Policy Paper 38

Livestock Farmers' Information Needs, Search Behaviours, and their Impact

Lessons for Extension Policy

Pratap S Birthal
Jaweriah Hazrana
Raka Saxena

G20 भारत 2023 INDIA

आज़ादी का अमृत महोत्सव

भा.कृ.अ.प.– राष्ट्रीय कृषि आर्थिकी एवम् नीति अनुसंधान संस्थान
ICAR – NATIONAL INSTITUTE OF AGRICULTURAL ECONOMICS AND POLICY RESEARCH

NIAP Publication Committee

P S Birthal
Shiv Kumar
N P Singh
Purushottam Sharma
Raka Saxena

The ICAR-National Institute of Agricultural Economics and Policy Research (NIAP) was established by the Indian Council of Agricultural Research (ICAR) to strengthen agricultural economics and policy research in the National Agricultural Research System comprising a network of ICAR institutions and State Agricultural Universities. The mandate of the Institute is:

- Agricultural economics and policy research on markets, trade, and institutions
- Growth and development models for sustainable agriculture
- Technology policy, evaluation, and impact assessment

ICAR-NIAP has emerged as a think tank in the area of agricultural policy and it has contributed to increased participation of the ICAR in agricultural policy-making. Besides ICAR, the Institute regularly provides research based inputs to the NITI Aayog, Government Departments, States, and other stakeholders for policy decisions in diverse areas related to agriculture.

Policy Paper 38

Livestock Farmers' Information Needs, Search Behaviours, and their Impact

Lessons for Extension Policy

Pratap S Birthal
Jaweriah Hazrana
Raka Saxena

भाकृअनुप
ICAR

ICAR – National Institute of Agricultural Economics and Policy Research
New Delhi - 110 012

Birthal P. S, J. Hazrana, and R. Saxena (2023). Livestock farmers' information needs, search behaviours, and their impact: Lessons for extension policy, Policy Paper 38, ICAR-National Institute of Agricultural Economics and Policy Research (NIAP), New Delhi

Published
March, 2023

Published by
Dr P S Birthal
Director
ICAR–National Institute of Agricultural Economics and Policy Research
New Delhi - 110 012

Printed at
M/s Chandu Press, 469, Patparganj Industrial Estate, Delhi 110 092.

Contents

List of Tables

List of Figures

List of Appendices

Preface

Since 2011-12, India's livestock sector has experienced an unparalleled growth of about 8%, contributing more than 50% to agricultural growth. Given the concentration of livestock resources among smallholders, and the high-income elasticity of demand for animal-source foods, the faster growth in the livestock sector may contribute to achieving the Sustainable Development Goals of zero hunger, no poverty, and improved nutritional security.

Nevertheless, there is apprehension regarding the sustainability of the recent growth in the livestock sector in the absence of appropriate policy and institutional support. The growth may come under a confluence of pressures, including scarcity of feeds, fodders and water, climate change, and poor delivery of livestock services and information. To an extent, these constraints can be lessened by the timely provision of the right kind of information on animal health, nutrition, breeding, and management, which, in turn, can improve animal productivity by about 15%, indicate findings of this study.

Livestock extension in India remains underdeveloped to meet the diverse information needs of livestock farmers. Extension activities account for hardly 2% of the total spending on livestock sector. In this context, it is imperative to enhance the outreach of the public extension system, and strengthen institutional arrangements for the effective delivery of information and services, capitalizing on the existing cooperative network of dairy cooperatives and public-private partnership.

Pratap Singh Birthal
Director, ICAR-NIAP

Executive Summary

India's livestock production has increased tremendously over the past five decades. Milk production increased tenfold, from 21 million tonnes in 1970-71 to 210 million tonnes in 2021-22. Production of other animal-source foods, particularly eggs and poultry meat, too experienced robust growth. Nevertheless, producing more animal-source foods remains as urgent as ever. Increasing per capita income, expanding urbanization, changing lifestyles, and improvements in logistics and supply chains have been triggering significant changes in food consumption patterns in favor of nutrient-rich foods, including animal-source foods. Notably, the factors underlying this transition in food consumption have been quite robust in the recent past, and they will unlikely subside soon, implying a faster growth in the future demand for animal-source foods.

Although India has a huge livestock population of different species, fulfilling the future demand for animal-source foods from domestic production will be challenging. The current productivity levels of most livestock species are low. For example, the annual milk yield of a cow in India is about 1700 kg, which is only one-sixth of that in North America and one-fifth of that in Europe. Productivity improvements are constrained due to several factors, including scarcity of feeds and fodders, poor flow of institutional credit, under-developed markets, and poor delivery of animal health and breeding services.

Information can aid in improving livestock productivity by influencing farmers' production decisions on the adoption of improved technologies, innovations, inputs, and management practices. Farmers' information needs are diverse. They require information on animal breeds and breeding practices, feeds and nutrition, health and disease management, animal housing, clean production practices, food safety standards, institutional credit, insurance, markets, prices, and international trade. Furthermore, with the emerging biotic and abiotic pressures on livestock production systems, the changes in consumer preferences for safe and hygienic food, and the increasing regulatory and non-regulatory barriers to participation in international trade, the demand for information is expected to upsurge exponentially. The future livestock production systems, thus, will be knowledge and information intensive.

Nonetheless, there is a lack of understanding of the flow of information into the livestock production systems in terms of farmers' requirements for different sorts of information, the sources dispensing these, and their impacts on production. Using data from a large-scale nationally representative farm survey in India and focusing on dairy farming, this paper has empirically probed these issues. The key highlights of this investigation are:

- Farmers face acute information constraints — only about one-fourth of the dairy farmers have access to information on different aspects of dairy farming. Farmers' information needs, however, are varying. The information on animal health is the most sought-after (by >50% of farmers), followed by the information on animal breeds and breeding practices (21%), feeds, feeding practices and nutrition (20%), and management (8%).

- For their information needs, dairy farmers depend on several formal and informal sources, the prominent being the informal ones, including the private service providers (39%), followed by the progressive farmers or social networks (17%), mass media (14%), and input dealers (13%). The outreach of the public extension system is limited to 14% of the dairy farmers.

- Using information in production decisions improves dairy productivity by 15%. However, different types of information have a differential impact. The information related to management aspects is more effective in raising milk yield (33%) than any other type of information —feeds and nutrition (17%), animal breeding (13%), and disease and health management (10%). However, bundling different types of information results in a more pronounced effect than any of the information used in isolation.

- Also, there is a source effect — the public extension system has the highest impact on dairy farming— a 14% higher milk yield. The effect of information from private sources is just half of it. The other information sources, including mass media, progressive farmers, and input dealers, do not affect productivity in a significant manner.

These findings have some important policy implications for extending support services to livestock farmers, particularly in developing countries where the information dissemination systems for livestock, including public extension system, have not received much attention in livestock development. Note, in India, extension activities are hardly allocated 2% of the total public spending for livestock development. The key issues that merit attention are:

First, given the maximum impact of the public extension system on productivity enhancement, the need for improving its outreach cannot be undermined. India has a large number of veterinarians and para-veterinarians primarily employed in the public sector, yet the delivery of livestock services has remained poor. The question is: Should the governments utilize the existing human resources and infrastructure or evolve new institutional arrangements to strengthen the flow of information to the livestock sector?

Second, India has a strong network of dairy cooperatives and a strong presence of private dairy processors in some states. How can policy facilitate the growth of such value chains to leverage their potential for delivering livestock information and services?

Third, depending on the ease of their adoption, a few livestock services, particularly those not complex and difficult to understand by the farming communities, can be considered for privatization. However, the relatively small impact of private information on productivity points towards the need for building/enhancing the capacities of private service providers in understanding animals' biological systems for accurate diagnosis of ailments and their remedies.

Finally, since farmers' information needs are diverse, and given the more significant impact of the joint use of information, the need for providing bundled information cannot be undermined. It also means the adoption of a single-window approach for the effective delivery of livestock services.

1 Introduction

In developing countries, which are dominated by resource-poor small landholders, livestock comprise an integral component of the agricultural production systems and one of the most important sources of livelihood for most of the agricultural and rural population. They perform several economic, social, and environmental functions. Besides providing nutrient-rich products for human consumption, draught power and dung manure for crop production, they act as a financial institution — a bank deposit with offspring as interest and a means of self-insurance during the economic crisis — and as an instrument for reducing social and economic inequalities (Delgado et al. 1999; Birthal et al. 2014) and the poverty (Heffernan 2004; Upton 2004; Birthal and Taneja 2012; Birthal and Negi 2012; Bijla 2018). Birthal and Negi (2012) have demonstrated that in India compared to the income from crop farming, the income from animal farming is more equally distributed and has a 1.4 times larger effect on poverty reduction. Bijla (2018) too has shown that livestock help households escape poverty and prevent them from falling into poverty.

