improved by crossing with semen from 'improved indigenous breeds' like Sahiwal and Gyr, while semen from crossbreds is used only for improving crossbred cattle. Local buffalos are also improved by crossing with improved buffalo breeds.

35 A2 milk is the milk that contains only the A2 type of beta casein protein, whereas A1 milk contains only A1 beta casein or A1 type variant. A1 protein variant is commonly found in milk from crossbreds and European breeds of cattle. A2 milk is found primarily in the indigenous breed cows and buffalos of India and Asia (Prasanta B. et.al. 2016).

In this section, besides presenting the results of the analysis of the WI-2 scenario, the impacts of the two cow dairy improvement scenarios, WI-1 and WI-2, are compared to see the advantages of each in order to recommend the interventions which would most likely result in the greatest benefits to Bihar, in terms of achieving its own development objectives: increasing milk production and achieving projected production-consumption balance, raising income per animal and returns on investment (IRR and BCR) in dairying, and in contributing the most to GSDP.

Cow dairy improvement targets and interventions under the WI-2 scenario

****All of the interventions listed under the WI-1 scenario previously presented apply equally to the WI-2 scenario.***

The difference between the WI-1 and WI-2 scenarios is the use of improved indigenous semen for crossing with local cows and the resulting herd population changes for cows and buffalos. In WI-1, semen from crossbred bulls is used with local cows to produce more crossbred cattle and the population of crossbred cows increases, while indigenous cows not crossed and are allowed to decrease in number. In the WI-2 scenario, semen from improved local cows is used to cross with unimproved cows thus raising their milk productivity, and the number of cows crossed with exotics remains constant. Moreover, the population of buffalos, including locals and crosses increase, as under WI-1.

Assumptions and targets for WI-2 cow dairy improvement interventions

****All of the animal and herd-level assumptions and targets included under the WI-1 scenario apply equally to the WI-2 scenario.***

WI-2 scenario intervention impacts

Projected cattle population in 15 years

The cattle population changes are based on the following growth rates:

Table 70: Cattle population growth rates for the two scenarios (WI-1 and WI-2)

	Livestock population annual growth rate (%)	
	WI-1 scenario growth rates	WI-2 scenario growth rates
Indigenous breeds	-3.72%	2.12%
Crossbreds	4.50%	0%
Total cattle	1.22%	1.22%

Table 70, above, presents the population growth rates under the two scenarios (WI-1 and WI-2). The projected population growth rates in the WI-1 and WI-2 scenarios are the fundamental differences between the two scenarios. For WI-2:

- The annual population growth rate of indigenous cattle for the coming 15 years of the LSA (2017–18 to 2032–33) is expected to be 2.12% (Tables 71 and 72).
- The annual population growth rate of crossbred cattle for the coming 15 years of the LSA is projected to be 0%.

As presented in Table 71, under both the WI-1and WI-2 scenarios, the total cattle population by 2032–33 grows by 20% from the baseline. However, breed-wise population growth rates have different trends under the two scenarios. Under the WI-1 scenario, the population growth rate for indigenous cattle breeds is negative while the growth rate for crossbreds is positive. In the WI-2 scenario, the indigenous cattle breeds over 15 years grow by 37% while the population of crossbred cattle is assumed to remain constant.

Table 71: Projected cattle population change and per cent change from baseline for WI-1 and WI-2 scenarios

Production zone	Breeds	Livestock population (in lakhs)		% change WI-1	Livestock population WI-2 2032–33 (lakhs)	% change WI-2
		Baseline 2017–18	WI-1 scenario 2032–33			
Northern	Indigenous breeds	39.0	22.1	-43%	53.5	37%
	Crossbreds	11.6	22.5	94%	11.6	0%
	Total	50.6	44.6	-12%	65.1	29%
Central	Indigenous breeds	14.1	8.0	-43%	19.3	37%
	Crossbreds	43.7	84.6	94%	43.7	0%
	Total	57.8	92.5	60%	63.0	9%
Southern	Indigenous breeds	18.3	10.4	-43%	25.1	37%
	Crossbreds	6.0	11.5	94%	6.0	0%
	Total	24.3	21.9	-10%	31.0	28%
Commercial dairy		0.1	0.1	60%	0.1	51%
Total population	Indigenous breeds	71.4	40.4	-43%	97.8	37%
	Crossbred	61.3	118.6	93%	61.4	0%
Grand total population		132.8	159.2	20%	159.2	20%

Source: LSA results

Projected production in 15 years

Compared to the base year (2017–18), in 2032–33, under the WI-2 scenario, milk production from cow dairy grows by 91%, compared to 182% under WI-1. The increase in the milk production comes from both crossbreds and indigenous cows. The increase in milk production from the indigenous breeds is about 160% and from crossbreds 72%.

Under the WI-2 scenario, the contribution of cattle to traction power in 2032–33 increases by 37% when compared to the base year (Table 72). This is due to the increase in the number of indigenous cattle under this scenario (WI-2). However, in both the BAU and WI-1 scenarios, the use of cattle for traction power shows a decrease due to the decrease in indigenous cattle which are normally used to provide traction.

Table 72: Production change and per cent change from baseline, for WI-1 and WI-2 scenarios

Products	Baseline 2017–18	Production in 2032–33 WI-1	% change under WI-1	Production in 2032–33 WI-2	% change under WI-2
Milk in indigenous breed family dairy (crore litres)	118.9	127.8	7%	309.1	160%
Milk in crossbred family dairy (crore litres)	417.3	1,386.5	232%	716.4	72%
Milk in commercial dairy (crore litres)	1.0	2.0	114%	2.0	114%
Total milk (crore litres)	537.2	1,516.3	182%	1,027.6	91%
Organic matter (lakh MT)	122.0	156.2	28%	143.5	18%
Traction power (lakh days)	1.7	0.9	-43%	2.3	37%

Source: LSA results

GSDP contribution for all cow dairy products

As shown in Table 73 below, the GSDP contribution of cow dairy in the WI-1 and WI-2 scenarios 2032–33 is about 226 and 115%, respectively, above the base year cow dairy GSDP contribution.

Table 73: GSDP contribution change and per cent change from baseline, for WI-1 and WI-2 scenarios (INR lakhs)

Products	Baseline 2017–18 (INR lakhs)	GSDP WI-1, 2032–33 (INR lakhs)	% change, under WI-1	GSDP WI-2 scenario, 2032–33 (INR lakhs)	% change, under WI-2
Milk— family indigenous	1,134.7	1,697.9	50%	4,107.0	262%
Milk—family crossbreds	5,966.7	23,280.5	290%	12,029.5	102%
Milk—commercial dairy	10.9	26.1	138%	26.1	140%
Total milk	7,112.3	25,004.4	252%	16,162.6	127%
Organic matter	1,830.5	2,342.5	28%	2,152.0	18%
Energy	1.3	0.8	-41%	1.8	42%
Total	16,056.4	52,352.2	226%	34,478.9	115%

Source: LSA results; *N/C - no change

Milk production-consumption balance in 15 years

Figure 20 presents the projected production-consumption balance in milk and milk products under the BAU, WI-1 and WI-2 scenarios. Milk consumption is projected to grow from 900 crore litres in 2017–18 to 2,130 crore litres in 2032–33 (a 136% increase), due to changes in human population, urbanization and incomes.

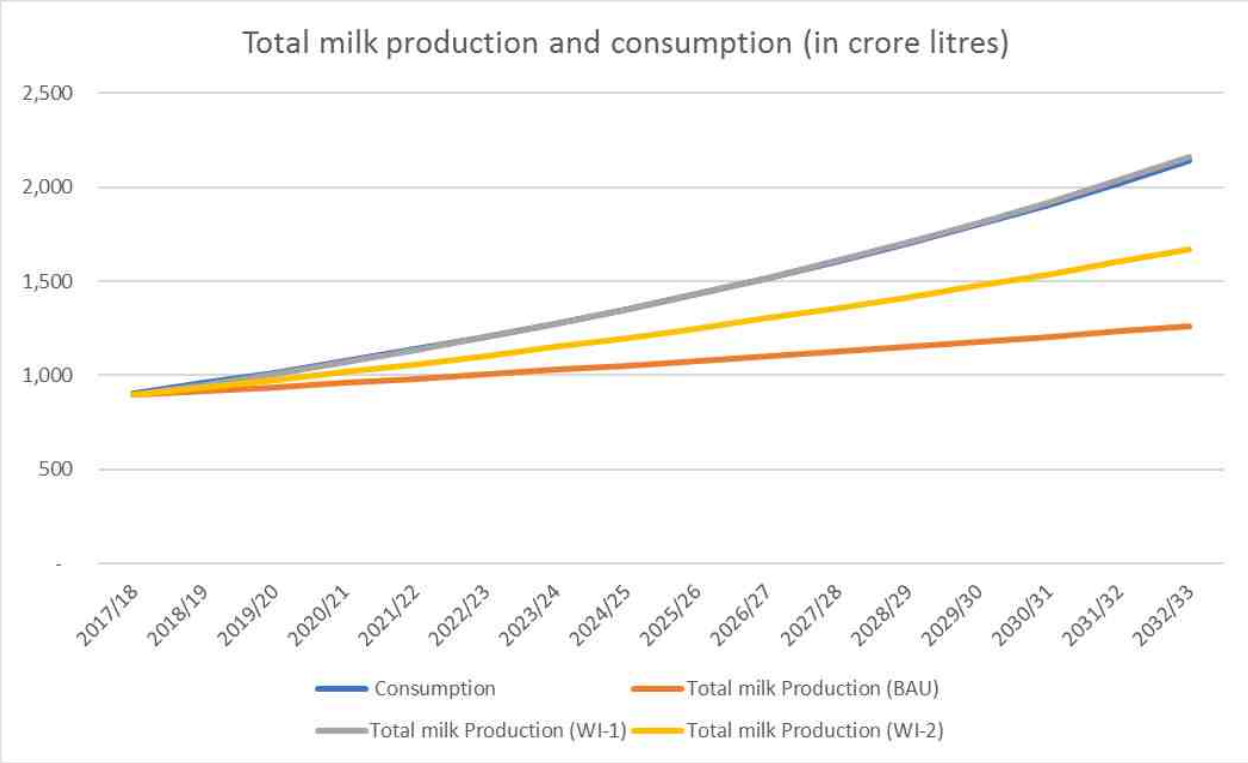
As shown in Figure 20 under the WI-2 scenario, with additional investment that primarily focuses on improving indigenous cattle production, overall milk production (from cattle, buffalos and goats) is projected to increase by only 86% over the 15-years horizon, from 896 crore litres in 2017–18 to 1,670 crore litres in 2032–33. Under such a scenario, the production-consumption gap continues to expand and will reach a deficit of 460 crore litters by the year 2032–33.

Under the WI-1 scenario in which both indigenous and crossbreds are improved with exotic semen and complementary interventions and less productive indigenous animals are replaced by crossbreds, milk production from cattle, buffalos and goats is projected to increase by 141% over the 15-years horizon, from 896 crore litres in 2017–18 to 2,159 crore litres in 2032–33, closing the milk production-consumption gap by the year 2032–33.

Lastly, it will be recalled that the WI-I scenario for cow dairy improvement interventions resulted in IRRs of 13% and 50% and BCR of 1.1 and 1.9 for indigenous and crossbred cattle, respectively (see Table 97). The investment analysis for WI-2 was not done since the investment costs would be almost the same as in WI-1 and thus the ROIs (IRR and BCR) would certainly be lower than for the WI-1 crossbred cow scenario.

Figure 20: Future projected production-consumption balance in milk and milk products under BAU, WI-1 and WI-2

scenarios



7.1 Buffalo milk and meat improvement

Intervention areas (production zones)

All the livestock production zones (Northern, Central and Southern) are target areas for buffalo milk and meat improvement interventions.

Buffalo milk and meat improvement interventions and targets

Feed

In addition to the feed interventions listed under the cow dairy improvement intervention options section, other major feed improvement focus areas are listed below:

- Supporting backyard, hedge and live fence etc. fodder production.
- As stated before, the area of land under permanent pasture/grazing during 2013–14 was about 15,000 ha. The plan to increase land productivity would be to oversow with improved grass and leguminous forage seeds and use of fertilizer, where feasible. The targeted goal is to increase rehabilitated permanent pasture/grazing land to be 50% of the total permanent pasture land by 2022–23, 80% by 2027–28 and remain at 80% by 2032–33.
- Improving production, marketing and quality control of forage seeds, forages and concentrates through strengthening of existing regulatory bodies.

Health

- Veterinary hospitals/poly clinics, veterinary dispensaries and veterinary aid centres presented in the cow dairy improvement intervention options section would cater to all species including buffalo.
- Buffalo receiving vaccinations for the important diseases (FMD (80% currently, started from 2015), brucellosis (90% currently, from 2017), HS, BQ (80% currently, historically implemented) will remain 80% by 2022–23. The major interventions are timely vaccination campaigns, improvement of deworming, sanitation and housing, and control of flood and drought.
- Farmers that adopt the recommended rate of external and internal parasite control treatments will reach 80% in the coming 15 years.
- Private veterinary service providers would be supported with incentives in remote areas.
- Mastitis control and prevention technologies would be supported.

Genetics

- The number of AI services performed for buffalos is usually reported together with cattle inseminations. By 2017–18, total cattle and buffalo inseminations performed were 27.96 lakhs. The targeted goal is to increase inseminations to 50 lakhs by 2022–23, 85 lakhs by 2027–28 and 110 lakhs[36] by 2032–33.

36 Assumptions include: per cent of adult females=58% for cattle, 48% for buffalo, parturition rate=50% for cattle and 45% for buffalo, number of repetitions=2.

- The upgrades and establishment of semen production centres, frozen semen banks, liquid nitrogen storage plants and AI centres targeted for cattle would also serve for buffalo.
- Currently, the number of buffalo breeding farms include only one under AH. The goal is to strengthen the existing farm and establish one new farm by 2022–23 and one more by 2032–33. These breeding farms could serve as breed improvement, breeding, nucleus and multiplication centres.

Extension

- Extension infrastructure listed under cattle would also cater to buffalo.
- By 2032–33, all of the AI/veterinary aid centres will provide extension services (training, input and marketing) to farmers.
- Extension departments at different levels would be involved in public extension services and support, control and regulate extension services (input, advisory and marketing services) provided by Pashu Sakhi, agri-clinics and agro-business operators, para-vets/community animal health workers, input suppliers, other private extension service providers and extension service providers at co-operatives/MCCs, farmer based organizations, farmer self-help groups, and telecommunication extension service providers/operators.
- Needed acts, regulations, guidelines and manuals would be developed/improved in the first two years of the plan to support the rapid growth of extension service providers. Bureaucratic procedures that hinder service providers would be reviewed and revised to support the ethical and responsible provision of services. Control of unregistered input, advisory and marketing service providers is also critical for survival of the legal service providers.
- Coverage of regular buffalo management training will reach 15% by 2022–23, 40% by 2027–28 and 80%[37] by 2032–33. Farmers will receive more intensive and continual training in buffalo management (feeding, breeding, deworming, tick control, hygiene and milk handling and transport).
- Strengthening the telecommunication extension service.
- The percent of MCCs and milk producer associations providing dairy input supplies, animal health, extension and financial services would increase to 80% by 2032–33.

Research

The interventions listed under the cow dairy improvement intervention options section will also serve for buffalos.

Processing and marketing

- Encouraging establishment of buffalo milk producer co-operative societies.
- Infrastructure listed under the cattle dairy intervention like MCCs, milk processing plants and bulk milk chilling units would also serve for milk produced by buffalos.

37 According to IFPRI (IFPRI, 2016), agri-clinic operators receive two months training; out of the trainees, 47% didn't succeed in the business in the past and served for about 500 households. Assume a training centre will provide two months training for 200 trainees/year. Currently, there are about 57 lakh households that own cattle.

- Increasing the functional capacity and utilization of existing MCCs.
- Incentivizing the private sector to take part in the marketing and processing of buffalo milk, separate from cow milk.
- Strengthening the capacity of milk quality and safety control laboratories.
- Creating an enabling environment to establish functional linkages between private milk traders, MCCs, co-operatives and processing plants.
- Supporting small-scale technologies for value addition of raw milk e.g. curd, ghee, paneer, khoa, etc.
- Establishing integrated abattoir and processing plants, one by 2022–23, one by 2027–28 and one by 2032–33.

Animal and herd-level assumptions for farmers adopting buffalo milk and meat improvement interventions

- Parturition rate to increase by 5% points.
- Mortality rate to decrease by 50%.
- Daily milk production of buffalo to increase from the current 5, 5.5 and 4.5 litres/day in the Northern, Central and Southern zones to 6, 6.5 and 5.5 litres/day, respectively (MAFW 2017; Vaidya 2017).
- Average live weight of buffalos to increase by 50-10%.
- Amount of fodder purchased to increase by 10%.
- Amount of purchased concentrate/processed feed to increase by 0.5 kg/day/lactating buffalos (Vaidya 2017).
- Each buffalo to be provided with 40-50 gm/day mineral supplementation and 30 gm/day common salt.
- Expenditure for veterinary services to increase by an additional INR 500 per animal/year.
- The price of hides to increase by 10% due to external parasite treatment/controls.

Impact of interventions

Projected population in 15 years

The current and projected serious feed shortage in the state (see Annex 3— feed balance analysis) does not support increased production through an increase in livestock population. Thus, the annual growth rate for the buffalo population is maintained at 2.49% under both the BAU and WI scenarios and there is the same 45% change in the buffalo population between BAU and WI in 2032–33. The major focus of the buffalo meat and milk improvement interventions is to increase productivity of buffalos, not to increase population.

Table 74: Buffalo population at production zone level for baseline, and under BAU and WI scenarios (in lakhs)

Production zone	Livestock population				
	Baseline (2017–18) (in lakhs)	BAU in 2032–33 (in lakhs)	% change under BAU	WI in 2032–33 (in lakhs)	% change under WI
Northern	40.7	58.9	45%	58.9	45%
Central	35.4	51.2	45%	51.2	45%
Southern	11.8	17.0	45%	17.0	45%
Total	87.8	127.0	45%	127.0	45%

Source: LSA results; *N/C - no change

Projected production in 15 years

Under the BAU scenario for buffalos, the change in meat and milk production under BAU from the base year (2017–18) to 2032–33 will be 45%, while the change in meat and milk production under WI scenario in 2032–33 from the base year (2017–18) will be 62% and 78%, respectively (Table 75). The results related to traction power (or energy) and manure (or organic matter), on the other hand do not show any difference as there is no change in the buffalo population between BAU (2032–33) and WI (2032–33).

Table 75: Production for baseline, and BAU and WI scenarios

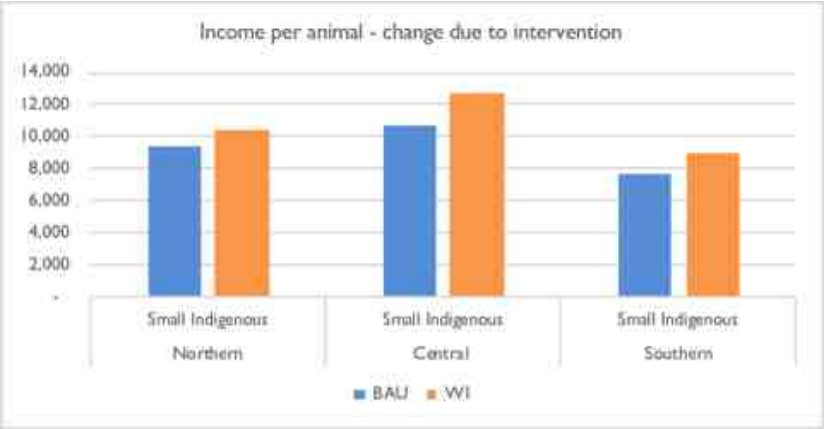
Products	Baseline (2017–18)	BAU Production in 2032–33	% change under BAU	WI Production in 2032–33	% change under WI
Buffalo meat (MT)	76,302	1,10,347	45%	1,23,589	62%
Buffalo milk (crore litres)	340.7	492.7	45%	606.5	78%
Organic matter (lakh MT)	109.0	157.7	45%	157.7	45%
Energy (thousand days)	41	59	45%	59	45%

Source: LSA results

Projected income per animal in 15 years

The income per animal in buffalo production is presented in Figure 21 below. The results indicate that income per animal under the WI scenario increases around 10% in the Northern and Southern livestock production zones, whereas in the Central production zone, in absolute terms the income per animal increases by more than INR 2,000 per animal due to the additional investment (WI).