Over the past five decades, driven by the increasing demand for animal-source foods, India's livestock production experienced a robust growth. Milk production, which had rarely exceeded 25 million tonnes during the 1960s and 1970s, reached 210 million tonnes in 2021-22 (GoI 2022). Similarly, the production of meat and eggs has experienced robust growth. Overall, the economic contribution of the livestock subsector has grown faster than that of the crop sector, turning it as an engine of agricultural growth. Its share in agricultural growth has increased considerably, from 32% in the 1990s to 36% in the 2000s (Birthal and Negi 2012), and further to over 50% in the recent decade (Birthal and Mishra 2021). In 2019–20, the livestock subsector contributed 4.5% to the overall gross domestic product (GDP) and 29.7% to the agricultural gross domestic product.

The necessity to produce more animal-source foods remains as urgent as ever. The increasing population, changing lifestyles, sustained income growth, and improvements in logistics and food supply chains have been triggering rapid changes in food consumption patterns in favor of nutrient-dense foods of plant and animal origin. The trends in these factors have been quite robust, and these are unlikely to subside in the near future, implying a faster growth in the demand for animal-source foods. By 2050, in a business-as-usual (BAU) scenario, the demand for most animal-source foods is projected to be twice of that in 2009 (Hamshere et al. 2014).

India has a large population of diverse livestock species, yet, fulfilling the future demand for animal-source foods from domestic production will be challenging. The current productivity levels of most livestock species are low. For instance, the annual milk yield of a cow in India is about 1,700 kilograms, which is just 16% in North America and 25% in Europe. Further, the resource-poor smallholders—or the households cultivating plots of land as small as one hectare or even smaller, with an average herd size that hardly exceeds two animals—dominate India's livestock production systems (Birthal and Mishra 2021). Smallholder farmers face several biotic and abiotic constraints, including scarcity of feed and fodder, poor delivery of livestock services, and underdeveloped markets and value chains.

Information has the power to transform food production systems. Several studies have shown that farmers' access to information influences their decisions on the adoption of improved technologies and practices, participation in markets and accessing credit, and, consequently, farm outcomes (Mwabu 2001; Liu 2013; Bandierra and Rasul 2006; Conley and Udry 2010; Birthal et al. 2015). However, most of these have assessed the impact of information on the returns from crop farming and crop prices. Our understanding of the impact of information on the performance of other agricultural activities, including animal husbandry, and fisheries, is imperfect.

The demand for information is expected to increase exponentially due to the increasing biotic and abiotic pressures on livestock production system, the changes in consumer preferences for safe and hygienic food, and the increasing sanitary and phytosanitary requirements in international trade. Furthermore, the inherent potential of ruminants' greenhouse gas (GHG) emission, and the zoonotic nature of several animal diseases will compel farmers to adjust their production practices to protect the environment, conserve natural resources, and ensure food safety and hygiene. The future livestock production systems will, thus, be knowledge and information intensive.

Farmers need different sorts of information; on animal breeds and breeding practices, feeds and feeding practices, health and disease management, animal housing, clean production practices, food safety standards, credit, insurance, markets, prices, and trade. A single source is unlikely to provide all of these. Therefore, farmers rely on multiple sources for their information needs, including traditional and modern, public and private, and formal and informal. These sources differ in the quality of human resources, method, and cost of information delivery; hence, we expect a significant difference in the effect of the information content and the source dispensing it on farm outcomes.

This study assesses the impact of information on the productivity of dairy farming in India. It uses data from a nationally representative survey of farm households conducted by the National Sample Survey Office (NSSO) of the Government of India in 2018-19. This survey contains data on the type of and source dispensing it, along with several farm and household characteristics, which allow us to assess the impact of different types and sources of information on farm outcomes, controlling for the potential impact of several other factors, tangible and intangible.

Nevertheless, establishing a causal relationship between the information and farm outcomes is challenging. Several observable and unobservable factors may simultaneously influence the uptake of information and the farm outcomes, resulting in a bias in its estimated impact (Aker 2011; Birthal et al. 2015). Hence, in this study, we employ the instrumental variable (IV) technique to estimate the impact of information on the efficiency of dairy farming.

The evidence on the impact of information on livestock productivity is anecdotal and has hardly been empirically assessed, to the best of our knowledge. The key findings of this investigation are as follows.

- Controlling for several observable and unobservable covariates, using the information in production decisions leads to a 15% improvement in dairy productivity.
- The impact of information differs by its content— information related to livestock management is more effective than information on animal breeding, feeding, and health.
- The payoff from using different sorts of information in combination is significantly larger than from using any type of information in isolation.
- There is also a source effect — the information from the public extension system impacts productivity greater than the information sourced from private service providers, social networks, mass media, and input dealers.

These findings have some important policy implications for developing countries, where the governments have rarely accorded any priority to livestock extension (Morton and Matthewman 1996). In India, for instance, the investment in extension accounts for hardly 2% of the total public spending on the livestock subsector (Birthal and Mishra 2021). Only 25% of livestock farmers access information from non-governmental sources. The outreach of the public extension system is limited to 14% of information users.

These findings indicate a need for designing a comprehensive livestock extension strategy to empower farmers to cope with the emerging challenges in the process of transformation of livestock production systems from subsistence to commercial ones.

- Animals have complex biological systems; hence, social networks, mass media, and input dealers cannot be relied upon for disseminating complex information, especially related to animal health and breeding.
- Should the government utilize existing infrastructure and human resources or evolve new institutional arrangements to deliver livestock services? The impact of public extension system is high. Most veterinarians are employed in the public sector, but their reach to the farmers is limited. Therefore, there is a need to look into the service functions of veterinarians and if necessary utilize their expertise for providing livestock extension services.
- The network of dairy cooperatives that links dairy farmers to markets is strong: 193,195 village dairy cooperatives procured 17.5 million tons of milk (9% of the total production) from 17.2 million farmers in 2020–21 (NDDB 2021). Private dairy processors procured as much. There is a need to strengthen this network and use it for the dissemination of information and delivery of services, especially related to livestock management, feed and feeding practices, animal hygiene, food safety, and waste management.
- The livestock population is large and diverse, as are the production systems. Therefore, certain livestock services need to be privatized, and the capacities of the private service providers be enhanced through regular interaction with the public extension system.

2 Overview of the Livestock Sector

Livestock comprise one of the important sources of livelihood for about two-thirds of the rural households in India, especially the resource-poor, viz., marginal and small farmers, and landless agricultural labourers. The factors driving the demand for livestock products (rapid urbanization, increasing population, and income growth) are expected to remain strong in the near future, which presents enormous opportunities for enhancing farmers' income and reducing farm poverty and improving nutrition (Saxena et al. 2017, FAO 2018).

2.1 Growth in livestock sector

Livestock is a rapidly growing sector, contributing almost 40% to the global agricultural gross domestic product (GDP) and plays a crucial role in food security worldwide (ILRI 2021). In India, although crop sector remains a major contributor to agricultural GDP, the contribution of livestock and fisheries has been growing faster than that of crops (Table 1). Since independence, the crop sector grew at an annual rate of 2.69%, the highest growth of 3.36% being during the 1990s. However, livestock, forestry, and fisheries have experienced significant growth of 7.73%, 4.28%, and 8.80%, respectively in the recent decade. The milk and milk products contribute