Figure 21: Income per animal for BAU and WI scenarios.



Returns on investment

Table 76 presents the results of the financial analysis for investments in buffalo production units across the three livestock production zones in Bihar. All the financial indicators based on 15-years discounted incremental cash flow analysis are viable.

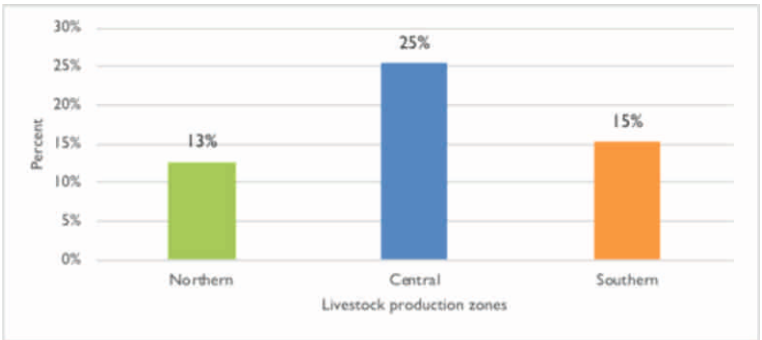
Table 76: Results of financial analysis for the combined livestock interventions in small buffalo production units in Bihar production zones, 2017–18 to 2032–33 (at buffalo production unit/herd level)

Buffalo production unit level by zone	Financial indictors based on 15-years discounted incremental cash flow analysis			
	NPV (INR thousands)	IRR (%)	BCR	EANPV (INR thousands)
Northern	8.6	13%	1.1	1.1
Central	18.5	25%	1.4	2.4
Southern	8.6	15%	1.1	1.1

Source: LSA results

However, investments in the Central livestock production zone are more than twice as rewarding. The NPV over the 15-years horizon is about INR 18.5 thousand per herd. The IRR for the Central zone is 25%, higher than the acceptable discount rate of 10%.

Figure 22: Investment impacts of the WI interventions: 15-years IRR (at zonal livestock production level).



GSDP contribution for all buffalo products

The total GSDP contribution of all buffalo products by 2032–33 would increase by 67% from the base year (2017–18) in the WI scenario, while the increase would be only 45% under the BAU scenario (Table 77). Milk accounts for most of the share of the buffalo VC contribution to GSDP. Furthermore, the GSDP contribution of milk increases by 76% under WI (by 2032–33) compared to the base year (2017–18), increasing from INR 6,540 to 11,520 crores. Under the BAU scenario, the GSDP contribution of milk increases by 2032–33 only 45% from the base year (2017–18). Similarly, the per cent change in GSDP contribution of meat under the BAU scenario (in 2032–33) from the base year (2017–18) would be 45%, while the per cent change under WI would be only 31%. The lower per cent change in GSDP contribution under WI (by 2032–33) compared with the BAU change by 2032–33 would be due to the lower returns due to the additional post-production investment costs to improve meat production and processing under WI.

Table 77: GSDP contribution for baseline, BAU and WI scenarios (INR crores)

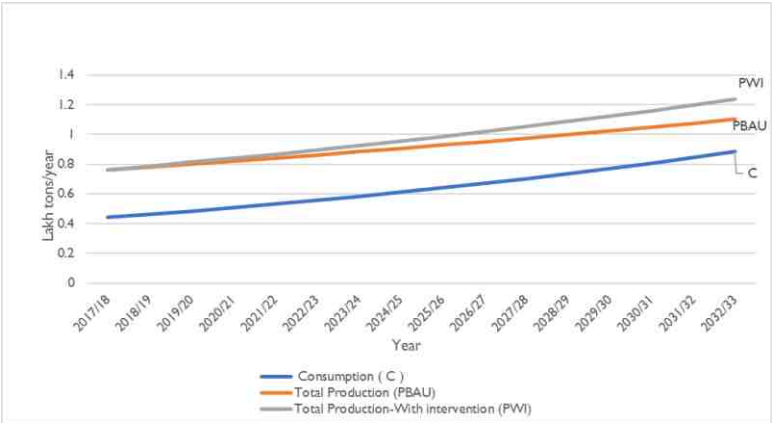
Products	Baseline GSDP in 2017–18 (INR crores)	BAU GSDP in 2032–33 (INR crores)	% change under BAU	WI GSDP in 2032–33 (INR crores)	% change under WI
Buffalo meat	498.9	721.5	45%	656.1	31%
Buffalo milk	6540.6	9458.9	45%	11,515.8	76%
Organic matter	1635.7	2365.5	45%	2,352.3	44%
Energy	0.3	0.5	45%	0.5	45%
Total	8,675.6	12,546.5	45%	14,524.6	67%

Source: LSA results

Projected buffalo meat production-consumption balance in 15 years

Figure 23 compares the future production-consumption balance in buffalo meat under the BAU and WI scenarios. Buffalo meat consumption in Bihar state is projected to increase by more than 100% over the 15-years LSA period to 2032-33, from the base year of 2017-18, but from only 0.4 lakh MT/year to 0.9 lakh MT/year. Production in 2017-18 is already higher than consumption, indicating surplus production already exists and it is being marketed to other states or exported.

Figure 23: Future production-consumption balance in buffalo meat under BAU and WI scenarios.



As shown in Figure 23 above, surplus buffalo meat production presently exists and is projected with the current level of investment or BAU. The increase in buffalo meat production which would result from additional investment or the WI scenario over the BAU scenario is relatively small, ranging from a 1% increase in 2017–18 to a 12% increase in 2032–33. However, under the WI investment scenario, meat production in Bihar is projected to increase by 45%, or from 0.76 lakh t/year in 2017–18 to 1.1 lakh t/year in 2032–33, in absolute terms. Whether WI or BAU is chosen as the preferred investment scenario, these results indicate that there would need to be ways developed to market this additional surplus to other states or to export it. Moreover, the additional investments to increase buffalo production under WI compared to BAU would need to be complemented with investments in buffalo meat processing, raising the cost per kg and lowering the meat contribution to GSDP, as earlier alluded to. Thus, under both the BAU and WI scenarios, a projected surplus over local demand would be generated, but a bigger one under WI. However, it would be worthwhile to invest in and implement the WI scenario only if the buffalo meat markets outside Bihar can be exploited.

7.3 Goat meat improvement

The intervention context

Bihar is endowed with a large number of goats—1.2 crores. Bihar is the third largest state in goat population, following Rajasthan and Uttar Pradesh (MoA, 2014b). Goats in Bihar are reared in a traditional and subsistence manner by some sects of the society (marginal and landless labourers) who are unable to rear large animals (Dey et al., 2007). This traditional way of keeping goats results in high mortality and low productivity. Although the most commonly used breed, Black Bengal goat, is highly prolific and resistant to diseases, feed shortages and inadequate health services result in high mortality. Thus, the goat meat improvement intervention focuses on reducing mortality in addition to improving parturition and prolificacy rates through feed improvement (feed availability and quality) and health services (primarily vaccination).

Goat meat improvement interventions and targets

Feed

- Supporting backyard, hedge and live fence etc. fodder productions.
- Educating farmers to feed dams/does with supplementary concentrate feeds a month before and after parturition to increase their mothering ability, birth weight and survival of kids (Chowdhury et al. 2002).
- The area of land under permanent pasture/grazing during 2013–14 was about 15,000 ha. The plan is to increase productivity by oversowing with improved grasses and leguminous forage seeds and use of fertilizer, where applicable. The targeted goal is to increase rehabilitated permanent pasture/grazing land to encompass 50% of the total permanent pasture land by 2022–23, 80% by 2027–28 and remain at 80% by 2032–33.
- Improving production, marketing and quality control of forage seeds, forages and concentrates through the strengthening of existing regulatory bodies.
- The number of fodder seed production farms targeted under cow dairy also serves for goats.

Health

- Veterinary hospitals/poly clinics, veterinary dispensaries and veterinary aid centres presented in the cow dairy improvement intervention options section to cater to all species including goats.

- Goats to receive vaccinations for critical diseases such as PPR, goat pox, enterotoxeamia, HS, FMD and BQ. Currently, about 80% of goats are receiving vaccinations for PPR by public campaign programs and it is assumed it will remain 80% by 2022–23. Adoption of vaccinations for other diseases is targeted to increase to 50% by 2022–23 and 80% by 2027–28
- Farmers that adopt the recommended rate of external and internal parasite control treatments would reach 80% over the next 15 years.
- Private veterinary service providers to be supported.

Genetics

- Improving local breed goats through breed selection
- Making the existing goat breeding farm functional by 2022–23 and establishing one more new breeding farm by 2032–33.
- Breeding farms to be used to develop and multiply improved local goat breeds.
- Community-based goat breed improvement programs to increase productivity of indigenous goats.
- Implementing AI on goats in collaboration with ICAR-Central Institute for Research on Goats, Mathura (Uttar Pradesh).

Extension

- Extension infrastructures listed under cow dairy would also cater to goats.
- Extension departments at different levels to be involved in the public extension services, and support, control and regulate extension services (input, advisory and marketing services) provided by Pashu Sakhis. Similarly extension service provided by agri-clinics and agro-business operators, para-vets/community animal health workers, input suppliers, and extension service providers at co-operatives/MCCs, farmer based organizations, farmer self-help groups, telecommunication extension service providers/operators, need to be controlled and regulated.
- Needed parliamentary acts, regulations, guidelines and manuals to be developed/improved in the first two years of the plan to support the rapid growth of extension service providers. Bureaucratic procedures that hinder the service providers to be reviewed and revised while continuing to support the ethical and responsible provision of services. Control of unregistered input, advisory and marketing service providers carried out for survival of the legal service providers.
- Provision of consistent goat management training to reach 15% by 2022–23, 40% by 2027–28 and 80% of farmers by 2032–33. Farmers to receive more intensive and continuous training in goat management (feeding, breeding, deworming, tick control, hygiene and milk handling and transport).

Research

- The interventions listed under the cow dairy improvement intervention options section to also serve for goats.

Processing and marketing

- Establishing three abattoirs by 2032–33 to be used for exporting.

Animal and herd-level targets and assumptions for farmers adopting goat meat improvement interventions

- Parturition rate to increase from 1.25 to 1.5 (Miah et al. 2016; Haque et al. 2013).
- Prolificacy rate will increase from 1.5 to 2.0 (Miah et al. 2016; Haque et al. 2013).
- Mortality rate to decrease by 50% (Kumar et al. (2003) and Chowdhury et al. (2002) reported mortality reductions of up to 70% through implementation of the above listed interventions).
- Live weight of goats to increase by 2 kg.
- Does to be fed with 200 gm per day of concentrate for a month before and after parturition to increase their milk production and mothering ability and improve survival of kids (Chowdhury et al. 2002).
- Each animal be be provided with 5 gm/day mineral supplementation and common salt.
- Expenditures for external and internal parasite treatment and control and vaccination for critical diseases to result in veterinary-related cost increases of INR 100 per animal/year. [38]
- Price of skins increases by 10% due to external parasite treatment/controls.

Impact of interventions

Projected population in 15 years

The goat population is currently growing at an annual rate of about 3.63% (i.e., in the BAU scenario). In the WI scenario, the annual growth rate remains at 3.63%. The major focus of the goat intervention is to increase productivity of goats, rather than impacting production through population increase. This is due to the serious current and projected feed shortage in the state (see Annex 3— feed balance analysis) which does not support increasing production through an exaggerated increase in livestock population.

Table 78: Goat population at production subsystem level for baseline, BAU and WI scenarios (in lakhs)

Production zone	Production subsystem	Livestock population				
		2017–18 baseline (lakhs)	BAU in 2032–33 (lakhs)	% change under WI	WI in 2032–33 (lakhs)	% change under WI
Northern	Small farms	63.1	107.9	71%	107.9	71%
	Medium farms	15.8	26.8	70%	27.0	70%
	Total	78.9	134.7	71%	134.9	71%

38 Vaccination for important diseases (PPR, ET, FMD, goat pox, HS, BQ etc.) - (INR 50), external parasite treatment INR 10 per year/animal (three/year), internal parasite treatment INR 15 per year/animal (three/year), other disease treatments INR 25.

Production zone	Production subsystem	Livestock population				
		2017–18 baseline (lakhs)	BAU in 2032–33 (lakhs)	% change under WI	WI in 2032–33 (lakhs)	% change under WI
Central	Small farms	31.3	53.5	71%	53.5	71%
	Medium farms	13.4	22.8	70%	22.9	70%
	Total	44.7	76.3	71%	76.4	70%
Southern	Small farms	17.3	29.6	71%	29.6	71%
	Medium farms	4.3	7.4	70%	7.4	70%
	Total	21.6	37.0	71%	37.0	71%
Total		145.3	248.0	71%	248.3	71%

Source: LSA results

Projected production in 15 years

Table 79: Production at baseline, and under the BAU and WI scenarios

Products	Production subsystem	Production 2017–18 baseline	Production 2032–33 BAU	% change baseline to BAU	Production 2032–33 WI	% change baseline to WI
Goat meat (MT)	Small farms	21,041	35,973	71%	63,689	203%
	Medium	8,877	15,089	70%	23,132	161%
Total goat meat (MT)		29,918	51,062	71%	86,821	190%
Goat milk (lakh litres)	Small farms	1,423.6	2,433.9	71%	2,827.1	99%
	Medium	421.7	716.8	70%	837.16	99%
Total goat milk (lakh litres)		1,845.3	3,150.6	71%	3,664.2	99%
Organic matter (MT)		188,352	320,503	70%	309448	64%
Skins (MT)		5,665	9,669	71%	28,161	397%

Source: LSA results

In the goat BAU 2032–33 scenario, the change in meat, milk and skin production from BAU in 2032–33 and the base year (2017–18) will only be 70-71% while the change in meat, milk and skin production under the WI scenario in 2032–33 and the base year (2017–18) will be about 190%, 99% and 397%, respectively (see Table 79, above). In the WI scenario, the state-level goat meat and skin production increases tremendously (about twofold and fourfold). This increase in meat and skin production is due to the increase in average live weight of

goats of 14% and the increase in offtake rate of 52%, which are a result of the decrease in mortality rate coupled with an increase in parturition and prolificacy rates (Table 80 below and subsection 7.3).

Table 80: Offtake and population growth rates and average live weight of goats when sold

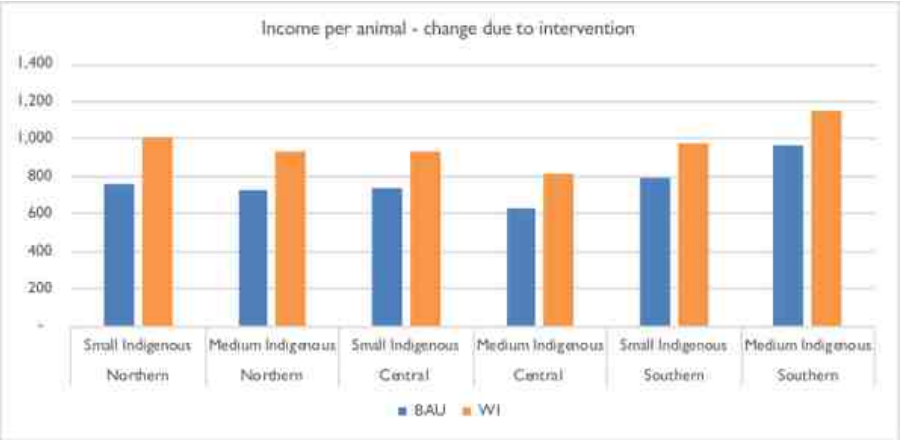
Parameters	Base year (2017–18)	WI in 2032–33	% change
Average live weight when sold (Kgs)	7	8	14%
Offtake rate (%)	58%	88%	52%
Population growth rate (%)	3.63%	3.63%	0%

Source: LSA results

Projected annual income per animal in 15 years

Figure 24 shows the annual incremental income per animal for both the BAU and WI scenarios in goat production. The results indicate that under WI (with intervention), the annual income per animal increases on average by only about INR 200 across all goat farm types and production zones. The highest income per animal as the result of additional investment interventions, about INR 247, is observed for small indigenous goat farms in the Northern livestock production zone. INR 200 is a very small amount of additional annual incremental income. Given the low additional income increases per animal under WI compared to BAU, and predominant small herd sizes, it becomes clear that the BAU scenario may be more attractive than WI for those goat keepers who can add more goats to their herd (with the existing available technology interventions) and those who are starting goat herding for the first time.

Figure 24: Annual incremental income per goat for the BAU and WI scenarios.



Returns on investment

Table 81 presents the financial analysis results for the combined livestock interventions (WI) for goat production in Bihar. All of the financial indicators based on 15-years discounted incremental cash flow analysis show that the investments in both small and medium goat farms in all livestock production zones are financially viable.

Table 81: Results of financial analysis for the combined livestock interventions (WI) in goat production in Bihar, 2017–18 to 2032–33 (at herd level)

Production zone	Goat production unit size	Financial return indictors based on 15-years discounted incremental cash flow			
		NPV (INR thousands)	IRR (%)	BCR	EANPV (INR thousands)
Northern	Small farms	1.2	25%	1.5	0.2
	Medium farms	8.4	48%	1.9	1.1
Central	Small farms	1.3	29%	1.5	0.2
	Medium farms	7.4	40%	1.8	1.0
Southern	Small farms	0.9	22%	1.4	0.12
	Medium farms	4.9	21%	1.4	0.6

Source: LSA results

As shown in Table 81 and Figure 25, the results indicate that investments in medium goat farms in the northern and central livestock production zones are more profitable than investments in small goat farms.

Figure 25: Impacts of interventions: 15-years IRR for WI for small and medium goat farms in different production zones (herd level).

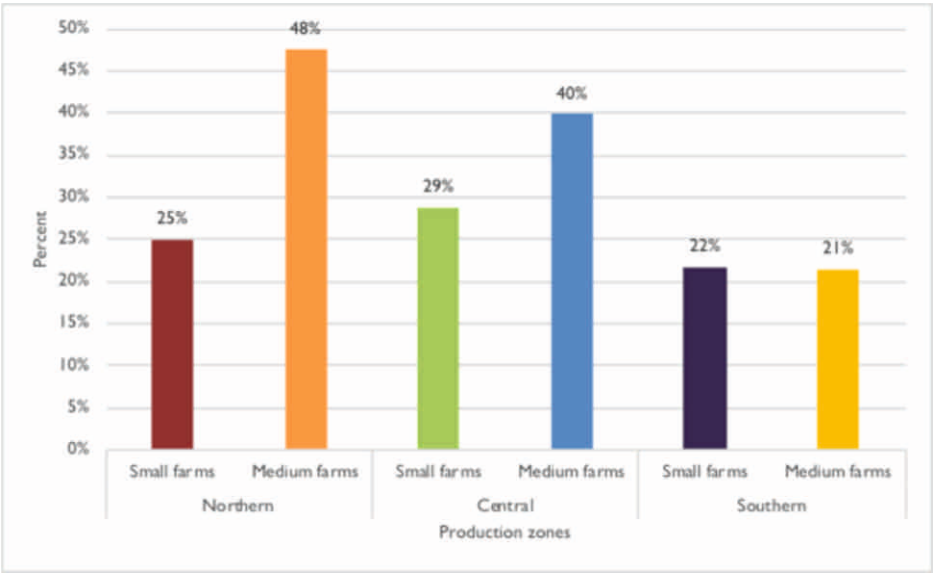
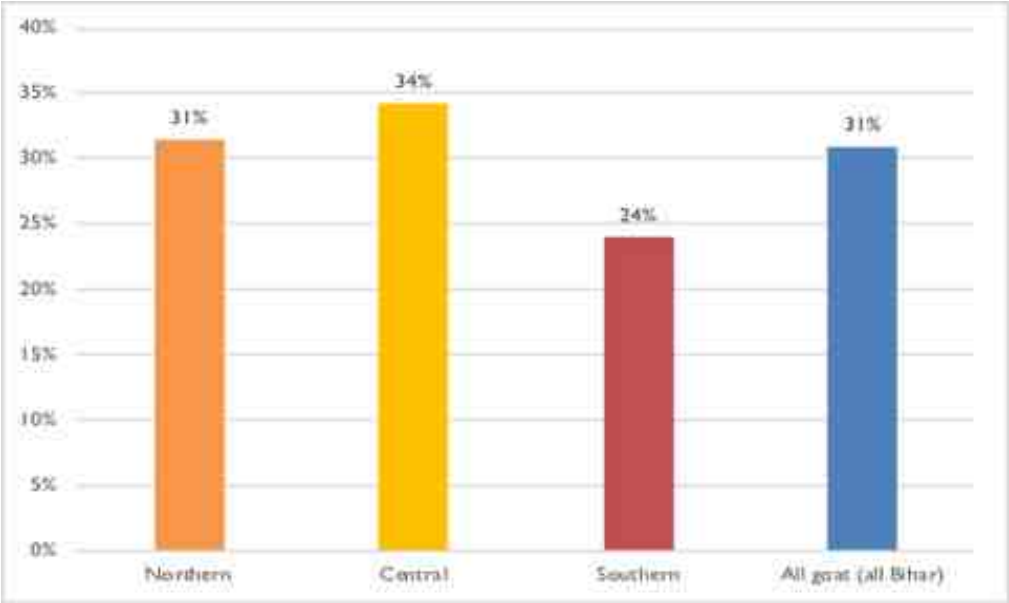


Figure 26 presents the IRR over the 15-years horizon for goat production in the three livestock production zones. Although the IRR is higher than the acceptable minimum discount rate of 10% in all livestock production zones, investments in goat production are more profitable in the Northern and Central livestock production zones.

Figure 26: Impacts of interventions: 15-years IRR for WI at production zone level.



GSDP contribution

The total GSDP contribution of goats by 2032–33 will increase by 197% from the base year (2017–18) in the WI scenario, while the increase will be only 71% in the BAU scenario (Table 82). Similarly, the change in GSDP contribution of meat and skins under BAU in 2032–33 will only be 71% while the change in GSDP contribution of meat and skins production under the WI scenario will be about 177% and 397%, respectively. The change in GSDP contribution of goat skins in 2032–33 under the WI scenario is fourfold due to the coupled effects of increases in number and price of skins produced. The number of goat skins increases due to the increased offtake rate in the WI scenario while the price of skins increases by about 10% due to less external parasites due to the treatments/controls. Goat milk is not valued in the GSDP contribution as the majority of the milk produced is consumed at home.

Table 82: GSDP contribution for baseline, BAU and WI scenarios (INR crores)

Goat meat	Baseline GSDP in 2017–18 (INR crores)	GSDP for BAU in 2032–33 (INR crores)	% change in GSDP due to BAU	GSDP for WI in 2032–33 (INR crores)	% change in GSDP due to WI
Small farms	664.2	1,135.6	71%	1,873.2	182%
Medium farms	193.2	328.3	70%	505.1	161%
Total goat meat	857.4	1,464.0	71%	2,378.3	177%
Skins	85.0	145.0	71%	422.4	397%
Total VA	942.4	1,609.0	71%	2,800.7	197%

Source: LSA results

Goat meat production-consumption balance in 15 years

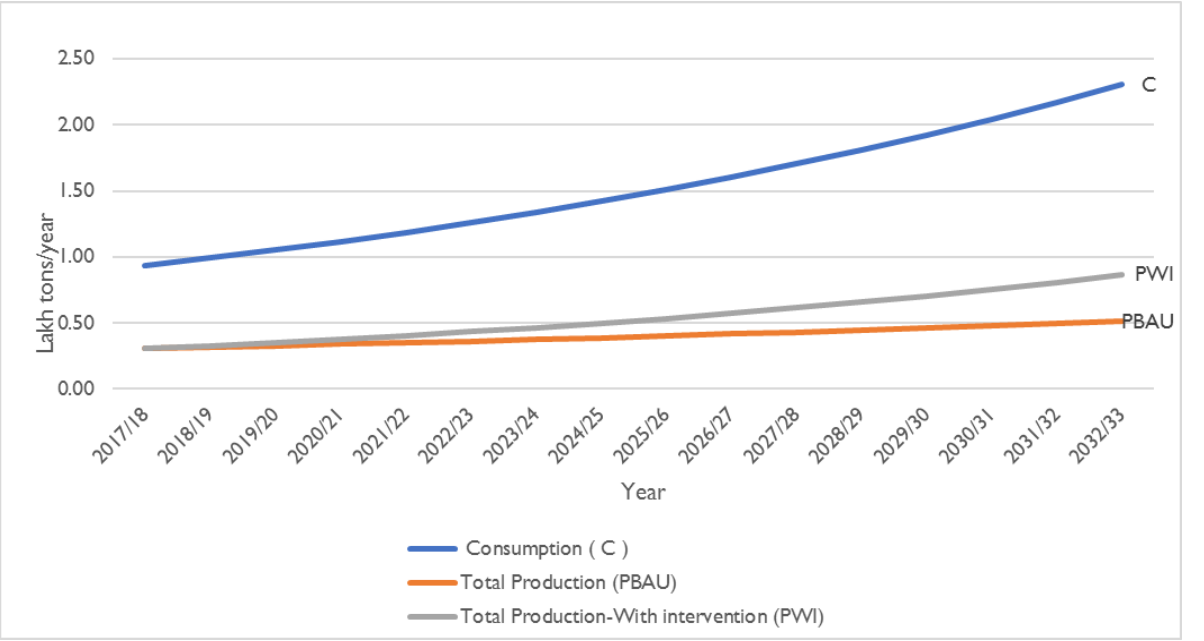
The future production-consumption balance in goat meat is presented in Figure 27 below. As the result of an increase in human population, urbanization and incomes, the quantity of goat meat demanded for

consumption in Bihar state is projected to increase to 2.31 lakh MT equivalent by the year 2032–33 from the baseline level of about 0.93 lakh MT in 2017–18, an increase of about 147%.

Meanwhile, during the same period, the quantity of goat meat produced is expected to increase by 67% without additional investment (BAU) and by 185% with additional investment in goat improvement interventions (WI). Although goat meat production is expected to increase significantly with WI, due to the projected rapid increase in expected demand for goat meat, the projected impact of the additional interventions (WI) on closing the gap between the goat meat produced and consumed is not significant over the 15-years investment period. It is projected that the supply shortage will continue under either BAU or WI.

Moreover, given the technology options presently available and the low additional returns to investment in WI compared to BAU, we conclude goat rearing is presently mainly a life-changing option for marginalized farmers and especially women, who are either going into goat production for the first time or can expand their herd sizes— for these farmers adopting WI will not help them much. Besides additional income from expanding herds, the benefits goats provide under BAU include empowerment due to the income and asset generation made possible, and help in achieving better household food security.

Figure 27: Future production-consumption balance in goat meat under BAU and WI.



7.4 Chicken meat and egg improvement

Chicken meat and egg improvement interventions and targets

Backyard family chicken (BYP) improvement interventions and targets

Intervention areas (production zones)

Improvement of traditional family backyard chicken farming system (BYP) is possible throughout the state— in all of the livestock production zones (Northern, Central and Southern zones)

Feed and feeding

- Supplementing scavenging chickens with locally available feeds with up to 25% of the nutritional requirements.
- Supplementing feed for incubating hens with at least 55 gm/day.

Genetics and reproductive management

- Improving indigenous chicken productivity through improved breed selection.
- Reducing reproductive wastage through early weaning of chicks and facilities to protect chicks (Hossen 2010).

Health

- Chickens to be vaccinated against chicken priority diseases (Newcastle Disease (ND) and fowl pox etc.) (GALVmed 2016).
- The percent of village chickens vaccinated for ND and fowl pox diseases to reach 50% by 2022–23 and 80% by 2027–28 (GALVmed 2016).
- Rationalize public and private veterinary services with privatization where feasible.
- Improve disease diagnostic and surveillance capacity of the Institute of Animal Health and Production.

Research and extension

- Research and extension improvement interventions listed in the cow dairy intervention improvement options section will also benefit chicken-related work.

Animal and herd-level targets and assumptions for farmers adopting backyard family chicken improvement interventions

- Average number of hens per flock to increase from 1.5 to 3 hens.
- Average number of clutches per year to increase from the current three to five (Hossen, 2010).
- Eggs laid per year to increase from 70 to 90 (Hossen, 2010).
- Chicken mortality before marketing to drop from 20% to 10%.

Scaling up commercial specialized chicken production

Intervention areas (production zones)

- Scaling up the commercial specialized chicken practice throughout the state and all of the livestock production zones (Northern, Central and Southern zones)

Priority interventions and assumptions

Feed and feeding

- Supporting production of processed chicken feed.

- Establishment of 69 medium and 5 large commercial feed producers over the next 15 years (Table 83). Also, commercial chicken farm owners to have their own feed-processing plant to cost up to INR 5–6 lakhs.
- Improving quality assurance of chicken processed feeds.
- Improving the feed quality testing and regulation capacity of the Institute of Animal Health and Production.

Table 83: Processed/commercial feed targets and number of chicken feed processing plants

Item		Targets in the three five-years LSA periods		
		(2018–19 to 2022–23)	(2022–23 to 2027–28)	(2027–28 to 2032–33)
Commercial feed needs (10 ^ 3 MT)		546.4	1,449.9	3,906.9
Chicken commercial feed processing plants (number)	Upgrade existing plant	3	2	-
	Establish new medium size plant	4	13	52
	Establish new large plant	0	2	3
Per cent of chicken feed expected to be produced by chicken farms themselves (%)		20%	30%	35%

With current maize, sorghum and millet production of around 38,45,700 MT and 12,508 MT, respectively, chicken production in Bihar takes up to 4% of the total production of these cereals. However, by 2032–33, given the current production of maize, sorghum and millet, the chicken sector will require 75% of the total production of these cereals (see Annex).

***This represents a potentially alarming chicken feed shortage which could be averted by increasing cereal production or purchasing cereal from other states. Currently, at the India state level, about 28% of the maize produced is utilized for food consumption, 11% for livestock feed, 48% for poultry feed, 12% in the wet milling industry (e.g. starch and oil production) and 1% as seed (Murdia et al. 2016).

- Support production and marketing of cereals to be used as row material for chicken feed production (maize and soybean).

Increasing the number of chickens in the commercial chicken production system

- The number of layers and broilers is targeted to increase from 13 and 69 lakhs from the base year to 4.7 and 24.8 crore, respectively, by 2032–33 (Table 84).

Table 84: Commercial layer and broiler chicken population (in lakhs) 2017–18 to 2032–33

Breed type	Base year (2017–18)	By (2022–23)	By (2027–28)	By (2032–33)
Layer population	13	43	142	470
Broiler population/cycle	69	227	751	2,479

Table 85: Annual population growth rate of commercial layers and broilers

Breed type	First five years (2017–18 to 2022–23)	Second five years (2022–23 to 2027–28)	Third five years (2027–28 to 2032–33)
Layer population	27%	27%	27%
Broiler population/cycle	27%	27%	27%

- Establish large and medium chicken multiplication centres and hatcheries to satisfy the increasing demand for day-old chicks (DOC).
- With an average of seventy lakhs DOC production capacity, about 152 hatcheries are recommended for the coming 15 years (Table 86).

Table 86: Number of hatcheries targeted by 2022–23, 2027–28 and 2032–33

Commodity	Number of hatcheries		
	until 2022–23	until 2027–28	until 2032–33
Hatcheries	10	33	109

Marketing and processing

- Support consumption of exotic chicken meat and eggs.
- Encourage construction of modern chicken slaughterhouses and cutting and processing plants.

Impact of interventions

Projected population in 15 years

Table 87: Chicken population at production subsystem level for baseline, BAU and WI scenarios (in lakhs)

Poultry production subsystem	Chicken population				
	Baseline, 2017–18 (lakhs)	BAU, 2032–33 (lakhs)	% change baseline to BAU	WI 2032–33 (lakhs)	% change baseline to WI
Indigenous backyard	204	296	45%	424	108%
Crossbred backyard	4.6	8.0	75%	8.2	80%
Layers	13	470	N/A*	470	N/A*
Broilers	6,9	226	229%	2480	N/A*
Total	290	1000	245%	3381	N/A*

Source: LSA results; N/A - not available; due to the baseline being a very small number

According to the 19th Livestock Census, Bihar ranked 16th in chicken population. Andhra Pradesh and Tamil Nadu are the two leading states in India in chicken population with a total of 16 and 11.2 crore chickens, respectively. The chicken population in Bihar is projected to grow by about threefold in the BAU scenario and by tenfold in the WI scenario. In the WI scenario, the chicken population grows to 34 crore in 15 years from the current 2.9 crore (Table 87 above).

Projected production in 15 years

Chicken meat and egg production show a huge increase over 15 years. Chicken meat production increases from the current 0.6 lakhs t to 15 lakhs t in 15 years (2032–33). Egg production also increases from 41 crore to 980 crore by 2032–33 (Table 88 below).

Table 88: Production for baseline, and in the BAU and WI scenarios

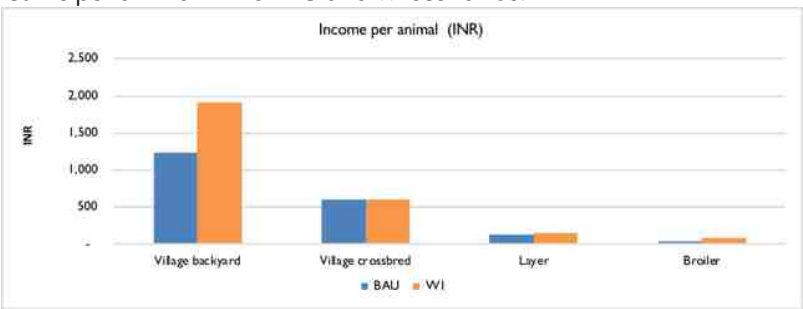
Products	Production in 2017–18 (baseline)	Production in 2032–33 under BAU	% change under BAU	Production in 2032–33 under WI	% change under WI
Chicken meat from indigenous backyard (MT)	19,371	28,096	45%	38,519	99%
Chicken meat from crossbred backyard (MT)	765	1,343	75%	1,378	80%
Chicken meat from layers (MT)	695	25,291	N/A*	25,291	N/A*
Chicken meat (MT)	41,145	1,35,499	229%	14,83,784	N/A*
Total chicken meat (MT)	61,975	1,90,228	207%	15,48,972	N/A*
Eggs from improved backyard (in crores)	12	17	45%	37	217%
Eggs from crossbred backyard (in crores)	3.8	66	75%	68	80%
Eggs from commercial layers (in crores)	26	934	N/A*	934	N/A*
Total eggs (in 000s)	41	958	N/A*	980	N/A*

Source: LSA results; N/A* - not available

Projected annual income per animal in 15 years

Figure 28 below presents the income per animal for the BAU and WI scenarios. The annual income per animal in the village backyard poultry (BYP) system reflects income per hen with eight chickens. The income per hen is approximately INR 155 and INR 240 under BAU and WI, respectively, due to additional chicken interventions. The income per animal in the village crossbred chicken system is relatively higher, about INR 611 per animal. The crossbred investment interventions are already ongoing in the village subsector (under programs such as the Bihar rural livelihoods project—'JEEViKA' project for India), as shown in Figure 28. Only small difference in incomes per animal are thus observed under the BAU and WI scenarios.

Figure 28: Annual income per animal in the BAU and WI scenarios.



Source: LSA results

Returns on investment in all poultry systems

The results of investments for chicken production under WI are summarized in Table 89. All financial indicators based on 15-years discounted incremental cash flow analysis indicate that the investments in both backyard and commercial chicken production systems are financially viable. However, it was found that the investments in commercial chicken production (broilers and layers) are more profitable than the investments in indigenous family backyard chicken production.

Table 89: Results of financial analysis for WI in poultry production in Bihar, 2017–18 to 2032–33 (flock level)

Poultry production size/flock	Financial indictors based on 15-years discounted incremental cash flow analysis			
	NPV (INR lakhs)	IRR (%)	BCR	EANPV (INR lakhs)
Indigenous family backyard (BYP)	0.33	N/A*	28	0.04
Commercial				
Broiler	17.8	178%	1.2	2.3
Layer	44.8	124%	1.1	5.9

Source: LSA results; N/A* - not available

GSDP contribution

The GSDP contribution of chickens by 2032–33 will increase by elevenfold from the base year (2017–18) with the interventions (WI) scenario while the increase will be twofold in the BAU scenario (Table 90 below). Like the findings in chicken production, the change in GSDP contribution of meat and egg between BAU (in 2032–33) and the base year (2017–18) will be about twofold and fivefold, respectively. However, the change in GSDP contribution of meat and eggs production between the WI scenario (in 2032–33) and the base year will be about fourteenfold and sixfold, respectively (Table 90).