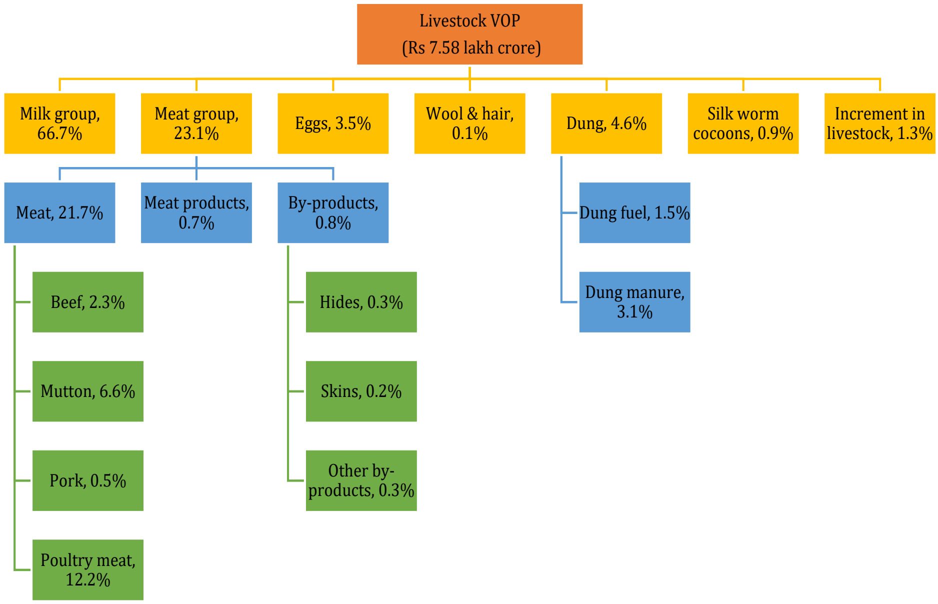
Table 1. Growth of gross value added (GVA) of agriculture & allied sector (at 2011-12 prices)

Period	Agriculture, forestry and fishing	Crops	Livestock	Forestry & logging	Fishing & aquaculture
1950-59	2.71	2.93	2.91	0.29	5.79
1960-69	1.51	1.27	**1.25**	3.33	4.00
1970-79	1.74	1.94	1.88	**-0.62**	**2.90**
1980-89	2.97	3.09	3.11	-0.26	5.67
1990-99	3.34	**3.36**	3.40	0.95	5.36
2000-09	2.56	2.52	4.16	-0.42	3.62
2010-22	**3.91**	1.74	**7.73**	**4.28**	**8.80**
1950-22	2.73	2.69	3.21	0.68	4.54

Source: Authors' computations

the highest (66.7%) to the value of output (VOP) from the livestock sector, and meat and meat products 23.1% (Figure 1). The milk basket comprises of 31.57% from crossbred and exotic cattle, 20.01% from indigenous and non-descript cattle, 45.44% from indigenous and non-descriptive buffalo, and only 2.98% from goats (GOI 2021).

Figure 1. Composition of livestock output (share in livestock VOP (%), triennium ending (TE) 2020-21)



Source: Authors' computations

2.2 Livestock population

India is rich in livestock resources in terms of numbers, diversity, and adaptability to a wide range of agro-climatic conditions. India possesses 302.8 million bovines, 74.2 million sheep, and 148.8 million goats (20th Livestock Census, 2019) (Table 2). The bovine population consists of indigenous, exotic & crossbred cattle, and buffaloes. A significant increase in the population of crossbred cattle has been reported during 2012-19. Crossbreds are yielding and require more of health care, quality breeding and feeding practices and better management. Hence, their growing population necessitates more information on these aspects.

Indigenous cattle are known for their stress tolerance and disease resistance and also have the advantage of sustaining productivity under low input conditions (Nyamushamba et al. 2017). Since 2012, their population decreased at an annual rate of 0.9%. Milk yield of indigenous cows is much less than of crossbreds and buffaloes, which is one of the reasons for replacing indigenous cattle with buffaloes and crossbreds. Further, increasing mechanization of agriculture and declining size of farms have forced smallholder farmers to abandon draught cattle (Srivastava et al. 2019). Buffalo population increased from 108.7 million in 2012 to 109.8 million in 2019. The population of small ruminants and poultry appreciably increased because of increasing demand for their meat.

Table 2. Trends in livestock population in India

Census Years	Cattle		Buffalo	Goat	Sheep
	Crossbred	Indigenous			
Population (million numbers)					
1992	15.2	189.4	84.2	115.3	50.8
1997	20.1	178.8	89.9	122.7	57.5
2003	24.7	160.5	97.9	124.4	61.5
2007	33.1	166.0	105.3	140.5	71.5
2012	39.7	151.7	108.7	135.1	65.1
2019	50.4	142.1	109.8	148.8	74.2
Growth rate (%)					
1992-97	5.7	-1.1	1.3	1.3	2.5
1997-03	4.2	-2.1	1.7	0.3	1.4
2003-07	6.0	0.7	1.5	2.5	3.1
2007-12	3.7	-1.8	0.6	-0.8	-1.9
2012-19	3.5	-0.9	0.2	1.4	1.9

Source: Livestock Census, various years

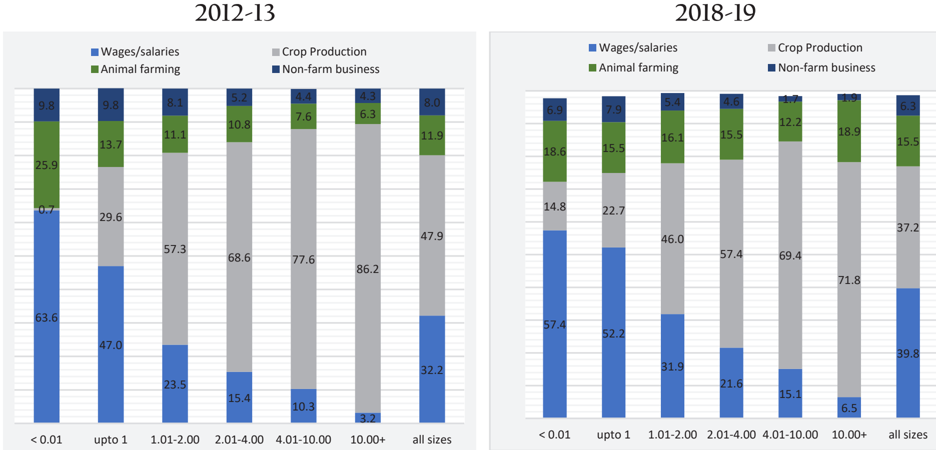
2.3 Contribution to livelihood

Livestock make significant and positive impact on farmers' welfare, in terms of income generation and poverty reduction (Birthal and Singh 1995; Adams and He 1995). The contribution of livestock to the total household income is almost equal for the small and large farmers but varying across ecologies. It is becoming increasingly important in fostering agricultural growth, reducing rural poverty, and augmenting farm households' capacity to withstand income shocks (Birthal 2008; Akter et al. 2008, Birthal and Negi 2012; Mellor 2004; Birthal and Taneja 2006). Undoubtedly, women play an important role in livestock management.

Livestock contribution to farmers' income has also been increasing. While the contribution of crop cultivation to agricultural household income has declined from 48% in 2012-13 to about 37% in 2018-19, livestock's contribution has increased from 12% in 2012-13 to 15% in 2018-19 (Figure 2). Decreasing land holdings, environmental degradation, and frequent extreme weather events have compelled farmers to diversify their income portfolio towards livestock, poultry, and non-farm activities. Additionally, livestock contribute to reducing inequality among rural households (Sendhilkumar et al. 2019).

Figure 2. Sources of income for rural households in India (% share in monthly farmers' income)

2012-13 | 2018-19



Source: NSSO, various rounds

2.4 Nutritional security

India has nearly 195 million undernourished people (Das and Krishna 2018). Livestock has emerged as a potential source of food and nutritional security. A shift in consumer preferences toward animal products, as a source of quality protein and micronutrients, causing an increase in demand for animal-source foods. Greater integration between livestock and nutrition is necessary to fight malnutrition (FAO 2020). In India, there is a gradual shift in dietary pattern towards the high-value animal-source foods, viz. milk, meat, and eggs, the best sources of high-quality protein and micronutrients (Table 3).