Table 90: GSDP contributions for baseline, and BAU and WI scenarios (INR crores)

Products	GSDP in base year (2017–18) (INR crores)	BAU GSDP in 2032–33 (INR crores)	% change baseline to WI	WI GSDP in 2032–33 (INR crores)	% change baseline to WI
Chicken meat from indigenous backyard	245	356	45%	799	225%
Chicken meat from crossbred backyard	9.7	17	75%	17	80%
Chicken meat from layers	8	290	N/A*	291	N/A*
Chicken meat from broilers	77	2,52	229%	2914	N/A*
Total chicken meat	340	915	169%	4022	N/A*
Eggs from improved backyard	70	101	45%	2,18	212%
Eggs from crossbred backyard	16	28	75%	29	80%

Products	GSDP in base year (2017–18) (INR crores)	BAU GSDP in 2032–33 (INR crores)	% change baseline to WI	WI GSDP in 2032–33 (INR crores)	% change baseline to WI
Total eggs	97	557	472%	686	605%
Organic matter	11	3.7	249%	50	370%
Total chicken	447	1510	237%	4975	N/A*

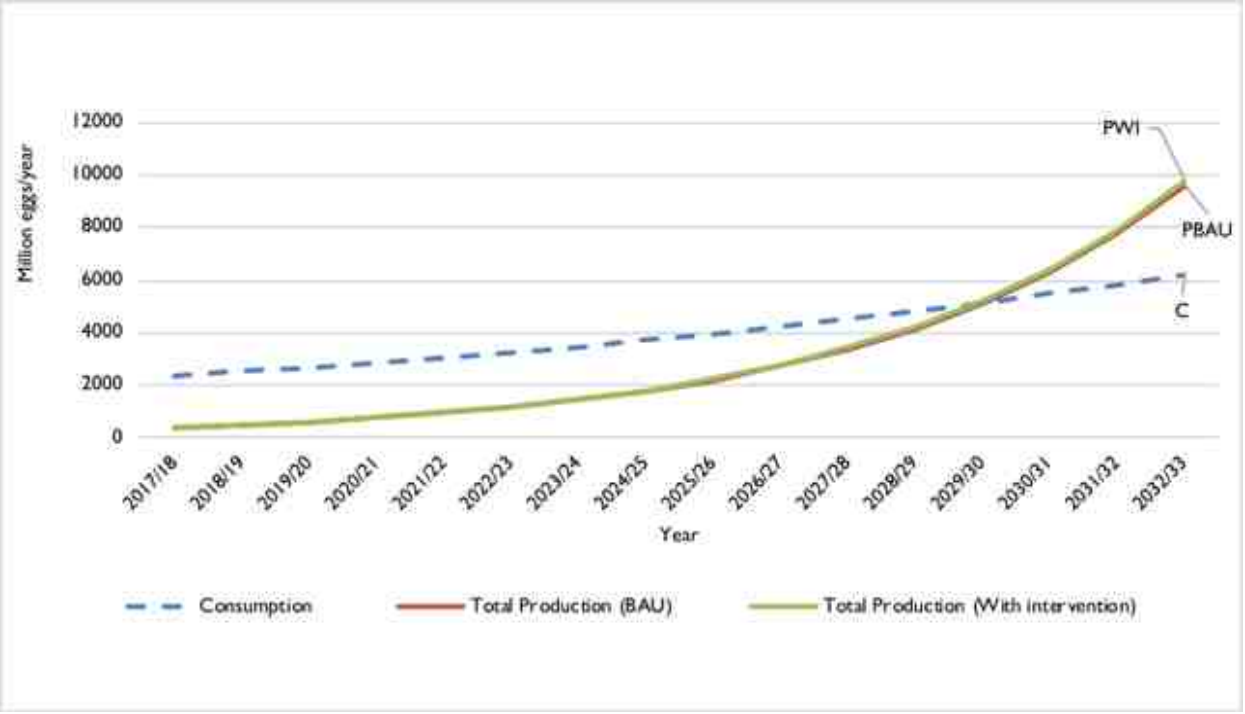
Source: LSA results; *N/A - not available

Chicken egg production-consumption balance in 15 years

Figure 29 shows the future production-consumption balance for eggs under the BAU and WI scenarios. Egg demand in Bihar state is projected to increase from 23 kharab eggs per year in the year 2017–18 to 62 kharab eggs per year in the year 2032–33, an increase of 163%. The projected increases in eggs demanded are due to changes in population, urbanization and incomes. Meanwhile, during the period of 2017–18 to 2032–33, egg production is expected to increase by 2,234% without investment (BAU) and 2,283% with investment (WI). This very close production projection for BAU and WI shows there is no need for the WI investment scenario to increase chicken egg production since it will already be increasing rapidly and will meet demand under the BAU investment scenario.

As shown in Figure 29, the egg supply gap in the state of Bihar is expected to continue until the year 2029–30, when egg production with (WI) and without (BAU) interventions is expected to overcome consumption. Under both scenarios (BAU and WI), only a very slight difference in egg production is expected due to any extra investments in egg production improvement in Bihar.

Figure 29: Future production-consumption balance for eggs under BAU and WI.

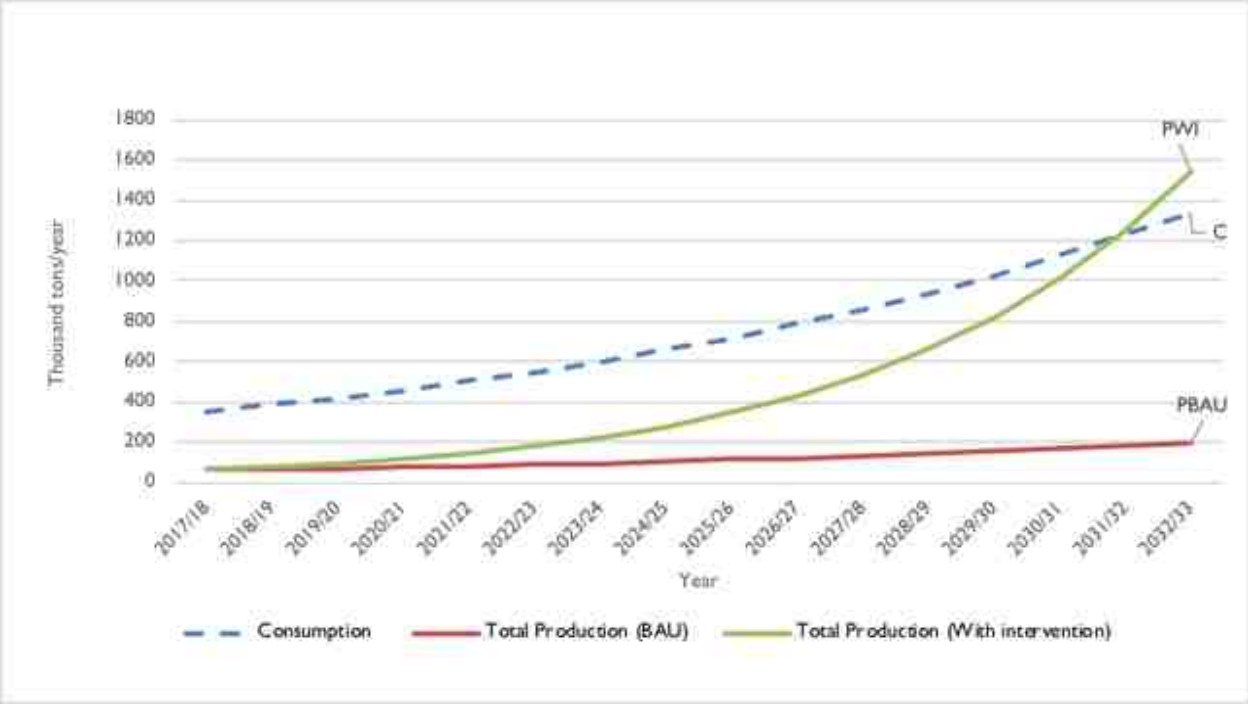


Chicken meat production-consumption balance in 15 years

The future production-consumption balance in chicken meat under the BAU and WI scenarios is presented in Figure 30. Chicken meat consumption in Bihar is projected to increase by 280% over the 15-years horizon (2017–18 to 2032–33).

Unlike in the case of the eggs, the LSA scenario analysis for chicken meat investment shows it will not be possible to close the demand gap without additional investment in chicken meat production improvement interventions (WI). With additional chicken production improvement interventions (WI) that are mostly targeted at increasing the population of broilers and poultry feed, chicken meat production is projected to increase by about 2,400% over the 15-years horizon, from 2017–18 to 2032–33. As shown in Figure 30, the chicken meat demand gap is expected to close by the year 2030–31.

Figure 30: Future production-consumption balance in chicken meat under BAU and WI.



7.5 Pig improvement

The investment context

Pig production in Bihar is divided into three main categories. The first and most predominant type of pig production is the traditional scavenging piggery system followed by semi-intensive and intensive production systems. The traditional piggery is characterized by very minimal/zero input; pigs obtain feed by scavenging locally available feed resources/vegetation, crop residues and kitchen wastes (Chauhan et al. 2016). Housing and management are very poor— pigs are exposed to extreme weather conditions and rain. The semi-intensive pig production on the other hand has better management, shelter and feeding while the intensive system is a commercial modern piggery. The intensive pig system is either specialized in fattening piglets or involved in breeding and fattening pigs (Chauhan et al. 2016).

Pig improvement interventions

Transforming the traditional backyard piggery production

Intervention areas (production zones)

· Transforming the traditional family pig to improved family pig throughout the state and all of the livestock production zones (Northern, Central and Southern zones)

Priority interventions and assumptions

The main objective of the traditional family piggery improvement intervention (WI) is to replace it with semi-intensive piggery interventions. In semi-intensive pig production, farmers provide better management, housing and feeding to pigs and improve their genetics through selection and breeding with locally adapted pig breeds.

Feed and feeding

- Improve availability of feed (produced, agro-industrial by-products and processed feeds).
    - o Make land available for production of pig feed and raw material for processed feed production.
    - o Provide incentives and suitable investment to support agro-processing industries and feed processing factories.
- Improve quality assurance of agro-industrial by-products and processed feeds.

Genetics

- Improve breed performance through crossing with improved breeds.
- Establish a breeding farm to ease breed improvement and multiplication of improved breeds.
- Establish improved breed piglet multiplication and distribution centres.
- Provide extension service to farmers on how to improve productivity of pig breeds through selection.

Health

- Advocate for periodic vaccination and treatments against internal and external parasites.
- Encourage private health service providers with incentives where necessary.

Extension

- Educate farmers to improve the piggery management in the traditional piggery system and to be able to move to improved and semi-intensive production. It is expected that farmers will adopt improved and semi-intensive production and move away from the traditional piggery.
- The number of pigs in the traditional piggery is expected to decrease annually by 5% while the pig population in the semi-intensive piggery is targeted to increase from the current almost nil situation (Table 91 below).

Table 91: Population projection in traditional and semi-intensive pig productions

Production type	Base year (2017–18)	End of first five years (2022–23)	End of second five years (2027–28)	End of third five years (2032–33)
Traditional piggery	1,32,188	1,02,285	79,146	61,242
Semi-intensive piggery	442	1,982	8,887	39,850

Source: LSA results

Processing and marketing

- Create market linkages between pig producers and pig abattoirs/pork processors.
- Establish pig producers' co-operatives to facilitate marketing of inputs and outputs.
- Establish pig abattoirs and pork processing factories.
- Assure the quality of live pig, pork and pork products marketed.

Priority targets and assumptions

Farmers moving away from the traditional piggery to improved piggery will realize the following benefits and costs:

- Number of piglets at birth to increase from the current 5-7 litters/sow;
- Mortality rate of young animals before weaning to decrease from 20–12%;
- Average marketable live weight of pigs to increase from 80–85 kg;
- Veterinary service expense of the farmer to increase to INR 350; and
- Per cent of feed purchased to increase from the current 0% in traditional piggery to 20% in the improved piggery.

Expanding the specialized commercial intensive piggery

- Intensive pig production system is planned to emerge and increase in size over the next 15 years.
- Intensive pig production has two forms: sow rearing and fattening of pigs (Table 92).

Table 92: Population projection in intensive pig production systems

Production type	Base year (2017–18)	1st 5 years (2022–23)	2nd 5 years (2027–28)	3rd 5 years (2032–33)
Intensive sow rearing	3,000	9,155	26,840	69,616
Intensive piglet fattening	500	1,244	2,557	4,507
Total	1,36,130	1,13,396	1,09,689	1,37,211

Source: LSA results

Impact of interventions

Projected population in 15 years

Table 93: Pig population at production subsystem level for baseline, BAU and WI scenarios (in lakhs)

Pig production subsystem	Pig population				
	Baseline (2017–18) (lakhs)	BAU in 2032–33 (lakhs)	% change baseline to WI	WI in 2032–33 (lakhs)	% change baseline to WI
Traditional backyard	6.6	7.7	16%	3.1	-54%
Improved backyard	0.22	0.06	-73%	1.9	NA*
Commercial	0.21	0.05	-73%	4.87	NA*
Fattening	0.01	0.001	-80%	0.05	NA*
Total	6.8	7.8	13%	9.9	46%

Source: LSA results; N/A - not available; * negative growth rate observed

According to the 19th Livestock Census, Bihar ranked fifth in pig population with a total of 6,50,000 pigs. Assam and Uttar Pradesh are the two leading states in India in pig population with a total of 16 and 12 lakhs pigs, respectively. As shown in Table 87 above, the pig population in Bihar between 2017–18 and 2032–33 is projected to grow by about 13% in the BAU scenario and 46% in the WI scenario. In the WI scenario, the pig population is projected to grow from the current 6.8 to 9.9 lakhs in 15 years.

Projected production in 15 years

The production of pork shows similar increases to that of population. Table 94 shows that the total pork production increases from 46,000 MT without intervention (BAU) to 1,62,000 MT with intervention (WI) in 15 years (2032–33).

Table 94: Production for baseline, and BAU and WI scenarios in 2032-33

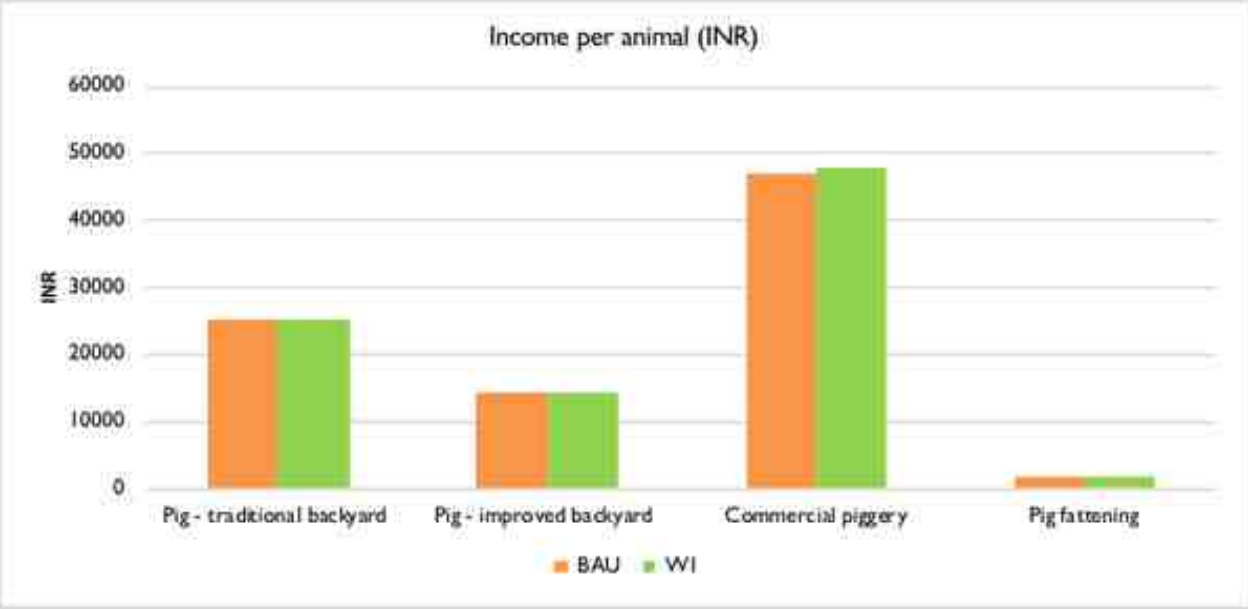
Products	Production 2017–18 (baseline)	BAU production in 2032–33	% change due to BAU	WI production in 2032–33	% change due to WI
Traditional backyard (MT)	39,189	45,633	16%	18,156	-54%
Improved backyard (MT)	323	88**	-73%	29,027	N/A*
Commercial (MT)	4,913	1,342**	-73%	1,13,964	N/A*
Fattening (MT)	96	26**	-73%	860	N/A*
Total	44,521	47,088	6%	1,62,013	264%

Source: LSA results; N/A - not available; **negative growth rate observed

Projected annual income per animal in 15 years

Figure 31 presents the annual income per animal for BAU and WI scenarios in pig farms. The results show there is very slight or no increase in income per animal due to the WI investment interventions in the traditional backyard system, improved backyard piggery and pig fattening farm types. The income per animal in the category of commercial piggery is significantly higher under the BAU scenario and pig improvement interventions (WI) result in additional income of only INR 1,008 per animal.

Figure 31: Annual income per animal for the BAU and WI scenarios.



Returns on investment

Table 95 shows the ex-ante impact assessment of improvements in pig production (due to WI). The results show a positive NPV and high IRR and BCR for all pig production herds. For commercial piggery and pig fattening, the investment resulted in a 15-years NPV of INR 19 lakhs for commercial piggeries and INR 12 lakhs for pig fattening.

Table 95: Results of financial analysis for the combined livestock interventions in pig production in Bihar, 2017–18 to 2032–33 (pig production size/herd level)

Pig production size/herd	Financial indictors based on 15-years discounted incremental cash flow analysis			
	NPV (INR lakhs)	IRR (%)	BCR	EANPV (INR lakhs)
Improved backyard	0.12	N/A	1.87	0.02
Commercial	19	63%	3.12	2.6
Fattening	12	60%	1.28	1.63

Source: LSA results

GSDP contributions

Table 96: Contributions for baseline, BAU and WI scenarios (INR crores)

Products	GSDP at baseline 2017–18 (INR crore)	BAU GSDP in 2032–33 (INR crore)	% change due to BAU	WI GSDP in 2032–33 (INR crore)	% change due to WI
Traditional backyard	175	204	16%	81	-54%
Improved backyard	0.7	0.2*	-73%	57	N/A
Commercial	17	4.6*	-73%	387	N/A
Fattening	0.3	0.1*	-72%	2	N/A
Total	193	209	8%	527	173%

Source: LSA results; N/A - not available; * negative growth rate observed

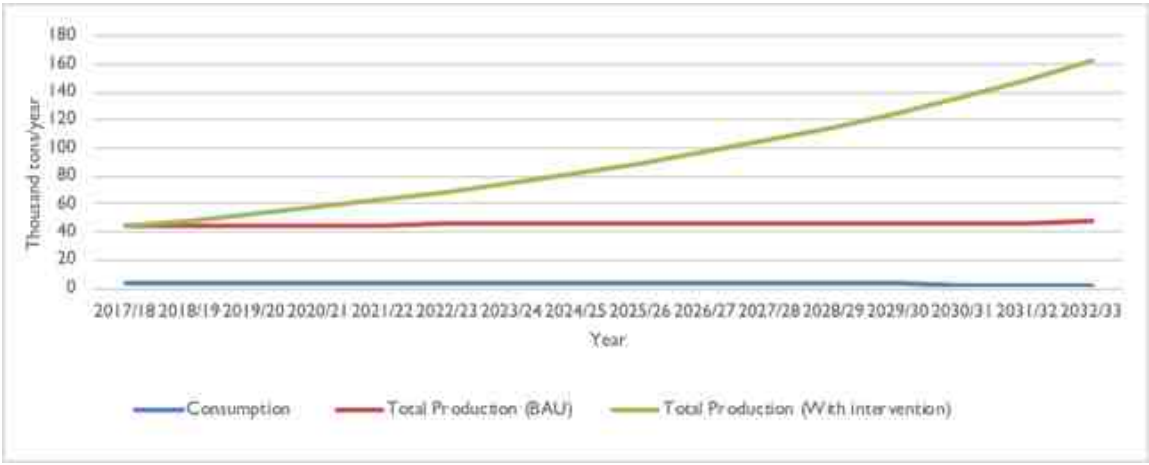
The GSDP contribution of pigs by 2032–33 will increase by 8% from the base year (2017–18) in the BAU scenario while the increase will be 173% in the WI scenario (Table 96). Of the total pig GSDP contribution, meat contributes 99%, while manure contributes the rest.

Pork production-consumption balance in 15 years

Figure 32 shows the projected production-consumption balance for pork under BAU and WI scenarios. During the period of 2017–18 to 2032–33, both pork demand and production under the BAU scenario are expected to decrease by 26% and 38%, respectively. Although pork production is steadily decreasing under the current investment or the BAU scenario, a huge pork production surplus is expected during the 15 years of the WI investment period, from 2017–18 to 2032–33.

Additional investments (WI) that target the commercial piggery sector and slaughter and marketing infrastructures will be necessary to increase pork production to supply pork to hotels, restaurants and cafeterias in Bihar and for marketing to neighbouring states and export to nearby countries.

Figure 32: Future production-consumption balance in pig meat under BAU and WI.