Table 3. Trends and patterns in consumption

Categories	Share in total consumption expenditure (%)									
	Rural					Urban				
	1993-94	1999-00	2004-05	2009-10	2011-12	1993-94	1999-00	2004-05	2009-10	2011-12
Quantity consumed (Per person per month)										
Cereals (Kg)	13.4	12.72	12.12	11.35	11.22	10.6	10.42	9.94	9.37	9.28
Pulses (Kg)	0.76	0.84	0.71	0.65	0.78	0.86	1.00	0.82	0.79	0.90
Milk (Litre)	3.94	3.79	3.87	4.12	4.33	4.89	5.10	5.11	5.36	5.42
Eggs (Number)	0.64	1.09	1.01	1.73	1.94	1.48	2.06	1.72	2.67	3.18
Fish (Kg)	0.18	0.21	0.20	0.27	0.27	0.20	0.22	0.21	0.24	0.25
Mutton (Kg)	0.06	0.07	0.05	0.05	0.05	0.11	0.10	0.07	0.09	0.08
Chicken (Kg)	0.02	0.04	0.05	0.12	0.18	0.03	0.60	0.85	0.18	0.24
Consumption expenditure (MPCE value shares, %)										
Cereals	24.2	22.2	18.0	15.6	12.0	14.0	12.4	10.1	9.1	7.3
Pulses & products	3.8	3.8	3.1	3.7	3.1	3.0	2.8	2.1	2.7	2.1
Milk & products	9.5	8.8	8.5	8.6	9.1	9.8	8.7	7.9	7.8	7.8
Edible oil	4.4	3.7	4.6	3.7	3.8	4.4	3.1	3.5	2.6	2.7
Eggs, fish & meat	3.3	3.3	3.3	3.5	3.6	3.4	3.1	2.7	2.7	2.8
Vegetables	6.0	6.2	6.1	6.2	4.8	5.5	5.1	4.5	4.3	3.4
Fruits & nuts	1.7	1.7	1.9	1.6	1.9	2.7	2.4	2.2	2.1	2.3
Sugar	3.1	2.4	2.4	2.4	1.8	2.4	1.6	1.5	1.5	1.2
Food (Total)	**63.2**	**59.4**	**55.0**	**53.6**	**48.6**	**54.7**	**48.1**	**42.5**	**40.7**	**38.5**
Non-food (Total)	**36.8**	**40.6**	**45.0**	**46.4**	**51.4**	**45.3**	**51.9**	**57.5**	**59.3**	**61.5**
Total expenditure	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: MOSPI, various reports
Note: MPCE stands for monthly per capita expenditure

The demand projections by Kumar (2016) for 2020 and 2030 demonstrate a shift in consumption pattern towards high-value food commodities. The demand for liquid milk for household consumption is projected to touch 90 million tonnes by 2032-33, with the aggregate milk demand reaching 220 million tonnes in 2032-33; concurrently the demand for eggs, meat, and fish would be 25 million tonnes (NITI Aayog 2018). Further, the demand for milk will increase much faster as compared to other food commodities with an increase in income. The increasing demand for high-value commodities like livestock products can be tapped better, by a shift in policy to focus on what would constitute the growth drivers in the coming years. This potential can be better harvested by reorienting the policy, to enhance investments in these allied sectors for improving productivity, quality, and efficiency.

2.5 Domestic supply chains and exports

At the backend, the source of milk supply chain largely remains with small rural producers. A study by the World Bank reveals that 60% of the total milk output is marketed, 36% through informal traditional chains and 24% through organized value chains (World Bank 2011). Thus, necessitates the requirement of systematic marketing and processing through its supply chain (right from the producers to final consumers) to realize the optimum value. The emerging value chains necessitate information on the safe handling, processing, and packaging of milk and milk products.

About one-fifth of the global trade of agricultural products comprises livestock produce. Indian milk producers are not able to adhere to food safety standards prescribed by different milk and dairy products importing countries (Rao et al. 2014). The assimilation of dairy farmers with the modern milk supply chain has been reported to have a positive influence on food safety compliance (Kumar et al. 2011), thus necessitating the dissemination of information on compliances and traceability standards. Further, the lack of information with regard to procedural norms and regulations of importing countries with regard to specifications as well as the process of sampling, inspection, and testing adds to the worries of livestock exporters (Kumar 2010).

2.6 Climate change

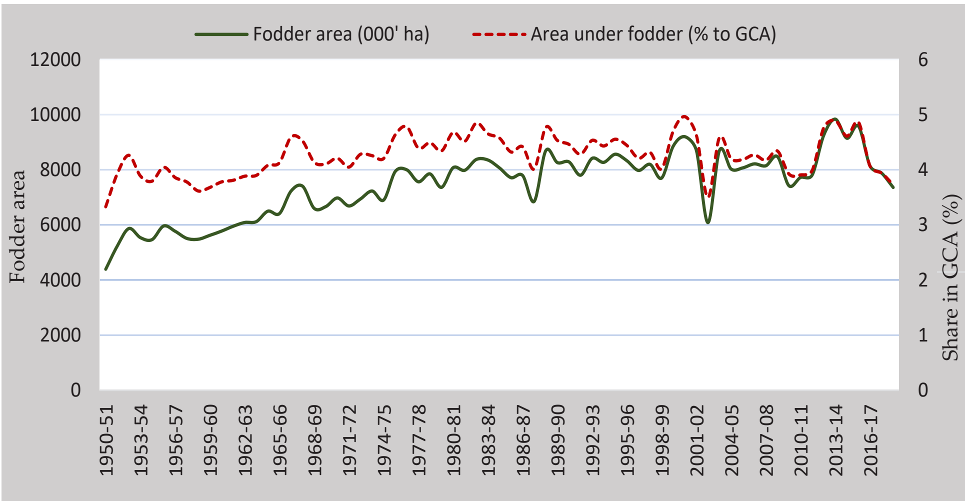
Dissemination of effective adaptation and mitigation strategies is essential to minimize the adverse impacts of climate change on livestock performance. Inter-Governmental Panel on Climate Change (IPCC) has predicted that the global average surface temperature to rise by 1.4 to 5.8°C in 2100 over 1990 (IPCC 2001). Climate change has a complicated impact on livestock performance. The weather and long-term climate firmly influence the growth, production (Choudhary and Sirohi 2019; Choudhary 2017; Kanwal 2018), reproduction (Nardone et al. 2010), health and well-being of the livestock via upsetting animal physiology; incidence of disease (Nardone et al. 2010; Thornton et al. 2009), and feed, fodder, water availability. Increasing climate variability is expected to aggravate such risks in addition to reducing capacity of livestock farmers to cope with these risks. Climate change is likely to induce disease outbreaks or may even encourage advent of new diseases, which may influence livestock that was earlier not exposed to these types of diseases (Thornton et al. 2009). Direct effects of climate change primarily through increased temperatures and frequent heat waves may result in temperature-related illness and changes in metabolic functions of livestock (Nardone et al. 2010).

2.7 Feed and fodder availability

In order to fulfil the feed requirement of the constantly growing livestock population, there is a need to increase fodder production. However, arable land is mostly used for food and cash crops, leaving meagre little land for fodder production. The share of fodder area in the gross cropped area has remained almost stagnant between 4 to 5% (Figure 3). Currently, the country faces a net deficit of 35.6% in green fodder, 10.95% in dry fodder, and 44% in concentrate feed. By 2050, the demand for green and dry fodder will reach 1012 and 631 million tonnes, respectively (IGFRI 2013). At the current rate of growth in forage resources, there will be an 18.4% deficit in green fodder and a 13.2% deficit in dry fodder in 2050. To meet this deficit, the supply of green forage must grow at an annual rate of 1.69% by using uncultivated land, and unexploited feed reserves, and increasing fodder productivity on a large scale.

Regional and seasonal deficiencies in fodder are more significant than at the national level. Future strategies should concentrate on developing dual-purpose grain and fodder crop varieties, and increasing forage productivity. Other potential strategies include processing and nutrient enrichment of low-quality roughages and designing cost-effective feeding systems.

Figure 3. Trends in fodder area in India



Source: DA&FW

2.8 Animal health services and infrastructure

Ensuring effective information on animal health and health services is crucial for reducing animal morbidity and mortality, thus, minimizing economic losses. The development of veterinary health care services in the country has not matched the growth in the livestock population in India. There are several diseases that affect livestock, which are still endemic in the country. Economic losses due to these diseases remain significant. For instance, it has been estimated that Brucellosis costs India at least Rs. 92.12 billion every year (Bardhan et al. 2020). The monetary loss due to Foot and Mouth Disease (FMD) in cattle and buffaloes in India is estimated at Rs. 209 billion a year (Govindaraj et al. 2020). The economic impact of peste-des-petits ruminants (PPR) disease in the small ruminant population was estimated between Rs. 45.71- 46.83 billion (Bardhan et al. 2017). On the contrary, the most likely range of expected losses due to hemorrhagic Septicaemia (HS) was reported between Rs 126.28–127.58 billion (Bardhan et al. 2020). These diseases affect the livestock farmers in the country and also affect the export potential of the livestock industry. Disease-infected milk and milk products, meat, and hides are not accepted by importing countries. Livestock insurance plays an important role in risk mitigation due to health hazards. The availability of formal insurance plans may induce poor and rural households to make productive investments (Farrin and Mirinda 2015). Further, the required infrastructure for livestock marketing and processing also needs to be strengthened. Most of the livestock markets are irregular, lack transparency in transactions and are marred with insufficient infrastructure and essential facilities (GOI 2017). Effective information dissemination is essential for improved animal health along with adequate marketing and processing infrastructure. Infrastructure for the livestock sector is the key to its accelerated growth. Efficacious livestock services with regard to animal health and production services are vital for livestock sector development, however, prompt delivery of these services has been a subject of continuous debate. Artificial insemination (AI) is not only an innovative technique to ensure impregnation in females, coincidentally it is also an influential technique for livestock quality improvement.

Table 4. Number of livestock institutions in India

Year	Veterinary hospitals/ Polyclinics	Veterinary dispensaries	Veterinary aid centres (stockmen centres/ mobile dispensaries)	Number of AI centres
2011	8732	18830	25195	74158
2021	11959	25850	27949	112361

Source: GOI 2021

The development of veterinary infrastructure is crucial for enhancing livestock health in India, and the government has implemented several measures to improve it. The number of veterinary hospitals/polyclinics and veterinary dispensaries has increased by approximately 37% between 2011 and 2021 (Table 4). However, the increase in the number of veterinary aid centers has only been 11% during the same period.

Artificial insemination is a significant strategy for improving the genetic potential of indigenous breeds, and currently, there are 112,361 artificial insemination (AI) centers (DAHD 2021-22). Artificial insemination has a significant drawback of a low conception rate (40% to 45%), especially in dairy animals, making it unappealing for producers. The main impediments to the implementation of cross-breeding technology are the shortage of quality semen and inadequate storage and delivery methods. To promote the use of advanced breeding techniques, it is critical to creating an effective information system.

These findings indicate the need for a greater flow of information to livestock farmers. An effective information system must capture wider livestock ecosystem and requires close attention to counter the existing and projected challenges. Preventive health care must reach the animals, and the infrastructure services to connect the output to consuming markets must be made readily available. Potential of science should be harnessed by adopting improved technologies. The newer information tools will also enhance animal productivity. Hence, there is a need to give thrust on efficient and effective extension services.

3 Access to Information

3.1 Data

This study uses data from a nationally representative survey of farm households conducted by the National Sample Survey Office (NSSO) of the Ministry of Statistics and Programme Implementation, Government of India, for the agricultural year 2018–19 (GoI 2021). This survey is a sequel to the surveys conducted in 2002–03 (GoI 2005) and 2012–13 (GoI 2014).

This survey aims to track the changes in the status of farming and farm households and the factors underlying these dynamics. The survey followed a multistage stratified random sampling procedure (see, GoI (2021) for sampling details) and collected data from 50,840 farm households spread over 5,885 villages across all the states of India. Compared to the previous farm surveys, this survey is extensive in its coverage of several characteristics of farming and farm households.

The survey provides data on the subsectors of agriculture (crops, livestock, and fisheries) and the subject and channel of information dissemination for each subsector. It contains data on the production and value of crops, livestock, and fisheries outputs and the farm and household variables (land and livestock holdings; irrigation coverage; income sources; access to credit; disposal of farm produce; and age, gender, education, social status (caste and religion) of household heads, and their affiliation with formal or informal farmer organizations). Nevertheless, a fundamental limitation is that it provides production cost data not for an individual commodity but at subsector level.

3.2 Characteristics of information users and non-users

The survey data show that over half of the farm households in India own one or the other species of livestock, and 63% of them are engaged in dairying (i.e., in-milk cows and buffaloes). In this study, our focus is on dairy farming. Dairy farmers face an acute information constraint—only one-fourth of them have access to information. Notably, most farmers accessing information also utilize it in their decision-making (92%). Hence, our analysis in this study is based on the use of information and not access to it.

Farmers' access to, and use of information is influenced by several factors, including demographic characteristics (age, education, and gender of the household head or decision-maker); availability of family labor for regular farm activities (family size); socio-economic status of the households (religion, caste, assets, and income); landholding size and irrigation; and access to credit, market and support services (Ali 2012; Alvarez and Nuthall 2006; Babu et al. 2011; Carter and Batte 1993; Okwu and Dauda 2011; Solano et al. 2003).

Table 5 compares the key characteristics of the non-users and users of information. Regarding demographic characteristics, the heads of information-using households are older and also have a higher level of schooling. The number of households reporting formal training in agriculture and allied activities and affiliation with the farmer organizations is extremely small, but their proportion is higher among the information users.

The information-using households have smaller families but a more diversified income portfolio (non-farm business activities, wages, salaries, and remittances). Interestingly, there is no gender bias in information access—the proportion of female-headed households is almost identical in both categories.

The social status of households can differentiate them in their access to and use of information—and its outcomes (Batte and Arnholt 2003; Ali 2012; Birthal et al. 2015). Caste is an important social identity in rural India. The households at the bottom of the caste hierarchy (Scheduled Castes and Scheduled Tribes) have lower access to information (Birthal et al. 2015). A look at the distribution of the non-users and users of information by caste shows a lower proportion of the lower-caste households among information-using households (Table A2 in the Appendix).

Regarding farm characteristics, both information non-users and users have an identical landholding size, but the users' access to irrigation is lower. On the other hand, the information users have a larger herd size (in-milk cows and buffaloes). Notably, the availability of information appears to facilitate households to spend more on feeds, animal health, and breeding.

The information users harvest almost 1.5 times more milk yield as the non-users (Table 5). The difference in the cumulative distribution functions

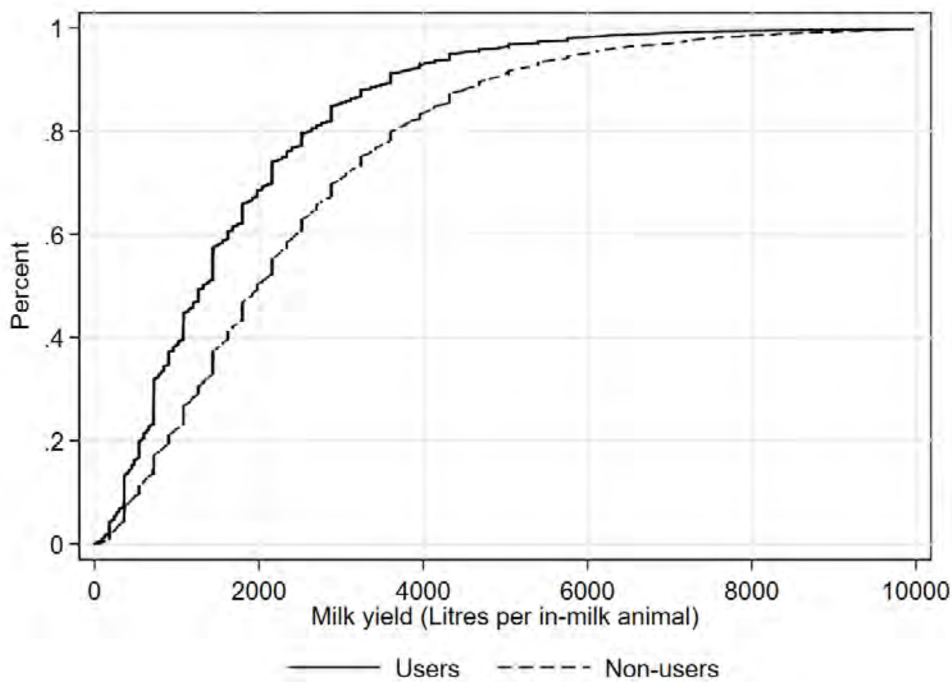
Table 5. Means and standard deviations of characteristics of users and non-users of information