7.6 Lessons for gender and social inclusion

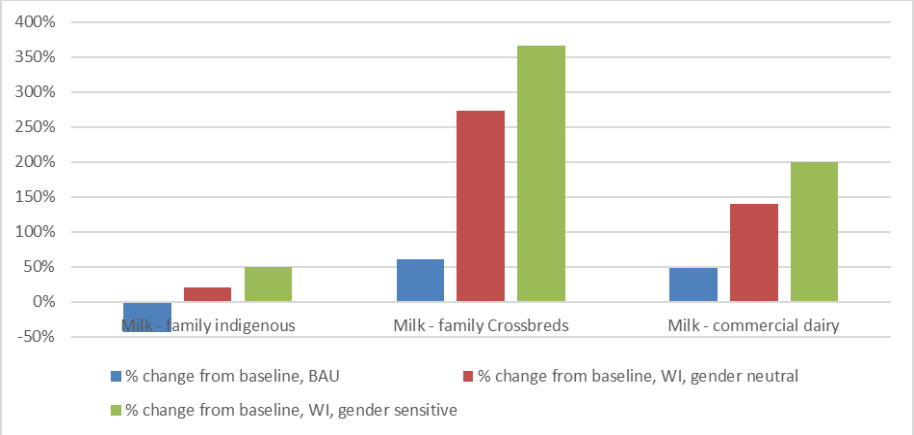
Most of the technical and market interventions listed earlier have positive impacts on productivity and revenues (GSDP contribution). This section complements the previous analysis by looking at the likely impact on gender and social inclusion. In addition to supporting productivity-enhancing technologies and practices, following a gender and social inclusion-sensitive approach will not only maximize impact of poverty reduction, but also sustain gains of productivity increases, as both women and men, marginalized communities and others, will benefit in a more equitable manner. Indeed, the World Bank (2011) estimated that productivity could increase in some countries (especially in Africa) by as much as 25% if the barriers that prevent women from entering the workforce were eliminated. Ravichandran et al. (2018 forthcoming) arrived approximately at the same percentage: there is about a 22% positive difference in income controlled by women for those in women-only co-operatives, compared to those in mixed co-operatives. In the following section, we discuss the gender and social inclusions implications of proposed interventions in each production system.

Cow/buffalo dairy improvement interventions

There is a strong imbalance between women's contribution to labour and their contribution in decision-making, including control over income. In dairy production, even though women contribute more labour compared to men (50-80%), amounting to four to five hours of labour per day, their contribution in decision-making for technical (breeding, feeding, health) and financial aspects (credit, purchase and sale of animal) are very limited (20-40%) (ILRI FDGs 2018). Such imbalances, due to social norms, are exacerbated by some government programs that are gender neutral. Indeed, women are unable to access technical and financial services due to household work burden, weak bargaining power and mobility issues (Kaaria et al. 2016). This situation has a negative impact on women's access to and control of milk income. It is worth noting that when the marketing of milk is through informal channels (compared to more formal or structured channels), women usually have greater access to and control of dairy income. As the proposed interventions include the support of co-operatives, it will be crucial to pay attention to women's and marginal communities' ability to participate in, and benefit from, such new marketing outlets (Ravichandran et al. 2018 forthcoming). In cases like in Bihar where there are deep gender inequalities within society, the support of women-centred activities (e.g. women only co-operatives) may provide an opportunity for expressing voice and opinions (World Bank 2011). Annex 4 Table 119 lists, for the different types of interventions, possible gender and social implications as well as promising strategies for more equitable inclusion of women and marginal communities in cattle and buffalo systems.

Figure 33 below illustrates the changes in cow milk revenues controlled by women compared to baseline, by production system and under different scenarios. Assuming no change in control over milk revenues by women for the BAU and WI gender-neutral interventions, the changes simply mimic the overall changes in milk GSDP contributions presented in Table 67. The last scenario, WI following a gender-sensitive approach as described in the last column of Table 119, assumes a 25% increase in women's control over milk revenues (from an estimated 44% to 55%), translating into a more than fourfold increase in women revenues, compared to the baseline.

Figure 33: Changes in cow milk revenues controlled by women, by production systems, under different scenarios.



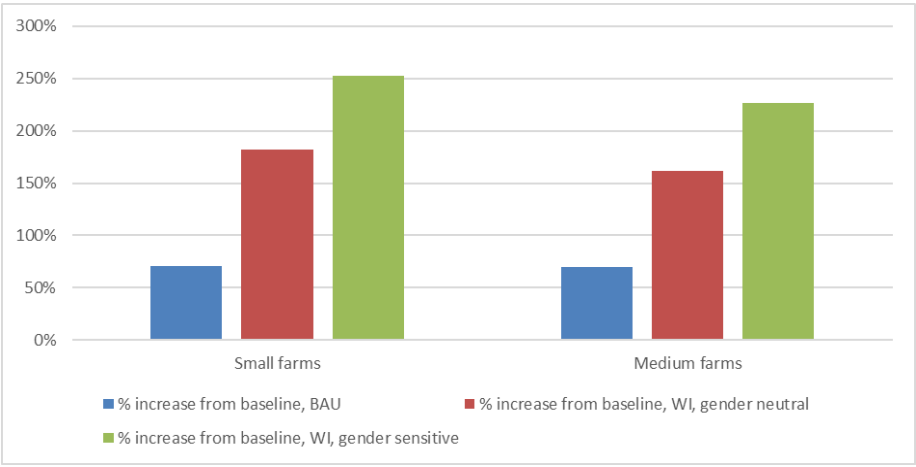
Sources and assumptions: baseline percentage of revenues controlled by women, average across zones, 44% (ILRI FDGs 2018). We assumed a 25% increase in women's control of revenues for the 'gender sensitive' scenario (from World Bank 2011). The same applies to the other figures in this section.

Goat production interventions

As mentioned previously, goats are mainly owned by the poorest and marginalized communities and managed by women. Women control about 63% of revenues from goats (ILRI FDGs 2018), and therefore any interventions targeting goats will likely benefit them. Households who do not keep cows due to feed and capital constraints keep goats. Annex 4, Table 116. lists the different types of interventions, possible gender and social implications as well as promising strategies for more equitable inclusion of women and marginal communities in goat systems.

Figure 34 below illustrates the changes in goat revenues controlled by women compared to baseline, for small and medium farms, under different scenarios. Assuming no relative change in control over goat revenues by women for the BAU and WI gender-neutral interventions, the changes simply mimic the overall changes in goat GSDP contributions on Table 76. The last scenario, WI following a gender-sensitive approach as described on the last column of Annex 4, Table 120, assumes a 25% increase in women's control over goat revenues (from an estimated 63% to 80%), translating into a more than threefold increase in women's revenues, compared to baseline.

Figure 34: Changes in goat revenues controlled by women, by farm size, under different scenarios.

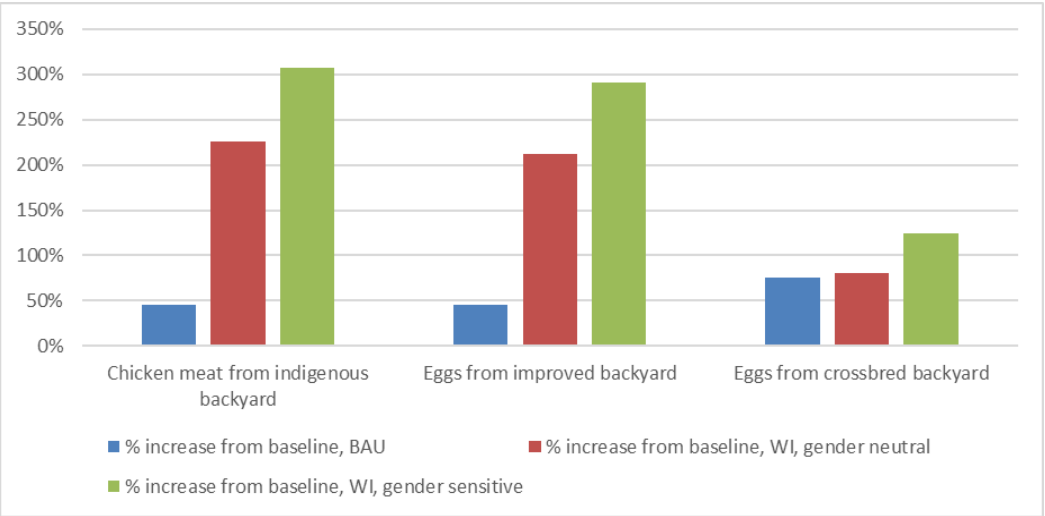


Backyard poultry production production interventions

Backyard poultry production (BYP) production is mainly managed by women from marginalized and landless community households. The major challenge is the high mortality during disease outbreaks, which not only affects subsistence revenues but also household food diversity. BYP production is considered a pro-poor policy which has more outreach for poor people and leads to improved food security than any other livestock intervention (Dolberg 2003). Annex 4, Table 121 lists the different types of interventions, possible gender and social implications as well as promising strategies for more equitable inclusion of women and marginal communities in BYP systems.

Figure 35 below illustrates the changes in backyard chicken revenues controlled by women compared to baseline for the different products and under different scenarios. Assuming no change in control over BYP revenues by women for the BAU and WI gender-neutral interventions, the changes simply mimic the overall changes in BYP GSDP contributions on Table 84. The last scenario, WI following a gender sensitive approach as described on the last column of Annex 4, Table 121, assumes a 25% increase in women's control over BYP revenues (from an estimated 66% to 69%), translating into a more than fourfold increase in women revenues for chicken meat from indigenous backyard, compared to baseline.

Figure 35: Changes in BYP revenues controlled by women, by product, under different scenarios.



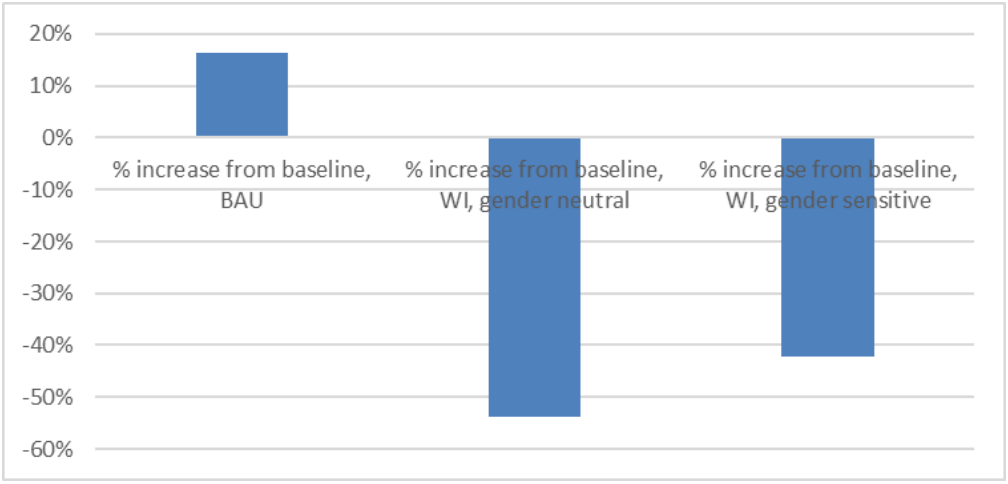
Pig production interventions

Approximately 8% of all animal-source protein in India is supplied through pig products, of which 15% is from Bihar, mainly from indigenous breeds (USDA 2016). As mentioned earlier, pigs are mainly owned by tribal communities. The major challenges faced by these communities are lack of access to health, feeding and breeding services to increase productivity. Weak bargaining power and poor social status are some of the barriers that existing government interventions are working to eliminate. More productive crossbred pigs are available but marginalized communities are unable to acquire them. Hotels and restaurants import pig meat products from other countries; indeed, marginal communities do not provide value addition due to lack of slaughterhouses for pork. Annex 4, Table 122 lists the different types of interventions, possible gender and social implications as well as promising strategies for more equitable inclusion of women and marginal communities in pig systems.

Figure 36 below illustrates the changes in pig (traditional backyard) revenues controlled by women compared to baseline, under different scenarios. Assuming no change in control over traditional backyard pig revenues by

women for the BAU and WI gender-neutral interventions, the changes simply mimic the overall changes in pig GSDP contributions in Table 96. Under the WI scenario, pig revenues experience a large decline, jeopardizing an important source of livelihood for the marginal communities. The last scenario, WI following a gender-sensitive approach as described in the last column of Annex 4, Table 122, assumes a 25% increase in women's control over pig revenues (from an estimated 73% to 92%), which cushions a bit the decrease in revenues. However, even if gender- sensitive interventions are followed, pig revenues controlled by women reduces by 42%, compared to baseline. It is crucial to re-examine these interventions to avoid a worsening of welfare amongst marginal communities. It will also be important to find mechanisms to support marginalized communities in their transition from backyard to semi-intensive systems.

Figure 36: Changes in pig revenues controlled by women, under different scenarios.



8 Summary and conclusions

Context

Bihar is predominantly an agricultural state and there is large scope for animal husbandry. Animal husbandry plays a critically important role in employment and income generation for rural people. Livestock provide significant employment to women and also agricultural workers belonging to the marginal strata of society. Moreover, the livestock sector contributes 26.7% to agricultural GSDP, but contributes only about 5.2% to state income, or GSDP, indicating the low incomes and value addition generated in the sector.

Bihar is particularly recognized for its large goat population (ranked fifth among states in India) and high milk production (ranked ninth among states in India), making the livestock sector core within any potential plans to help achieve the development goals of the state. Most goats are cared for by marginal castes and women, so they can be particularly important in poverty reduction strategies and activities.

The growth and performance of the dairy subsector in Bihar, meanwhile, is better in comparison to many other Indian states (DAHDF, 2017). The COMFED dairy co-op, which is supported by the government, has played a very critical and successful role in developing the dairy subsector, and in raising dairy cow productivity and milk production, as well as in raising dairy farmer incomes.

To help raise more investment resources to achieve even greater livestock development in Bihar, the DAFR of the GoB asked ILRI to provide technical assistance to develop an LSA) as a first step in developing an LMP or five-years livestock sector investment plan for Bihar. This effort was generously funded by the Bill & Melinda Gates Foundation, South Asia Agriculture Program. This initiative is meant to help increase and target investments to further modernize the livestock sector and enable it to make an even more substantial contribution to state development goals.

The main objective of the Bihar LSA has been to provide quantitative and evidence-based justification for more public and private investments in prioritized priority commodity value chains (VCs) of the Bihar livestock sector chosen. The recommendations are based on analysis of scenarios where the returns on investment (ROIs) from investments in new and/or additional combined technology and policy interventions were tested. The LSA is also meant to inform the development planning of DAFR, together with other Bihar government agencies working on livestock sector development in the state, as well as the investment planning of development partners or donors, nongovernmental organizations (NGOs), civil society organizations, private sector actors and development banks.

To accomplish its mission, the ILRI LMP team engaged with senior and technical staff of the Bihar DAFR, and other livestock experts to understand the existing development priorities of the Bihar government, to agree upon the relevant framework of key species, production systems and a typology of agroecological zones to be

analyzed, as well as the commodity value chains to be included in the LMP diagnostic process, collect reliable livestock data and parameters, build a state herd and economic sector model (HESM), and carry out the sector analysis to understand the current situation and future potential of the sector.

In the investment scenarios carried out in the LSA on productivity-enhancing technology interventions, combined with better policies, state development objectives of Bihar were identified by the sector stakeholders and DAFR. The measurable indicators in parentheses were used as decision criteria for testing and comparing the alternative investment interventions (combined technology and policy) to be considered for inclusion in the LMP.

Bihar has adopted the following development objectives (and indicators):

- reduce poverty (improve household incomes)
- economic growth (contribution of livestock sector to Agriculture State Domestic Product and GSDP
- increase the food and nutritional security of all people—rural and urban ASFs, including more protein and carbohydrates
- surplus trade with the rest of India (value of marketing to other states)
- contributing to industrialization and employment (especially employment for women, youth, and scheduled minorities)
- contributing to social equity (household production income and investment increases for women, youth and scheduled minorities)

The LSA results show that further investments in the development of the livestock sector could be a means of improving incomes and greatly reducing poverty while meeting other state development goals.

Challenges and opportunities

Despite the successes of COMFED in building up the dairy subsector and raising the productivity of dairy cows and buffalos, and DAFR and NGO efforts at raising the productivity of goats, dairy productivity is still lower in Bihar than the all-India average. In addition, more attention is required to increase the production of chicken meat and eggs, and wool and skins in Bihar (DAHDF 2017).

A lack of sufficient animal feed may be the greatest challenge hindering long-run development of the sector. One specific feed challenge will be how the food grain-focused agriculture can be converted into a food-fodder based agriculture-livestock sector (Rahman, 2017).

Besides scarcity of feed, other prominent challenges were identified by stakeholders in the livestock sector, and are borne out by the sector analysis:

- poor feed quality regulation
- lack of organized and continuous livestock training on productivity-raising production practices
- loss of livestock due to flooding
- lack of private sector investment in input production and supply, and post-harvest value-addition processing

- inadequate government budget to help develop the sector

The livestock value chains chosen for sector analysis

Based on the input from the government of Bihar, sector experts and stakeholders, the commodity value chains investigated and compared for impacts were: cow and buffalo dairy; red meat from buffalos and goats; chicken meat and eggs from improved backyard semi-scavenging chickens; commercial chickens—broilers and layers, and pigs and pork (improved traditional and commercial piggeries). Some of these VCs are presently important for food production, household incomes and state income growth, as well as meeting equity goals such as poverty reduction (especially cow and buffalo dairy and commercial chickens with broilers and layers), while others (backyard dual-purpose chicken, and buffalo and pigs for meat) were analyzed for their potential to grow to become of major economic and livelihood importance in future.

To tap the opportunities and cope with the challenges facing the livestock sector in Bihar, livestock improvement interventions and investments in feed, extension, health, genetics and marketing and processing are critical. The impact of these interventions on the incomes of farmers, productivity of animals and production of ASFs and GSDP (or state income) contributions to the sector were measured and the impacts of priority interventions analyzed in the LSA quantified in the 'with intervention (WI) scenario' as compared to the 'business as usual (BAU)' scenarios.

These two types of projections of sector impacts were measured for the investment interventions (combined technologies and policy) in the LSA:

- BAU or the current level and type of investment interventions (policy and technology)
- WI or with additional and/or new investment

Priority interventions to further modernize the sector were proposed to include:

- Improve the quantity and quality of livestock feed resources through training of farmers to use all available areas to produce forage crops and upgrade feed quality testing and regulatory institutes to test quality of feed in the market.
- Improve genetics through selection of local breeds and crossing them with improved indigenous and exotic breeds across all species and improve semen production and AI delivery through more PPP and private service providers where appropriate.
- Increase the quality and availability of animal health services and improve producers' access to these services through private and/or PPP in order to decrease livestock mortality and morbidity.
- Introduce interventions to improve collection and marketing systems (creation of feedlots, increasing the number and improving the management of dairy co-ops and strengthening co-op partnerships with COMFED).
- Increase value-addition processing (establishment of slaughterhouses, sales and retail store chains (cold chains and product packaging) etc.
- Design and implement policies and institutional interventions which encourage private and PPP investment interventions in animal husbandry, input production, processing and delivery, as well as output processing and marketing.

Summary of investment impacts across livestock commodities

As shown in Table 97 below, the IRR and BCR values for investments in all the interventions are sufficiently attractive to warrant investment. As expected, the returns on investments (ROIs) are higher for crossbred cows than indigenous cows, but the investment returns in indigenous cattle are marginally attractive, as well. Meanwhile, the investments in indigenous buffalos and goats are financially worthwhile, and there are added societal benefits since improving the value chains for these species can be targeted at women and socially disadvantaged castes, . Meanwhile, the benefits from investment to intensify family chicken and backyard pig operations are higher than the returns from investing in commercial chicken or commercial piggeries or pig fattening. Finally, the contributions to state income or GSDP by commodity value chain are positive in all cases.