	Non–users		Users		Difference in means and proportions (t–statistic)
Milk yield (litre/in–milk animal/annum)	1716.84	(1498.28)	2467.96	(1873.30)	−26.7***
Household characteristics					
Family size (No.)	5.51	(2.58)	5.07	(2.45)	9.8***
Age of the household heads (years)	51.94	(13.21)	52.56	(13.04)	−2.65**
Female–headed household (%)	7.07	(0.26)	6.82	(0.25)	0.6
Education level (% household heads)		–		–	
Illiterate	34.79	(0.48)	31.71	(0.47)	3.65***
Below primary	8.96	(0.29)	10.62	(0.31)	−3.2**
Primary	14.65	(0.35)	16.10	(0.37)	−2.3**
Middle	16.03	(0.37)	15.64	(0.36)	0.6
Secondary	12.88	(0.33)	14.76	(0.35)	−3.15**
Higher secondary	7.01	(0.26)	6.29	(0.24)	1.6*
Graduate and above	5.68	(0.23)	4.88	(0.22)	2**
Caste (% households)		–		–	
Scheduled caste	11.31	(0.32)	7.68	(0.27)	6.75***
Scheduled tribe	13.56	(0.34)	11.05	(0.31)	4.25***
Other backward caste	45.68	(0.50)	52.19	(0.50)	−7.4***
Upper or other caste	29.45	(0.46)	29.08	(0.45)	0.45
Net assets (Rs/person)	1699.05	(19173.66)	3468.42	(48848.71)	−1769.375***
Formal training in agriculture (% households)	1.81	(0.13)	3.23	(0.18)	−5.55***
Non–farm business income (% households)	7.84	(0.27)	8.97	(0.29)	−2.35**
Wages, salary, and remittance (% households)	46.89	(0.50)	53.07	(0.50)	−7***
Farm characteristics					
Landholding size (ha/household)	1.04	(1.41)	1.05	(1.76)	−0.5
Area irrigated (%)	63.14	(0.44)	52.87	(0.47)	12.9***
Herd size (No. of in–milk animals /household)	1.54	(1.15)	1.92	(2.50)	−13.9***
Proportion of buffaloes in the herd	22.04	(0.71)	25.63	(0.80)	−2.8**
Breeding charges (Rs/animal)	123.64	(1,088.06)	306.18	(3,475.02)	−5.35***
Feed cost (Rs/animal)	3507.37	(3,873.81)	5021.27	(5,584.56)	−19.8***
Veterinary charges (Rs/animal)	90.91	(465.97)	250.67	(659.06)	−17.5***
Membership of farmer organizations (% households)	0.34	(0.06)	2.42	(0.18)	−11.3***

Note: Standard deviations are in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

of milk yield for the information non-users and users is significant (Figure 4), and it is confirmed by the Kolmogorov-Smirnov test (K-S =0.21, p=0.0).

Figure 4. Cumulative distribution functions of milk yield



3.3 Heterogeneity in information and its sources

Farmers' information needs are diverse, ranging from information on breeds and breeding practices, feed and nutrition, diseases and their management, animal hygiene and shed management, food safety standards, markets, prices, and trade. Farmers acquire such information from several sources, including public and private, formal and informal, and traditional and modern. The public information system comprises government institutions, including veterinary hospitals, dispensaries, artificial insemination centers, research institutions, Krishi Vigyan Kendras (agriculture science centres), agricultural universities /colleges, dairy cooperatives, government extension agents, and farmer-producer organizations (FPO). Following Anderson and Feder (2007) and Aker (2011), the rest of the information channels are aggregated into private information channels, mass media, input dealers, and progressive farmers. Private information channels include private clinics, nongovernmental organizations (NGOs), and private commercial agents (i.e., contract farming sponsors and companies and commodity traders and processors).

Mass media comprises telephones, mobile phones, the internet, print media, radio, and other electronic media.

Since farmers need different sorts of information, they seek information from multiple sources, but these are not mutually exclusive. The information on a subject can be accessed from more than one source, or a single source can provide all sorts of information. About 73% of farm households seek only one type of information, and 60% of them acquire it from two or more sources. The rest seek more than one type of information, mostly from more than one source (Table A1 in the Appendix).

Two-way frequency distribution of dairy farm households by the subject and the source of information shows private service providers comprising the dominant source of information (Table 6, Figure 5). Overall, 39% of dairy farm households have relied on private sources for their information needs. Their access to other information sources, including the public extension system, is almost equal; around 15% of the dairy farm households relied on each of these.

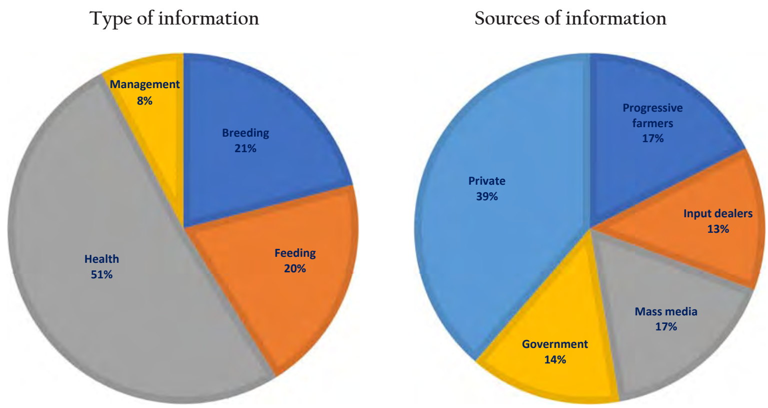
Table 6. Frequency distribution of information by its subject and source

	Breeding	Feeding	Health	Management	All
Progressive farmers	19.83 16.48 [440]	26.99 23.38 [599]	43.85 14.92 [973]	9.33 21.12 [207]	100 17.43 [2219]
Input dealers	21.15 13.37 [357]	20.97 13.82 [354]	45.56 11.79 [769]	12.32 21.22 [208]	100 13.26 [1688]
Mass media	22.60 17.90 [478]	18.87 15.57 [399]	50.73 16.45 [1073]	7.80 16.84 [165]	100 16.61 [2115]
Government	21.22 14.19 [379]	20.49 14.29 [366]	51.62 14.14 [922]	6.66 12.14 [119]	100 14.03 [1786]
Private	20.63 38.05 [1016]	17.14 32.94 [844]	56.53 42.69 [2784]	5.71 28.67 [281]	100 38.68 [4925]
All	20.97 100 [2670]	20.12 100 [2562]	51.21 100 [6521]	7.70 100 [980]	100 100 [12733]

Note: Figures in the upper row against an information source are the percent of households seeking different kinds of information from that source, and the lower row contains the percent of households seeking information from different sources. The square bracket contains the number of households seeking information from a particular source.

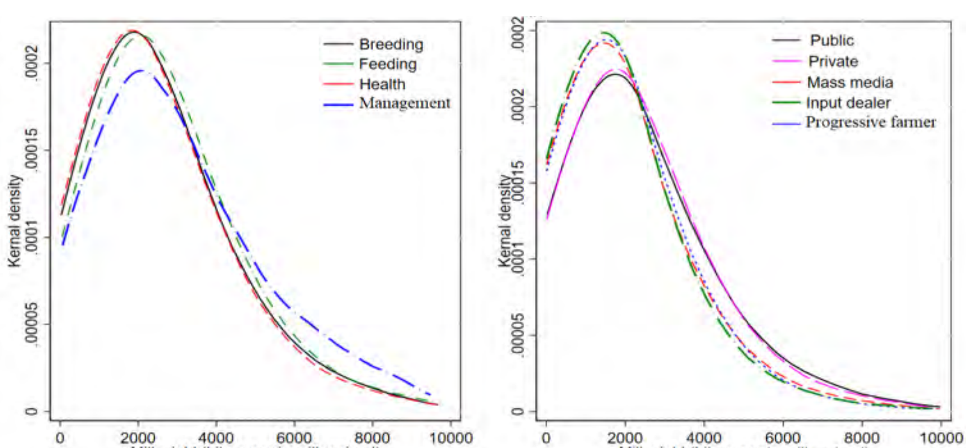
The information on animal health and disease management is the most sought-after, and over 50% of dairy farmers acquired it from private sources. Private sources are also important for disseminating information on animal breeding (38%) and feeds and nutrition (33%). The mass media and social networks (farmer-to-farmer exchange) are utilized by around 17% of the farmers. The outreach of the public extension system is limited to only 14% of the farmers, irrespective of the type of information they need.

Figure 5. Use of information by type and sources



The possibility that the content of the information and the source dispensing the information may affect productivity cannot be ruled out. Figure 6 presents the kernel density functions of milk yield by the type of information (panel A) and also by the source of information (panel B), and these are different (Figure 6). This provides preliminary evidence of their differentiated impact of different sorts of information and the sources dispensing these on dairy productivity.

Figure 6. Kernel density functions by the type and the source of information



4 Impact of Information

4.1 Method of estimation

To assess the impact of information on dairy productivity, we begin by estimating the following linear function:

$$Y_i = \alpha + \beta D_i + \gamma X_i + \eta_i \qquad (1)$$

where,

Y_i denotes dairy productivity for the i[th] farm household;

X_i is a vector of demographic, farm, and institutional characteristics;

D_i is a categorical variable, taking the value of 1 if the household uses information in decision-making, and 0 otherwise; and

η_i is an independent and normally distributed error term.

If X_i includes all the variables that influence the use of information, and is simultaneously uncorrelated with the error term (η_i), then an ordinary least squares (OLS) estimate of β in Equation 1 is consistent, that is, it provides the true effect of information on Y_i. However, it is possible that X_i does not include some of the variables such as farmers' inherent abilities, skills, risk preferences, and social ties that may influence the use of information. Such unobservable factors cannot be controlled for and may lead to an omitted variable bias.

To correct for such potential biases, we follow the instrumental variable (IV) approach. Accordingly, an ideal instrument must be correlated with the use of information (I_i has a direct effect on D_i) but not with the outcome (I_i does not have a direct effect on Y_i). Being correlated with the use of information, and uncorrelated with the outcome, the instrument effectively randomizes the sample households across treatments and achieves equal distribution of both the characteristics and the pre-treatment outcomes. Additionally, the IV approach addresses both the overt and unobserved biases in estimating the average treatment effect.

To construct an instrumental variable, we evoke the role of local social networks in information transmission (Evenson and Mwabu 2001; Bandierra and Rasul 2006; Conley and Udry 2010; Liu 2013). The rationale for using the social networks to construct instruments is that if a larger proportion of the farmers in the network are informed, then the likelihood of a particular farmer being informed would be greater (the first condition of IV is likely to be satisfied). In addition, the proportion of informed farmers in the network should not directly affect the productivity on a particular farm (the second condition of IV is satisfied).

The literature does not provide a definite definition of the "social network". Hence, in this study, we consider the social network composed of individuals whose mean outcome and characteristics influence an individual's outcome and characteristics (Bandiera and Rasul 2006; Conley and Udry 2010). In rural India, the reference group for a farm household need not be the most proximate geographically, but it is the similarity of caste, religion, or ethnicity that define the reference group (Fontaine and Yamada 2011). Hence, in this study we define a social network for each farm household based on geographical proximity (residing in the same village) and social identity (belonging to the same caste).

Table A2 shows farm households' access to different information sources by their caste group. With these conditions in mind, we define our instrument as the proportion of informed farmers in a given network and specify the following equation to determine whether or not a farmer uses information.

$$D_i = \delta + \theta I_i + u_i \qquad (2)$$

Combining Equations 1 and 2

$$Y_i = \vartheta + \tau I_i + \gamma X_i + \eta_i \qquad (3)$$

where,

$\vartheta = \alpha + \beta\delta$, and

$\tau = \beta\theta$.

Hence, the estimate $\hat{\beta}$ can be obtained as $\hat{\tau} / \theta$. The instrumental variable estimator is an unbiased and consistent estimator of β in large samples.

The farm survey randomly selects households in a village. The actual proportion of the households using information within a social group in a village may not equal the proportion estimated from the sample, i.e.,

$I_i = I_i^* + \omega_i$. This can lead to the attenuation bias in θ, due to which the analysis may provide the lower bound of θ. However, the estimated treatment effect is unbiased as long as ω_i is uncorrelated with D_i and η_i.

Equation 1 includes a dummy variable for information, that is, whether or not a farmer has used any type of information. However, the farmers' information needs are diverse, as are the sources dispensing these, and it is likely that different types of information and their different sources may impact dairy productivity differentially. To capture the heterogeneity in their impacts, Equation 1 is augmented by including the type of information (on breeding, feeding, health, and management) or the sources of information (public, private, mass media, progressive farmer, and input dealer), and their corresponding instrumental variables, as in Equation 3.

$$Y_i = \vartheta + \tau_B I_{Bi}^k + \tau_F I_{Fi}^k + \tau_H I_{Hi}^k + \tau_M I_{Mi}^k + \gamma X_i + \eta_i \quad (4)$$

Where, I_{Bi}^k, I_{Fi}^k, I_{Hi}^k and I_{Mi}^k represent the instruments for the information on animal breeding, feeding, health, and management.

Similarly, we incorporate instruments for the information sources in Equation 3:

$$Y_i = \vartheta + \tau_G I_{Gi}^s + \tau_{MM} I_{MMi}^s + \tau_{PF} I_{PFi}^s + \tau_I I_{Ii}^s + \tau_P I_{Pi}^s + \gamma X_i + \eta_i \quad (5)$$

where, I_{Gi}^s, I_{MMi}^s, I_{PFi}^s, I_{Ii}^s and I_{Pi}^s represent the instruments for the public, mass media, progressive farmer, input dealer, and private information sources.

To account for the heteroscedasticity and autocorrelation, we estimate linear regressions using robust (heteroskedastic-consistent) and cluster-robust variance estimates.

4.2 Impact of information on dairy productivity

4.2.1 Identification tests

Table 7 presents validity tests for the instrumental variables. First, we look at the results of the under-identification tests. The p-values are highly significant, rejecting the null hypothesis that the instruments are irrelevant and the model is under-identified. Further, we look at the Hansen J-statistic that tests the null hypothesis that the instruments are valid and uncorrelated with the error term. The higher p-values provide strong evidence that the instruments are valid.

Table 7. Instrumental variable tests

	Eq. 3 [1]	Eq. 4 [2]	Eq. 5 [3]
Under-identification test (F test of excluded instruments)	33911.48	71.20	3239.36
H0: instruments are jointly irrelevant in the first stage	0.0000	0.0000	0.0000
Under-identification test (Kleibergen-Paap rk LM Statistic)	5975.22	224.70	3303.96
H0: model is under-identified, instruments are not good	0.0000	0.0000	0.0000
Over-identification test (Hansen J statistic)	0.8789	0.8056	0.8465
H0: exclusion restrictions of instruments are valid	0.8752	0.6533	0.6256
Weak identification test (Cragg-Donald Wald F-statistic)	12000	4991.80	12000
Weak identification test (Kleibergen-Paap-rk Wald F-statistic)	34000	36.92	765.62
H0: weakly identified system (Stock-Yogo critical value 10 %)	16.38	10.27	10.83

Notes: Tests in Columns 1, 2, and 3 are based on the estimation of Equations 3, 4, and 5, respectively. The results of the full models for Equations 3, 4, and 5 are presented in Column 2 of Table 5, Column 3 of Table 5, and Column 3 of Table 6.

We also test for the failure of the relevance condition and weak instruments. Both the Cragg-Donald Wald F-statistic (preferred in the case of no heterogeneity) and Kleibergen-Paap rk Wald F-statistic (preferred in the case of heterogeneity) are more than the Stock-Yogo critical value, rejecting the null hypothesis that instruments are weak. These test statistics enable us to conclude that the application of the IV method is necessary in our case and that the proposed IVs are valid.

4.2.2 Impact of different types of information

The OLS estimates corresponding to Equation 1 are given in Table 8. Dairy productivity is positively and significantly influenced by the age and education of household heads. The effect, however, differs across social groups — it is lower for lower-caste households than for upper-caste households.

Productivity is negatively associated with land size, assets, and access to non-farm income sources. The effect of herd size, however, is insignificant. Further, as expected, productivity is positively and significantly associated with expenditure on animal breeding, feeding, and health. These findings