Table 97: Summary of profitability and GSDP impacts by 2032–33 of investments in the livestock sector

Value chain and production zone	IRR%	BCR	Increase in GSDP in WI scenario by 2032–33 (%)	
			In comparison with the base year (2017–18)	In comparison with the BAU in 2032–33
Family cow dairy - indigenous	10%	1.00	191%	112%
Family cow dairy - crossbred	35%	1.60		
Buffalos	15%	1.00	67%	16%
Goats	31%	1.60	197%	74%
Backyard chickens	N/A (large number)	28.99	N/A (small base year value)	230%
Broilers	178%	1.25		
Layers	124%	1.21		
Pigs - Improved Backyard	N/A (large number)	1.87	173%	152%
Commercial piggery	63%	3.12		
Commercial Pig fattening	60%	1.28		

Source: LSA results

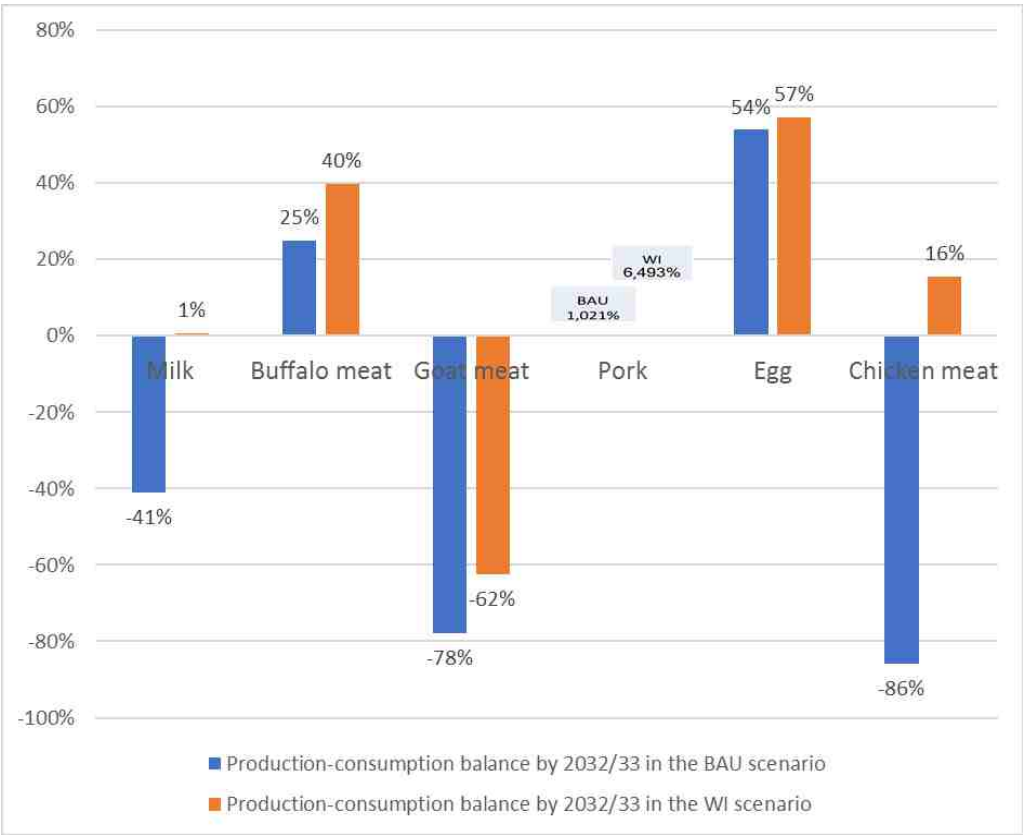
Summary of investment impacts on future production and consumption balance

Projections of future production and consumption balance (production over consumption in percentages) for the major livestock products (milk, eggs and meat) with and without policy and technology interventions (the BAU scenario) and with additional investment in policy and technology interventions (the WI scenario) were made to assess the potential for and size of potential future supply and demand gaps. This projection is critical to anticipate the magnitude of required future investment in livestock production interventions which would be required to close any production-consumption gaps.

This projection of current and future consumption requirements for livestock products is needed and requires base year information on quantities of livestock products consumed by households, income elasticities of demand for the various livestock products, the growth rates of real per capita GDP, and the growth rates of human population and urbanization. With the projected consumption requirements over time and the herd and economic model results for projected production possible over time, the impact of the WI intervention scenarios on the production-consumption balance of livestock products can be calculated and analyzed.

The impact of the BAU and WI intervention scenarios on the production-consumption balance for the major livestock products relevant in Bihar are summarized in the Figure 37 below. The production-consumption balance for milk and milk products by 2032 is projected to be -41% in the BAU scenario, while under the WI investment scenario the consumption of milk could be satisfied by milk produced in Bihar state— or no consumption gap is projected. Buffalo, pork and egg production-consumption balances are positive through 2032 under both the BAU and WI scenarios, but are higher under WI, suggesting these extra commodities could be marketed to other states or exported to nearby countries. Meanwhile, the goat meat production-consumption balance is projected to remain negative under both the BAU and WI scenarios, since demand is growing very rapidly, but ways to increase animal productivity as rapidly over the next 15 years could not be identified and tested with the HESM. The production-consumption balance for chicken meat is also negative under the BAU scenario but is projected to be and about 16% in surplus under the WI scenarios for broilers and improved backyard chicken production.

Figure 37: Production-consumption balance by 2032–33 comparing the BAU and WI scenarios.



Source: LSA results

Bihar LSA conclusions and recommendations

Cow and buffalo dairy value chain

Dairy will continue to be a key commodity value chain which can increase contributions to the development goals of the state: poverty reduction, economic growth, increasing food and nutritional security, contributing to industrialization and employment, and contributing to social equity.

- The milk and dairy product-consumption balance (production over consumption in percentages) is projected to be 59% and 101% in 15 years under the BAU and WI-1 scenarios, indicating that the WI-1 investment will be required to ensure no production-consumption gap.
- To take the dairy subsector to the next level, there is a need to open processing more to private investment, especially in areas where COMFED is not already dominant
- The major interventions required to improve the dairy commodity value chain are improving feed availability and quality, breeding/crossbreeding with exotic dairy and improved indigenous breeds
- Inclusion of women and marginalized communities in all investment interventions, included in increased processing of milk and marketing of milk products
- The WI-1 scenario is the preferred dairy value chain improvement intervention scenario since it contributes far more than WI-2 to improving milk production and other development impacts of the dairy value chain
- Yet, the positive investment returns to WI-2 showed it could be a complementary activity to dairying with crossbred cows for farmers who could also manage the A2 milk producers.

Chicken meat and egg value chains

Chicken is the emerging subsector in Bihar with the most potential for further growth. It is critical to meeting the development goals of the state and especially meeting growing meat consumption requirements. Investment needs to focus mainly on broilers, not layers, but also backyard dual-purpose scavenging birds, as well, to raise incomes of very poor farmers, including women and all people from scheduled castes. To realize the developmental potential of chicken, there will be a requirement to dramatically increase production of the cereals that go into chicken feed, particularly maize, and/or to purchase these cereals from other states.

- Egg production with layers does not need additional investment (WI) to produce surplus production— Bihar can stay with BAU
- Chicken meat from broilers
    - A deficit in chicken meat is projected with BAU in 15 years
    - Additional investment or WI is needed in broilers
- Backyard semi-scavenging crossbreds
    - Additional PPPs or private investments, not only public efforts, would seem advantageous to be able to significantly scale up backyard poultry with crossbreds which are dual-purpose semi-scavenging, including for women and scheduled castes

Goats and goat meat value chains

Goats show much potential, mainly for aiding equitable achievement of development objectives, especially for women and marginal ethnic groups.

- A deficit in goat meat is projected with BAU; but additional investment (WI) does not close the supply gap
- Additional investment (WI) is thus not needed; the deficit in goat meat with WI is still projected due to the feed shortage and other technology and marketing factors
- Goat rearing presently is thus mainly a life-changing option for marginalized farmers and especially women, who are either going into goat production for the first time or can expand their herd sizes under BAU technologies
- Decreasing mortality in goats would result in significant improvement in goat production and productivity, as well as incomes for farmers and higher GSDP contributions
- A state breeding policy for goats also needs to be developed and implemented
- A change of management practices (introduction of stall feeding, planting fodder trees, use of locally available feed resources) could have significant positive impacts on goat productivity and production, but need to be combined with better breeds when they become available in future
- Credit and insurance for goat farming needs be scaled up since goats are mainly held by very poor women from marginalized communities
- If further productivity-increasing interventions could be identified and introduced, especially addressing better genetics and the severe feed constraint, increased marketing and sales to other Indian states and/or exports to nearby countries could help to increase local goat prices and the incomes of women and scheduled castes further

Buffalo milk and meat value chains

Buffalo production shows potential to grow in Bihar due to projected increasing demand in future. The benefits will increase most if more productive buffalo breeds are introduced and AI services are expanded.

- More buffalo milk is needed to help close the overall milk gap. It is combined with cow milk and it is highly appreciated due to its high fat content
- Specialized buffalo milk and milk products collection, marketing and processing could help ensure a premium price and higher incomes for buffalo milk producers, benefiting scheduled castes
- Surplus buffalo meat could be produced with BAU and WI—WI is needed when investment in buffalo slaughter is also increased.
- Not much preference exists for buffalo meat in Bihar so meat processing and marketing to other states or exports need to be increased to raise prices and incomes to farmers, and state income

Pigs and pork value chains

Public support for investment in this emerging sector could particularly be instrumental in achieving tribal community development, which would need to be supported in the transition towards more intensive systems.

- With additional investment in production and marketing, surplus production of pig and pork production is projected in 15 years
- The pig sub-sector has potential to provide development benefits through better marketing and export of pigs and pork. This could start with supporting marketing and export of live pigs, and later investments in pork processing and marketing/exports
- Investments to improve pig production need to focus on improving both backyard and commercial scale operations, as well as introducing pig fattening
- Pig producers from marginalized communities need to be supported to make the transition to semi-intensive and later commercial pig operations
- Additional investment needs also to be focused on establishment and improvement of marketing coops for pigs, with training for coops to help producers to market to hotels and other states

Policy recommendations

- Dairy processing needs to be made more attractive to private investment, especially in areas where COMFED is not already dominant
- For the chicken value chain, the policy priority is on creating a more conducive environment for private and private-public investment in feed production and inputs and services delivery, as well as chicken meat processing and marketing
- Feed quality standards and regulation enforcement is urgently needed in all livestock value chains, and feed quality testing and regulatory institutes need to be upgraded
- The quality and availability of animal health services and improved producers' access to these services need to be improved through encouragement of private service providers and/or PPPs
- Greatly increased semen production and AI delivery through more PPP and private service providers where appropriate need to be enabled, with incentives, if needed
- Gender mainstreaming and social inclusion strategies are required at all levels

Main entry points for improving gender mainstreaming and social inclusion

- Greater access to and control of resources for livestock production
- Greater access of women and marginalized communities to credit to be able to purchase animal health care, feeds and good genetic stock
- Targeted information to support innovative production by individual women and women's self-hep groups
- Land tenure policies to expand production and access to markets for appropriate returns

Also needed:

- Research to develop evidence-based policies, including to promote gender and social inclusion
- Gender mainstreaming within government departments (budget, staff and expertise)

- Building on knowledge gained from positive experiences

Key policy recommendations to mainstream gender and social inclusion

- In dairy, women could benefit from increased milk production through membership in co-operatives, to ensure they maintain control of this income
- Goats are already the domain of women, so investments in this sector will benefit women, although greater access to feeds and forages will need to be resolved, as well as reducing demands on women's labor
- Pig and pork production are mainly in the hands of tribal communities, so marketing access to reach demand centers would benefit these communities
- In poultry, as women are involved in backyard production and if there is a push for semi-intensive systems, it will be important to ensure women included in this transition, both for better incomes and nutrition

Finally, the commodity value chains recommended for investment in the LMP, in order of priority are:

1. Cow and buffalo dairy
2. Chicken meat and eggs
    a. Improving backyard chicken through dual-purpose crossbreds
    b. Commercial chicken—broilers and layers
3. Goat meat, milk and skins (focusing on improving the traditional systems of women)
4. Meat from buffalos and goats
5. Pigs and pork (focusing on the traditional systems of marginalized castes)
    a. Intensifying the traditional piggery system through stall production and better breeds
    b. Improving and increasing commercial piggeries and pig fattening

9 Annexes

Annex 1: The process and methodology used in the Bihar LSA and LMP

Process used to prepare the Bihar LSA and LMP

The joint Bihar DAFR and ILRI LMP team first carried out stakeholder consultations and a study tour to better understand the Bihar livestock sector.

A comprehensive data base on the state livestock herd and baseline (depicting the current state of development in the livestock sector– livestock numbers, animal and herd productivity levels and herd production, and the monetary value of animal products produced) was then collected. Data collection took place from existing secondary-source data, and gaps were filled in by consulting Bihar livestock sector experts for reliable productivity parameters.

The data and productivity parameters were used to specify a dynamic state-level herd model and economic sector model, jointly referred to as the HESM. The herd model builds from animal level productivity to herd productivity and production, and the impacts on herd population growth. The household herd types modeled include those found in the production systems of the three (3) commonly used livestock production zones of Bihar (north, central and south), as chosen and characterized by the Bihar livestock experts, as well as the representative household (HH) and HH herd types. This is described in section 3 of the LSA.

The two models are linked together to form the HESM, or herd and economic sector model, to do the livestock sector analysis or LSA to create a long-run 15-year sector strategy, which then forms the basis for preparing the LMP or medium-term 5-year livestock investment plan or livestock master plan (LMP).

The Livestock Sector Investment and Policy Toolkit (LSIPT), developed under the auspices of AU-IBAR by the World Bank, CIRAD, and FAO, was used to create the HESM and LSA for the Bihar livestock sector. Then, LMP tools developed by ILRI were used to produce the LMP or 5-year investment plan to inform public and private investment planning, as well as influence the development support investments and programs of donors and the private sector.

In the LSA stage, the HESM was used to carry out a unique, multi-faceted analysis of the Bihar livestock sector. The relevant representative household and production system types were chosen by the livestock experts of the country, based on their unique assets, including the household herd. Then, the key livestock commodity value chains considered in the sector analysis were chosen with the sector livestock experts. They included: local cattle for milk and dairy products; goats for goat meat and milk; dairy grade cows and water buffalo for milk and dairy products; chickens for meat and eggs; pigs for pork meat; and buffalo for meat. The quantities and values of intermediate products, including manure and traction, were also measured. Perhaps most importantly, the sector experts also helped choose the candidate technologies and policy interventions to be tested in the sector

analysis.

The impacts of the alternative candidate interventions were tested and compared based on their unique impacts on key state development objectives identified with the pertinent government decision makers. Measurable indicators for these development objectives provided the criteria for testing and comparing the proposed individual and combined technology/policy interventions using the herd and economic livestock sector model (HESM) for Bihar.

For Bihar, the HESM was used to provide quantitative measures of the potential future impacts of the proposed alternative combined technology/policy interventions on the following state development objectives (and measurable indicators):

- Poverty reduction (impact on household and/or enterprise income)
- Achievement of state-level food security (state-level consumption-production balance)
- Economic growth (contribution to state income or GSDP (Gross State Domestic Product)
- Decrease in input and livestock purchases from other states or excess production available for sale to other states and surrounding countries

In addition, recognizing the known importance of the role of women and marginalized communities in livestock production in Bihar, we added an additional development objective and analyzed:

- Employment and income impacts (increased employment, asset control, and income) for women and marginalized groups

While LSIPT, and thus the HESM built using LSIPT, does not differentiate labor components and explicitly consider intervention impacts on gender, youth and disadvantaged groups, we used qualitative survey tools to filter and interpret the outputs of the analytical results of the HESM analysis of proposed technology-policy interventions in the LSA and LMP value chains. Based on the results investments and policies with the most positive impacts on gender and disadvantaged groups have been identified in the LSA and LMP recommendations.

The LSA commodity value chain assessments also included an end market analysis of projected consumption growth of livestock products over time (or demand with constant prices). The analysis also included identification and analysis of priority policies (to go hand in hand with the proposed technologies, training, and infrastructure investments) which could create incentives for improved primary production through adoption of production technologies. The investment interventions (policies combined with investments in primary production technologies, as well as in infrastructure) were tested with the LSIPT cost-benefit analysis (CBA) sub-module.

Lastly, the interventions (combined policies and interventions), and related prioritized species and commodity value chains, which demonstrated the most promise to contribute to the achievement of the chosen Bihar state development objectives formed the basis for the recommendations for public and private investment in the LMP.

LSIPT Methodology - Livestock Sector Investment and Policy Toolkit

The ILRI team used LSIPT, the Livestock Sector Investment and Policy Toolkit, to build the herd and sector model (HESM) to then carry out the analysis to produce the LSA and LMP.

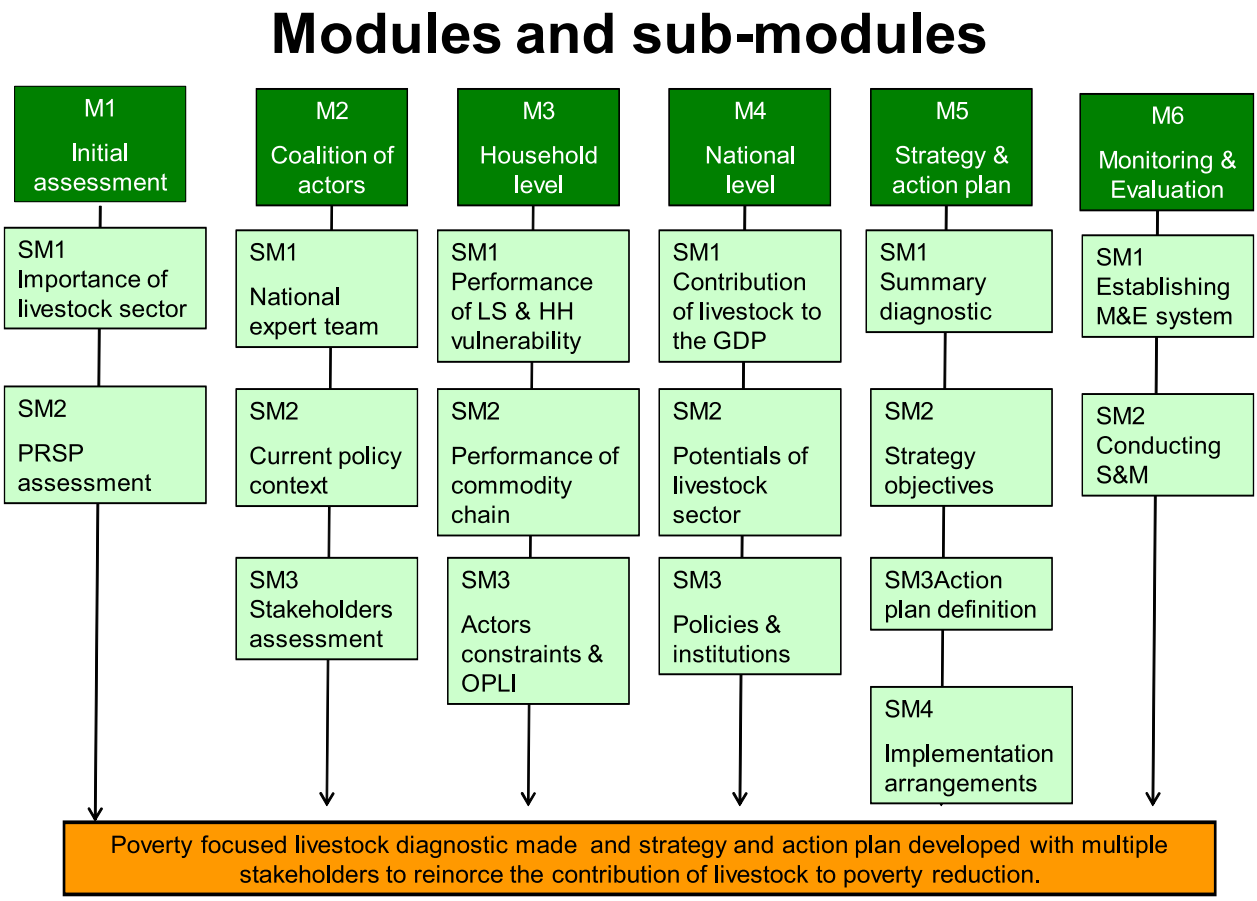
Spearheaded by AU-IBAR, LSIPT was developed by livestock experts at CIRAD, FAO and the World Bank. It had been tested in Mali and Zambia and is now operational and has been applied in Ethiopia, Tanzania and Uzbekistan by the ILRI LMP team and national collaborators from the ministries of agriculture and/or livestock.

LSIPT integrates micro, meso, and macro analysis for quantitative and qualitative assessment of household vulnerability, the role of livestock in strategy for poverty reduction, and the contribution of livestock to the overall economy. It accounts for the multiple functions of livestock, including: those of cultural importance; the contribution to food security and nutrition; and the supplier of draught power and manure for soil fertility.

LSIPT provides a systematic framework for organizing accessible quantitative data (mostly from secondary sources) and includes tools to carry out analyses which help to understand the production potential of the sector, and its contribution to agricultural and overall economic growth (GDP), as well as reduction in rural poverty and food insecurity. Furthermore, LSIPT enables the running of alternative technology and policy scenarios to gauge the supply response of potential government investments in research and extension (such as technologies that impact on feed availability, animal health, etc.), as well as private sector investments over 5 to 15-year projection periods. The scenario analysis is transparent and readily understandable, and thus useful to policy makers and development investors. Moreover, analysis of potential impacts from changes in key aspects of policy, such as the enactment of food quality standards and regulations required to compete in formal markets (including export markets) can also be evaluated with the toolkit. Further description of the LSIPT methodology is given in the diagram (below).

The elements of LSIPT are described in the diagram below. The core modules of LSIPT are 3, 4 and 5. Module 3 assesses the productivity at household, production systems and value chain levels. These micro and mesa data figures are then consolidated and extrapolated to the national level in module 4. Once this data base is established, the participatory tools of module 5 can be used to identify, with all stakeholders, the priority sectors, target groups, and the most promising technology and policy interventions, to ensure optimal use of scarce human and financial resources. Once the interventions are identified, financial, economic, social and environmental impacts can be rapidly assessed using the database established in modules 3 and 4. Finally using the tools, implementation arrangements can also be established on a mutually agreed upon basis.

Figure 38: Diagram showing the different modules and sub-modules of LSIPT



Key information and data needed for the quantitative analysis carried out in Module 3 and 4 include:

a. A typology of the main different production systems prevailing in the country, state or region, with the respective number of households keeping livestock and livestock numbers

b. Main livestock performance data for each species of livestock in each production system in each typology zone, with a breakdown by age group and sex, reproductive performance, mortality by age group and sex, average production, live-weight, off-take rate, carcass weight, etc.

c. Feed requirements by species, age and sex of animals, as well as feed availability, as related to land and water availability for forage production, and crop residues and industrial byproducts

d. Dry matter yields of grass and crop lands (for crop-residues estimates for animal feed) in each of the main agro-ecological zones

Available data and parameters required for the herd models were collected from published papers and consultancy reports, as well as other "grey" literature. Gaps were filled through consultations with Bihar state livestock experts.

Annex 2: Institutional and policy constraints and opportunities supporting Section 6

Table 98: Review of current policy constraints and proposed actions in animal health services

Priority policy or institutional constraint/gap	Evidence, group affected and rationale for change	Required policy action
Weak private sector and weak PPP	Animal health care is heavily dependent on public sector Limited reach of animal health care services to most of the rural farming communities Doorstep animal health services which is in high demand by farmers is only performed through a few private health service providers and most of them lack proper training High cost of prevention and control of diseases of economic importance Persistence of incidences of some animal diseases (e.g. FMD, BQ, HS etc.) in some areas and high mortality rates, especially among young stock Absence of formal coordination and co-operation between public and private sectors	Strengthen the use of private service providers for vaccination campaigns Encourage the private sector to operate in rural areas through provision of incentive packages such as fixed performance contracts with government (e.g. mass vaccinations) Prepare a policy statement providing for cost sharing for prevention and control of diseases of economic importance Develop feasible and cost-effective control and prevention strategies, with greater emphasis on prophylactic control measures rather than curative, for specific priority diseases Use of information, communication and technology platforms for dissemination of information on disease/vector control

Priority policy or institutional constraint/gap	Evidence, group affected and rationale for change	Required policy action
Inadequate infrastructure	Limited number of veterinary hospitals Limited facilities for animal health service delivery (e.g. ambulances, diagnostic facilities-laboratories) at all levels The number of livestock units served per livestock institution in Bihar is 2.5 times more than the national average A serious concern is the cold chain management due to irregular power supply and lack of refrigerated vans for bulk transport, deep freezers/refrigerators/flasks etc. Lack of adequate infrastructure in field institutions Lack of quarantine facilities at designated border posts Limited zoonosis sanitary inspectorate facilities (e.g. at border posts) Lack of communication facilities at all levels (e.g. inadequate computers (operation facility) at all levels of the National Animal Disease Reporting System)	Improve budget allocation to facilitate provision of essential public animal health infrastructures Resolve the administrative constraints that inhibit the launch of mobile clinics Strengthen the capacity of the laboratory diagnostic network and improve diagnostic services Encourage community-level infrastructure development Strengthen cold chain management at retailers

Priority policy or institutional constraint/gap	Evidence, group affected and rationale for change	Required policy action
Absence of clear policy to ensure quality of veterinary education	One veterinary college exists and the intake of students is limited The efforts of COMFED, BAIF, J.K. Trust and some NGOs in providing animal health services are satisfactory but are mostly concentrated around Patna and other urban centres Prevalence of quacks (cattle vaidya)/uncertified practitioners No adherence to the prevention of contagious diseases act Lack of proper compliance with vaccination protocols Indiscriminate usage of antibiotics and hormones often administered by poorly trained livestock service providers Inadequate computer literacy at all levels of National Animal Disease Reporting System	One more Veterinary college be added and also increase the intake of students Develop strict regulations and enforcement that ensures quality of veterinary education Expand universities and colleges providing higher level education to meet the required skilled manpower Organize training in animal health services to rural educated youths, especially to those who are performing job of cattle vaidya in rural areas
Low adoption of GMP and technologies.	Adoption of GMP is inadequate and results in spread of diseases like mastitis Unhygienic management practices. Limited number of livestock farmers using available technology such as vaccines	Strengthen veterinary extension services to transfer of technologies and relevant information Provide incentives/premium price for quality livestock produce as adherence to GMP Boost and strengthen working relationships between livestock farmers and various service providers to foster usage of technologies Provide credit and extension services to the livestock producers

Priority policy or institutional constraint/gap	Evidence, group affected and rationale for change	Required policy action
Inadequate technical support services	Low average number of qualified animal health personnel compared to the number of animals requiring services Low availability of various technical support services at farm level Absence of formal mechanism for collecting information on veterinary drugs and biologicals pertaining to their failure or adverse effects	Promote and strengthen PPP in delivery of animal health services Establish a reporting system that will facilitate collection of information on veterinary drugs/vaccines performance at all levels

Table 99: Review of current policy constraints and proposed actions in animal breeding

Priority policy or institutional constraint/gap	Evidence, group affected and rationale for change	Recommended policy action
Absence of clear policy regarding ensuring quality and monitoring AI operations	No mention about regulatory authority to regulate use of germplasm in the breeding policy Institutional framework for implementation of regulatory framework is not mentioned in the breeding policy The breeding policy does not include monitoring of AI works Climate change is going to have an impact on crossbred animals but there is no mention about this issue in policy No regulation for breeding of small ruminants—small ruminants like goats naturally mate with any available village bucks	Revise the breeding policy to address policy gaps Develop regulation for breeding of small ruminants Supply male goats to progressive farmers in rural areas Enhance capacities for policy implementation

Priority policy or institutional constraint/gap	Evidence, group affected and rationale for change	Recommended policy action
Privatization of AI	Breeding is largely conducted by public breeding service providers Revised government guidelines say it is the responsibility of the breeding service provider to follow up with the AI calf for two months which discourages NGO operations The government engaged NGOs (BAIF and J.K. Trust) to provide AI services by allocating villages to them to prevent overlapping of services, but such delineation of public/private roles has not yet taken place—limited progress in privatization Lack of awareness about the potential of AI in the rural areas, along with initiative of improving semen quality, especially, blood level supply of different varieties of bull semen Lack of monitoring and coordination among the public and private sectors	Encourage private involvement in AI service delivery Use of ICT in service delivery as promoted by the National Dairy Development Board Encourage and provide incentives to private AI workers to provide doorstep services Provide training to rural private AI workers Increase coverage with quality, efficiency and cost-effective services to the small farmers
Insufficient improved genetic resources	Poor animal identification system and no performance testing Lack of progeny-tested bulls Large population of nondescript animals Indiscriminate breeding is one of the major problems Farmers do not maintain breeding records Blood levels very high	Establish and strengthen bull stations and frozen semen banks Strict enforcement of breeding protocols Improvement of nondescript buffalo through Murrah
Inadequate expertise and infrastructure	Prevalence of quacks (cattle vaidya)/uncertified practitioners Poor heat detection and insemination skills Unavailability of liquid nitrogen plant Irregular supply of liquid nitrogen	Create awareness among farmers Educate AI service providers and monitor AI services in the state Maintain the only non-functional liquid nitrogen plant

Table 100: Review of current policy constraints and proposed actions in animal nutrition

Priority policy or institutional constraint/gap	Evidence, group affected and rationale for change	Recommended policy action
Localized and seasonal scarcity of fodder, both in quantity and quality	The state is heavily deficient in production of green fodder (only 4.4% requirement is met by the produced fodder) Persistent seasonal scarcity of dry fodder in the Northern production zone	Develop animal nutrition strategies Strengthen animal feed factories and distribution selling points Develop policies/regulations and incentives to support private-sector investment in animal feeding. Support household-level improved grass and leguminous feed production (such as backyard feed production) Encourage establishment of storage facilities of feed ingredients in harvesting season Increase awareness among farmers for the conservation of fodders
Poor quality control and regulation of animal feeds	Insufficient and uncontrolled commercial feeds Fodder seeds in markets are unregulated Low quality control of manufactured feed	Strengthen quality audit and compliance of the commercial feeds Strengthen existing regulatory bodies to improve quality control of forage and forage seeds Research on improved forage seeds
Insufficient land for forage production and grazing and poor management of common resources	Lack of farming lands for forage production High competition for land with crops Lack of grazing lands Presence of 'zero grazing' policy	Encourage backyard forage production Support oversowing of grazing land with improved grass and leguminous forage seeds Encourage allocation of land for production of improved pasture/forage
Inadequate technical support services	Lack of skilled capacity in the areas of feed production and formulation	Provide technical assistance for feed formulation Strengthen capacity building for research scientists and extensions agents Research on improvement of forage seeds
Inadequate infrastructure and poor marketing system	Poor fodder storage facilities Inadequate forage compressing technologies and transportation system Unorganized fodder markets	Strengthen and establish forage storage facilities Improve forage transportation system Develop cost-effective and efficient compressing machines to make fodder blocks Encourage community fodder banks Strengthen animal feed factories and distribution selling points

Table 101: Review of current policy constraints and proposed actions in dairy sector

Priority policy or institutional constraint/gap	Evidence, group affected and rationale for change	Recommended policy action
Inadequate support services and insufficient supply of dairy stocks.	Insufficient number of inseminators Predominantly public and inadequate animal health and breeding services Quality veterinary treatment is limited by a lack of medicines Ineffective cold chain management Inadequate access to quality vaccination services No system of quality control and regulation of services provided by private animal health workers High incidence of repeat breeding An irregular supply of liquid nitrogen Prevalence of FMD and mastitis in crossbred animals	Strict enforcement of the breeding policy Enhance capacities for policy implementation Strengthen monitoring of the AI operations Improve the capacity of AI service delivery through capacity building programs and PPP Reinforce programs combating all animal diseases to improve productivity
Poor availability of animal feeds	Insufficient commercial feeds Low quality of feed stuff High feed prices and seasonal variation Scarce and expensive feed ingredients and raw materials Feed for lactating animals is mostly low quality Incidence of animals suffering from mineral deficiencies due to low-quality paddy straw and local grasses that are low in minerals	Strengthen animal feed factories and distribution selling points Develop policies/regulations and incentives to support private sector investment in animal feeding Encourage household level improved grass and leguminous feed production (such as backyard feed production) Strengthen existing regulatory bodies to improve quality control of forage and forage seeds Research on improved forage seeds varieties using PPP model

Priority policy or institutional constraint/gap	Evidence, group affected and rationale for change	Recommended policy action
Poor quality of milk	Quality control in terms of microbial load is mostly not functional Milk supplied to the consumers by farmers and dairies rarely meet the required standards Absence of quality assurance system at milk procurement High incidences of flood particularly in north Bihar Poor transport: lack of trucks with chilling equipment, poor road infrastructure Lack of power for cooling and cold storage facilities	Establish more BMCU Strengthen quality control at all levels Carry out education campaigns for all intervening parties on improvement of the quality of milk and dairy products.
Limited coverage of DCS (6.8%)	Insufficiency of milk for dairies Dairies function below their capacities Uneven distribution of DCS High seasonal supply variation Most of the milk produced is sold through informal circuits	Encourage private sector investment along the dairy value chain Encourage formation of DCS in new areas Provide incentive to milk co-operative societies
Inadequate access to credit and insurance services	Poor access to credit Low repayment rates for loans created reluctance of banks and credit institutes to provide loans to dairy farmers Institutional mechanisms to protect animals against risks are weak—only 6% of farm animals (excluding poultry) are covered by insurance	Enhance credit access by dairy farmers Link credit for dairy animals with a functional livestock insurance system Encourage private institutions to enter into livestock insurance markets

Table 102: Review of current policy constraints and proposed actions in the poultry sector

Priority policy or institutional constraint/gap	Evidence, group affected and rationale for change	Recommended policy action
Inadequate availability of feed resources, poor quality of feeds	High variability in quality of feeds and the formulation High feed prices and seasonal variation Scarce and expensive feed ingredients and raw materials	Provide technical assistance for feed formulation Strengthen quality audit and compliance of the commercial feeds Increase feed processing plants through PPP model
Prevalence of diseases	The poultry industry has suffered many setbacks due to new or re-emergence of diseases	Develop effective bio-security and implementation of successful hygienic procedures
Low productivity and genetic quality	Dominance of BYP Low productivity Lack of proper nutritional management	Develop genetic improvement of the national herd of poultry that considers diseases prevention, feeding systems, marketing, extension and training and credit facilities Strengthen/upgrade chicken multiplication centres
Inadequate infrastructure and poor marketing structure and organization	Lack of basic infrastructure such as storage and transportation Absence of cutting and processing facilities Price of chicken meat is high Inadequate mothering units and distribution centres Inadequate chicken multiplication centres. Marketing of eggs and broiler meat are not fully organized except few in urban sectors Eggs are still transported in open conditions and in unrefrigerated vehicles Eggs are sold in open markets without consideration for preservation of their quality	Encourage private investments Strengthen facilities for hygienic slaughter and preservation of eggs Establish more mothering units and distribution centres Support formation of producer co-operatives/associations and rural market yards Develop reliable and stable market chain year round for marketing of poultry products
Inadequate access to credit facility	Lack of operating capital to increase production	Provide credit access to farmers and other actors in the value chain
Inadequate MThnical support services	Lack of skilled capacity in the areas of poultry feed and health	Strengthen capacity building for research scientists (poultry nutrition and health) and support staffs

Table 103: Review of current policy constraints and proposed actions in the buffalo sector

Priority policy or institutional constraint/gap	Evidence, group affected and rationale for change	Recommended policy action
Poor quality and genetic stock	Low productivity of local buffalo Low growth rate that leads to long period to reach marketing age	Improve the breeding services Provide better health and feeding services Establish genetic improvement program
Inadequate infrastructure and marketing system	Inadequate abattoirs and slaughterhouses Insufficient meat processing plants Inadequate milk collection and distribution centres	Promote PPP policy for infrastructure investments Improve credit access throughout the buffalo value chain Expand the co-operative networks

Table 104: Review of current policy constraints and proposed actions in the goat sector

Priority policy or institutional constraint/gap	Evidence, group affected and rationale for change	Recommended policy action
Lack of clear policy towards the sector	Sector largely neglected in policy focus	Develop a policy for small ruminant sector focusing on critical issues such as health services, breeding issues, common property resources and producer associations for marketing linkages
Poor quality and genetic stock	Low productivity of local goat Low growth rate that leads to long period to reach marketing age Poor performance recording and communication	Develop breeding programs for small ruminants that consider: • animal species involved • type of traits considered • availability and affordability of different breeds • production environment
Inadequate infrastructure and marketing system	Inadequate transportation system Inadequate abattoirs and slaughterhouses Insufficient meat processing plants No market regulations exist for marketing goats and sheep There is no proper marketing facility	Promote PPP policy for infrastructure investments Strengthen market price and related information Develop proper marketing systems for goats and sheep, including grading system Support formation of goat and sheep producer associations

Priority policy or institutional constraint/gap	Evidence, group affected and rationale for change	Recommended policy action
Inadequate feed resources, lack of effective CPR policies	Poor management of forests and grazing lands Insufficient and uncontrolled commercial feeds	Develop CPR policies Develop animal nutrition based on locally available and affordable feed resources
Prevalence of diseases and poor quality control	Lack of regulation for vaccine quality control Weak private sector involvement High disease prevention and control costs Predominance of backyard slaughterhouses Low sanitary inspection at all stages of the value chain	Reinforce the control and prevention of strategies for specific priority diseases Encourage private sector to operate in rural areas through incentive packages and regulatory framework Strengthen sanitary inspection regulations
Inadequate technical support services	Many fragmented small producers without real support from the government No training strategy of the abattoir industry No formal mechanism for credit access	Reinforce the extension services Develop industry training strategy for abattoirs that include hygiene and safety standards, quality assurance, meat inspection and qualification regarding meat processing

Table 105: Review of current policy constraints and proposed actions in the pig sector

Priority policy or institutional constraint/gap	Evidence, group affected and rationale for change	Recommended policy action
Poor animal nutrition	Shortage of farming lands Insufficient and uncontrolled commercial feeds Limited use of agricultural by-products	Develop animal nutrition based on locally available and affordable feed resources.
Poor quality of genetic stock	Low productivity of indigenous breeds Poor performing local breeds Lack of productivity data regarding the local breeds	Establish genetic improvement program.
High prevalence of animal diseases	Prevalence of diseases Weak private sector involvement	Reinforce the control and prevention of strategies for specific priority diseases. Encourage private sector to operate in rural areas through incentive packages and regulatory framework

Priority policy or institutional constraint/gap	Evidence, group affected and rationale for change	Recommended policy action
Lack of farmers' organizations	Low organizational capacity throughout the value chain	Strengthen the organization of the different stakeholders of the supply chain Develop a joint strategy, together with representatives of research, extension, NGOs and private sectors to come up with a widely-disseminated plan for the development of the pig industry in the country
Inadequate infrastructure, marketing system and quality control	Low level of meat processing (cutting and transformation) Inadequate slaughterhouses (delivers whole or semi- and quarter carcasses) Poor transport facilities Low level of pork consumption Taboos related to pork meat Low sanitary inspection at all stages of the value chain Predominance of backyard slaughterhouses	Encourage PPP for infrastructure investments Develop standards for: Transportation of meat by cold storage Meat processing and transformation (meat sausage and meat cutting) Promote consumption of pork Strengthen sanitary inspection regulations
Inadequate technical support services	Many fragmented small producers without real support from the government	Reinforce the extension services Develop industry training strategy throughout the pig value chain

Table106: Review of current policy constraints and proposed actions in the hide and skin sector

Priority policy or institutional constraint/gap	Evidence, group affected and rationale for change	Recommended policy action
Poor quality skins and hides, Low recovery of skins	Poor quality is attributed to poor animal husbandry practices Lack of appropriate slaughter facilities and tools, poor storage and preservation techniques Lack of incentives to producers to improve quality	Encourage proper branding, slaughtering, flaying, preservation and storage of hides and skins Boost trading of hides and skins according to grades Strengthen marketing information and support services Boost investment in processing facilities of hides and skins; Strengthen stakeholder organizations

Priority policy or institutional constraint/gap	Evidence, group affected and rationale for change	Recommended policy action
	Price setting that does not encourage quality	Develop and support skin and hide standards Strengthen disease control efforts (lumpy skin, FMD)
Capacity utilization of tanneries and investment	Few private tanneries are presently operational in Bihar Capacity utilization of tanneries remains low—the local tanning industry is confined to a few working tanneries in Muzaffarpur and another BATA tannery at Mokhamaghat, as a result most of the raw material is destined for Kolkata, Kanpur and Chennai	Encourage private sectors to build leather processing plants Strengthen capacities of stakeholders including technical personnel
Effluent treatment problems and adherence to sound environmental management standards	The tanneries in Bihar which are concentrated in Muzaffarpur lack proper effluent treatment plants The plan to construct a Common Effluent Treatment Plant for Muzaffarpur tanneries is still pending	Strengthen guidelines for skins, processing effluent treatments and environmental standards Strengthen private tanneries in terms of processing technology Establish common effluent treatment plant through PPP model
Poor and deteriorating physical infrastructure	Irregular supply of power Outdated technology Abattoirs, slaughter slabs are in most cases in poor condition	Provide credit facilities and set standards for upgrading slaughter facilities

Table107: Review of current policy constraints and proposed actions in livestock and livestock products marketing and processing

Priority policy or institutional constraint/gap	Evidence, group affected and rationale for change	Recommended policy action
Inadequate marketing system	Inadequate livestock marketing regulation Lack of regulation for transporting animals	Develop grading system for all meat sectors Strengthen livestock market prices and related information
Inadequate investment in marketing and processing facilities	Marketing of eggs and broiler meat is not fully organized except in a few urban sectors Inadequate marketing facility for small ruminants Inadequate abattoirs and slaughterhouses Inadequate milk and meat processing plants	Encourage and support private investments in developing marketing and processing infrastructure
Poor quality of livestock products	Eggs are still transported in open conditions and in unrefrigerated vehicles Eggs are sold in open markets without consideration for preservation of their quality Poor quality control of meat slaughtering and retailing	Set standards to improve the quality of livestock products and hygienic practices that would meet the sanitary and phytosanitary specifications for export Strengthen extension and communication campaigns
Insufficient number of co-operatives and other forms of collective actions	Most co-operatives are related to dairy production The available farmers' organizations involve the small groups of farmers with a weak platform	Support establishment of various organizations throughout the livestock value chain

Table 108: Review of current policy constraints and proposed actions in livestock research

Priority policy or institutional constraint/gap	Evidence, group affected and rationale for change	Recommended policy action
Inadequate operational resources and low private sector participation	The share of animal sciences in total expenditure remains low More emphasis on crop research than livestock research Insufficient funds for operational costs, training and capacity development	Establish a livestock research centre through a PPP model Strengthen Research capacity for quality and sustainable delivery of research services Promote PPP
Inadequate facilities and infrastructure	Poor networking due to lack of means of transport, GPS, veterinary, computers etc. Insufficient laboratories	
Inadequate capacity and insufficient expertise	Most of the livestock research is skewed towards milk production and disciplinary oriented The share of animal sciences in total agricultural research staff is low Public staff are overburdened with implementing state and centralized schemes	Development of multidisciplinary systems-oriented livestock research Capacity building for research scientists including animal scientists (nutrition, animal health, genetics etc.) Improve government scheme of services Enable environment for research at institute level especially across paths and availability of mentors
Weak linkages and rare partnerships among research collaborators with other stakeholders	The link between research and extension is very weak Research–extension link has rarely absorbed feedback from farmers and extension staff Outputs generated by the research systems are not adequately and properly packaged and disseminated Inadequate coordination among various agencies collecting statistics	Encourage experimentation in farmers' fields and establish a network of farmer researchers Facilitate coordination meetings that involve stakeholders Development of participatory research agenda that must include all stakeholders Formulation of research, extension and farmers platform

Table 109: Review of current policy constraints and proposed actions in livestock extension services

Priority policy or institutional constraint/gap	Evidence, group affected and rationale for change	Recommended policy action
Inadequate resources and weak private sector participation	Low allocation of public or private funding to livestock extension services Most of the livestock extension is conducted by the Bihar animal husbandry department, which has neither the resources nor the expertise to conceive and operate technology transfer packages	Allocate adequate resources for livestock extension and training Promote PPP Harmonize institutional policies to ensure full participation of private sector in extension activities Introduce progressive disengagement of public sector from extension service delivery in favour of private extension service delivery
Weak research-training-extension-farmer linkages	Low coverage of technology that has maintained low adoptions among stakeholders Only few famers have access to any kind of information on animal husbandry from formal extension services A large segment of animal health services is in hands of quacks/ uncertified service providers who lack technical competencies	Support research, training and extension linkages and platforms Strengthen group formation, e.g. FFS Establish bottom-up technology formulation participatory approach
Inadequate infrastructure and facilities	Lack of means of work for extension workers (means of transport, GPS, veterinary kits, computers etc.)	Encourage PPP Facilitate extension staff in transport, houses and other equipment
Insufficient extension expertise	Lack of expertise to formulate and implement technology transfer packages services are mainly run by veterinarians Prevalence of quacks/uncertified practitioners	Support voluntary farmers' extension services providers Support rural innovation community centres Facilitate in-service training Establish support services to private extension services (AI, animal health units etc.) Strengthen technical capacities of male/female producers by means of subcontracting with service providers Organize technical and organizational training needs assessment

Annex 3: Results of LSIPT Analysis

Table 110: Feed balance analysis for base year (2017/18) of Bihar state by production zones

	Feed available (crore MJ ME equivalent)	Current feed need (crore MJ ME equivalent)	Feed balance (crore MJ ME equivalent)	Percent of feed available over feed need (%)
Northern	5,566	11,757	-6,191	47%
Central	6,164.6	12,208.5	-6,043.9	50%
Southern	1,816	4,458.6	-2,642.6	41%
Bihar state	13,546.6	28,441.5	-14,894.9	48%

The feed analysis result shows that the feed balance gap in Bihar between what is required and available is huge and depicts the need for strong interventions towards bridging these feed deficit. As the table above shows, the Central livestock production zone has relatively better feed resource compared to other zones. However, by 2032/33 the deficit will be much worse for the central than the other zones (Table 110). This is due to the fact that majority (about 70%) of crossbred cattle are currently found in the Central zone and also targeted in the WI-1 scenario to have more replacement of local breeds with crossbred cattle in the central than the other zones. Crossbred cattle have higher feed need than local, due to their higher body weight and productivity.

Table 111: Feed balance analysis for projected (2031/32) of Bihar state by production zones

	Feed available (crore MJ ME equivalent)	Projected (2031/32) feed need (crore MJ ME equivalent)	Feed balance (crore MJ ME equivalent)	Percent of feed available over feed need (%)
Northern	5,566	14,820.4	-9,254.4	38%
Central	6,164.6	22,913.8	-16,749.2	27%
Southern	1,816	5,429.1	-3,613.1	33%
Bihar state	13,546.6	42,423.8	-28,877.3	32%

Level of competition of chicken and pig with human for cereals

The amount of feed consumed by chicken and pig is estimated using feed conversion ratio of the two species. Based on this estimate, it is found that chicken and pork are consuming about 4% of major cereals (maize, sorghum and millet) produced by 2016/17. However, due to the anticipated huge increase in the number of chicken in the coming 15 years, their consumption requirement is also expected to increase. By 2032/33, it is

expected that the share consumed by chicken and pig will reach 75% of the amount of currently produced cereals (maize, sorghum and millet).

Currently, at India level, about 28% of maize produced is utilized for food purpose, 11% for livestock feed, 48% for poultry feed, 12% in wet milling industry (for example starch and oil production) and 1% as seed goes (Murdia L.K., 2016).

Table 112: Competition of chicken and pig with human for cereals

Chicken and pig products	Production (MT)		Cereal equivalent of poultry meat, pork and egg productions (with 1.37 conversion ratio)	
	Base year (2017/18)	2032/33	Base year (2017/18)	2032/33
Chicken meat (MT)	61,975	15,48,972	84,906	21,22,091
Pork (MT)	44,473	1,62,013	60,928	2,21,958
Egg (MT)	16,409	3,91,061	22,480	5,35,754
			1,68,315	28,79,803
			Poultry meat, pork and egg cereal equivalent/ cereals produced (%)	
			4%	75%

Table 113: Production of maize, sorghum and millet in Bihar (2016/17)

Major cereals	Production by 2016/17 (MT)
Maize	38,45,700
Sorghum & Millet	12,508
Total	38,58,208

Source: Govt of Bihar - Department of Agriculture

Table 114: Results of financial analysis for the combined livestock interventions in cow dairy production in Bihar 2017–18 to 2032–33 (livestock production zone level)

Production zone	Financial indictors based on 15-years discounted incremental cash flow analysis			
	NPV (INR lakhs)	IRR (%)	BCR	EANPV (INR lakhs)
Northern	2,25,060.60	15%	1.1	29,589.57
Central	24,47,512.15	40%	1.7	3,21,783.67
Southern	88,039.04	14%	1.2	11,574.83
All cow dairy	27,60,706.89	31%	1.5	3,62,960.56

Table 115: Results of financial analysis for the combined livestock interventions in buffalo production in Bihar 2017–18 to 2032–33 (livestock production zones level)

Livestock production zone	Financial indictors based on 15-years discounted incremental cash flow analysis			
	NPV (INR lakhs)	IRR (%)	BCR	EANPV (INR lakhs)
Northern	1,74,587.05	13%	1.1	22,953.62
Central	1,16,290.08	25%	1.4	15,289.10
Southern	1,61,495.82	15.3%	1.1	21,232.47
All buffalo	4,52,372.95	15%	1.0	59,475.18

Table 116: Results of financial analysis for the combined livestock interventions in small and medium goat farms in Bihar 2017–18 to 2032–33 (goat production subsystem level)

Goat production subsystem	Financial indictors based on 15-years discounted incremental cash flow analysis			
	NPV (INR lakhs)	IRR (%)	BCR	EANPV (INR lakhs)
Small farms	1,25,515.28	29%	1.6	16.501.96
Medium farms	44,628.30	40%	1.9	5,867.45

Figure 39: Impacts of interventions: 15-years IRR for WI scenario in small and medium goat farms (goat production subsystem/farm level).

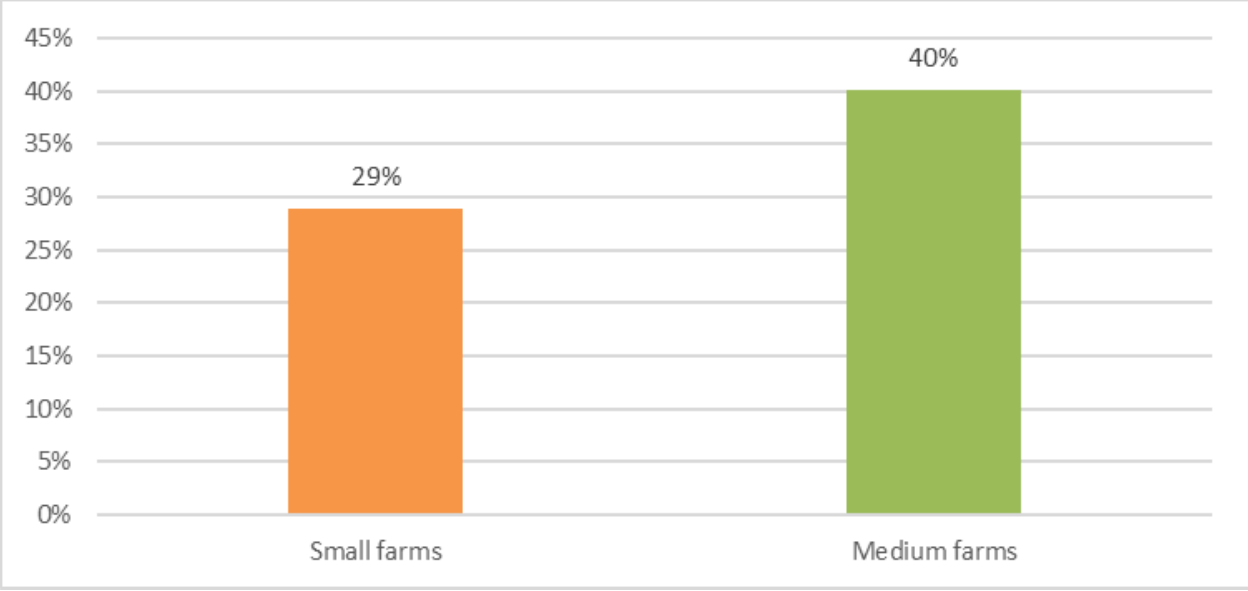


Table 117: Results of financial analysis for the combined livestock interventions in goat production in Bihar 2017–18 to 2032–33 (livestock production zones level)

Livestock production zone	Financial indictors based on 15-years discounted incremental cash flow analysis			
	NPV (INR lakhs)	IRR (%)	BCR	EANPV (INR lakhs)
Northern	1,01,680.42	31%	1.676	13,368.31
Central	50,442.30	34%	1.7	6,631.84
Southern	18,020.86	24%	1.4	2,369.27
All goat	1,70,143.59	31%	1.6	22,369.42

Table 118: Results of financial analysis for the combined livestock interventions in pig production in Bihar 2017–18 to 2032–33 (production subsystem level)

Flock size class/farm type	Financial indictors based on 15-years discounted incremental cash flow analysis			
	NPV (INR lakhs)	IRR (%)	BCR	EANPV (INR lakhs)
Improved backyard	5,76,052.51	N/A	27.99	75,735.80
Commercial				
Broiler	2,77,175.78	226%	1.25	41,432.94
Layer	54,693.46	172%	1.21	7,190.76

Annex 4: Gender and Social Inclusion

Table 119: Gender and social inclusion possible strategies, cow/buffalo dairy improvement interventions

Intervention area/proposed/issue	Gender and social implication	Possible strategy for social equity
Dairy genetics: genetic improvement through AI, sexed semen and embryo transfer Crossbred dairy cows are given in subsidy for women, marginalized and poor communities (existing)	Women and marginalized communities have poor access to these services due to higher cost, mobility issues and additional requirement of feed for improved breeds Women, ST and SC prefer buffalo over cow for dairy production due to easy handling and scarcity of cow feed	Doorstep delivery of services through decentralized systems/co-operatives/SHGs and subsidy for poorest households Decisions made by women and the poorest about species preference Apart from milk, buffalo meat is a good source of animal protein for scheduled caste people
Feed: Low productivity of dairy animals from marginalized households because of lack of balanced feed Feed: land rental issue	Women and marginalized people have limited access to better feed/concentrate due to high cost and mobility issues Marginalized communities have issues with renting land which is main source for feed production for dairy animals	Decentralized target-based feed distribution (encourage small-to-medium enterprises) through co-operatives/JEEViKA SHGs, boost surplus to demand area fodder transactions Establish land rental regulations to reduce exploitation of marginalized communities
Extension: support training centre and extension agents and expansion areas (all species)	Women and marginalized communities are excluded in the centralized extension system due to distance, work burden and social status	Decentralized extension system with at least 30-50% women extension agents Support village-based digital extension systems which are good for illiterates and do not discriminate (applicable also for goat and other small animals)
Processing, marketing: support dairy co-operatives	Gender neutral co-operatives will not benefit women as there are gender inequalities within households and communities which hinder participation and access to dairy income	Women-only dairy co-operatives and support of women leaders in union and federation level at least to 50% level

Table 120: Gender and social inclusion possible strategies, goat improvement interventions

Intervention area/proposed/issue	Gender and social implication	Possible strategy for social equity
Feed: promotion of backyard fodder production Pasture land improvement	Will compete for land allocated to food production, with possible negative impact on household nutrition No involvement of marginalized/women for common land management	Promotion of fodder banks/supplement feed—facilitate transactions of fodder from surplus to demand area (Like Gaya Nalanda fodder market) Community and women participation in committees of common land fodder management (e.g. UK)
Health: high mortality and vaccination and deworming goats	Services will not reach women and marginalized due to distances, weak bargaining and political power, governance issues	Training and promotion of decentralized women private health service providers would facilitate easy communication based on community selection and preference Target based subsidy for marginalized communities to provide services from these providers to reduce governance challenges
Genetics: community-based goat improvement programs	Given that women are those managing goats, excluding women and marginalized will not bring any improvement	Include women from marginalized communities in feed improvement programs and award system for local improved breeds
Processing, marketing: strengthen existing market, abattoirs	Women from marginalized communities have access to local markets Traders, abattoirs may discriminate against women as in other formal livestock markets	Facilitate linkages with women SHGs, trader or butcher associations and abattoir linkages; i.e. emphasis on strengthening existing systems based on local markets Introduce micro insurance for women traders to cushion them against losses

Table 121 : Gender and social inclusion possible strategies, BYP improvement interventions

Intervention area/proposed/issue	Gender and social implication	Possible strategy for social equity
Feed: feed supplementation	Women and marginalized have limited access to poultry feed due to high cost, lack of capital and knowledge	Support target-based subsidy feed to women SHGs of SC/STs (same as JEEViKA program)
Health: vaccination	Women from marginalized and tribal communities have limited access to vaccination	Training and support of decentralized women private health service providers, in a similar way as goats (integrated service for poultry, goats and pig-PRADAN model impact is explained in Annex)

Intervention area/proposed/issue	Gender and social implication	Possible strategy for social equity
Genetics: improve productivity through selective breeding	Opinions and knowledge of women and marginalized communities for breed selection are usually not considered so promoted breed is not adopted	Community-based breed selection and development through entrepreneurship to supply chicks and breed saviour awards, to support farmers who maintain and improve indigenous breeds (as done by the Self Employed Women's Associ ation)
Marketing: lack of collective marketing, high transaction	Women and poorest members have poor negotiation skills due to lack of market information, leading to lower return on labour	Support of collective marketing and integer system with private (for input and market support) collaboration through SHGs as done in JEEViKA

Table 122: Gender and social inclusion possible strategies, pig improvement interventions

Intervention area/proposed/issue	Gender and social implicati on	Possible strategy for social equity
Feed and system: transitioning from scavenging to semi-intensive system	Women from tribal communities don't have access to feed and lack capital to invest in improved feed practices	Provide concentrate pig feed to SHGs in tribal communities in target-based subsidy to promote semi-intensive system; assess better use of communal resources
Marketing: formal channel through slaughterhouse	This will have positive implications for women in tribal communities, with possibility of employment	Collective marketing through SHG to slaughterhouse and link to northeastern states for value addition and supply A special project assigned under the Mahadalit program will develop slaughter and hygiene skills within tribes
Health: vaccination and deworming	Positive implication in terms of increased productivity and reduced mortality	Under the Mahadalit program, train women and men as community-based animal health workers to treat pigs, BYP and goats

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