Table 8. Estimates of OLS regression

Dependent variable: Ln milk yield	Any information [1]		Different types of information [2]	
Household characteristics				
Family size	0.0536***	(0.0131)	0.0548***	(0.0131)
Age	0.0305	(0.0218)	0.0283	(0.0218)
Gender	0.0025	(0.0227)	0.0006	(0.0227)
Education level				
Below primary	0.0301	(0.0207)	0.028	(0.0207)
Primary	0.0334	(0.0177)	0.0333	(0.0176)
Middle	0.0266	(0.0178)	0.026	(0.0178)
Secondary	0.1123***	(0.0177)	0.1071***	(0.0176)
Higher secondary	0.0966***	(0.0223)	0.0976***	(0.0223)
Graduate and above	0.1525***	(0.0248)	0.1531***	(0.0247)
Caste				
Scheduled caste	-0.1833***	(0.0223)	-0.1867***	(0.0222)
Scheduled tribe	-0.0588**	(0.0194)	-0.0580**	(0.0194)
Other backward caste	0.0413**	(0.0131)	0.0410**	(0.0131)
Net assets	-0.0127***	(0.0018)	-0.0128***	(0.0018)
Formal training in agriculture	0.0285	(0.0421)	0.0223	(0.0420)
Non-farm business income	-0.0481*	(0.0207)	-0.0490*	(0.0207)
Wages, salary, and remittance	-0.0971***	(0.0122)	-0.0975***	(0.0122)
Farm characteristics				
Landholding size	-0.0276***	(0.0039)	-0.0255***	(0.0039)
Area irrigated	0.0940***	(0.0143)	0.0965***	(0.0143)
Herd size	0.0101	(0.0148)	-0.0006	(0.0148)
Proportion of buffaloes in the herd	0.0043	(0.0083)	0.0058	(0.0082)
Breeding charges	0.0404***	(0.0035)	0.0389***	(0.0035)
Feed cost	0.4668***	(0.0127)	0.4640***	(0.0127)
Veterinary charges	0.0248***	(0.0025)	0.0241***	(0.0024)
Member of farmer organizations	-0.0535	(0.0671)	-0.1055	(0.0654)
Information type				
Any information	0.1386***	(0.0144)		
Breeding			0.1028***	(0.0220)
Feeding			0.1704***	(0.0225)
Health			0.0820***	(0.0159)
Management			0.2618***	(0.0413)
Constant	3.1461***	(0.1397)	3.1804***	(0.1395)

Notes: District dummies are included in the regressions. Figures in parentheses are village-clustered standard errors. ***, **, and * denote significance at 1%, 5%, and 10% levels, respectively.

indicate that small farm households with fewer assets and limited access to non-farm income sources spend more on productivity-enhancing inputs to compensate for the scale effect on farm income.

The information has a significantly positive impact on dairy productivity. It raises milk yield by 14%. The impact, however, differs by the content or subject of the information—the information on dairy management raises productivity the most (26%), followed by the information on feed and nutrition (17%), animal breeding (10%), and health (8%).

The OLS estimates, however, could be biased. The bias-corrected estimates from IV regressions are presented in Table 9, and Figure 7 shows the impacts of different types of information on milk yield. These results confirm the role of information in enhancing dairy productivity. Controlling for the influence of several observable and unobservable factors, the impact of information is marginally higher, that is, 15%. This is true for all sorts of information, especially information on management and breeding. The estimated productivity effect of management information is now higher by 27% and of breeding information by 30%. These results imply that the correction for selection and omitted variable bias was important in our study.

A glance at Table A1 in the Appendix shows that most farm households (73%) use the information on a single subject and only 5% on more than one subject (three or more). This motivates us to probe whether a bundle of information is more effective at raising productivity than any information used in isolation. To know this, we estimate IV regressions for sub-samples of households using (1) only one type of information, (2) two types of information, and (3) three or more types of information. Notably, the impact of using three or more types of information, that is, a bundle of information, is more than four times larger than the isolated use of any information (Table A3).

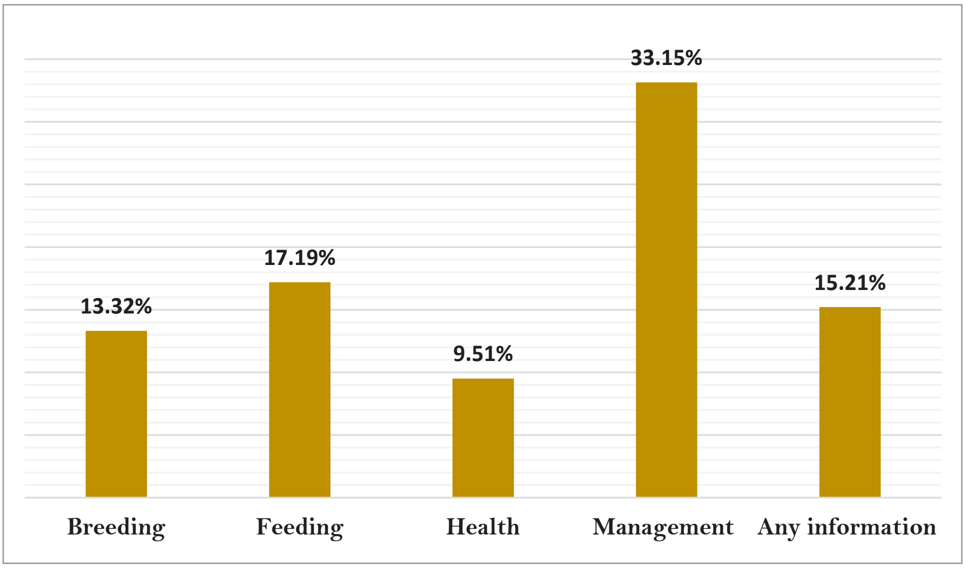
These findings indicate a pecking order in the effect of different types of information. It is linked to the complexity of the problem and the technical expertise required for its remedy. The more technical or complex the information, the less the impact on productivity. Disease diagnosis and management and animal breeding require significant knowledge and technical skills. On the other hand, the information on feed and feeding practices, financing, markets, and post-production management do not involve much technical expertise and skills.

Table 9. Estimates of IV regressions

Dependent variable: Ln milk yield	Any information [1]		Different types of information [2]	
Household characteristics				
Family size	0.0543***	(0.0131)	0.0559***	(0.0131)
Age	0.0297	(0.0218)	0.0266	(0.0217)
Gender	0.0028	(0.0227)	0.0005	(0.0226)
Education level				
Below primary	0.0297	(0.0206)	0.0266	(0.0206)
Primary	0.033	(0.0176)	0.0325	(0.0176)
Middle	0.0264	(0.0178)	0.0253	(0.0178)
Secondary	0.1119***	(0.0176)	0.1053***	(0.0176)
Higher secondary	0.0966***	(0.0223)	0.0973***	(0.0223)
Graduate and above	0.1525***	(0.0247)	0.1528***	(0.0246)
Caste				
Scheduled caste	−0.1833***	(0.0222)	−0.1868***	(0.0221)
Scheduled tribe	−0.0585**	(0.0194)	−0.0575**	(0.0193)
Other backward caste	0.0408**	(0.0131)	0.0402**	(0.0130)
Net assets	−0.0128***	(0.0018)	−0.0130***	(0.0018)
Formal training in agriculture	0.0277	(0.0420)	0.0201	(0.0419)
Non−farm business income	−0.0481*	(0.0206)	−0.0490*	(0.0207)
Wages, salary, and remittance	−0.0977***	(0.0122)	−0.0983***	(0.0121)
Farm characteristics				
Landholding size	−0.0271***	(0.0039)	−0.0245***	(0.0039)
Area irrigated	0.0948***	(0.0143)	0.0979***	(0.0142)
Herd size	0.0083	(0.0147)	−0.0049	(0.0149)
Proportion of buffaloes in herd	0.0046	(0.0082)	0.0066	(0.0082)
Breeding charges	0.0403***	(0.0035)	0.0383***	(0.0035)
Feed cost	0.4659***	(0.0127)	0.4621***	(0.0127)
Veterinary charges	0.0244***	(0.0024)	0.0234***	(0.0024)
Member of farmer organizations	−0.0574	(0.0669)	−0.1221	(0.0645)
Information type	–	–	–	–
Any information	0.1521***	(0.0150)		
Breeding			0.1332***	(0.0242)
Feeding			0.1719***	(0.0249)
Health			0.0951***	(0.0170)
Management			0.3315***	(0.0434)
Constant	3.1546***	(0.1394)	3.1978***	(0.1391)

District dummies are included in the regressions. Figures in parentheses are village-clustered standard errors. ***, **, and * denote significance at 1%, 5%, and 10% levels, respectively.

Figure 7. Impact of information on milk yield (%)



4.2.3 Impact of sources of information

The literature indicates differential impacts of different information sources on farm outcomes (Birol et al. 2015; Glaeser et al. 2002; Putnam 2001; Feder and Slade, 1986; Foster and Rosenzweig, 1995; Singh et al. 2003; Bhagat et al. 2004). Nonetheless, most studies have analyzed the impact of a single information node at a time, while farmers depend on multiple sources for their information needs.

Table 10 provides the IV estimates of the impact of information sources on dairy productivity. These indicate significantly different impacts of different information sources. The information sourced from the public extension system institutions has the maximum positive impact (13.6%), almost twice that of private sources (Figure 8). Mass media and social networks do not affect productivity much. The impact of information sourced from the input dealers is negative and significant.

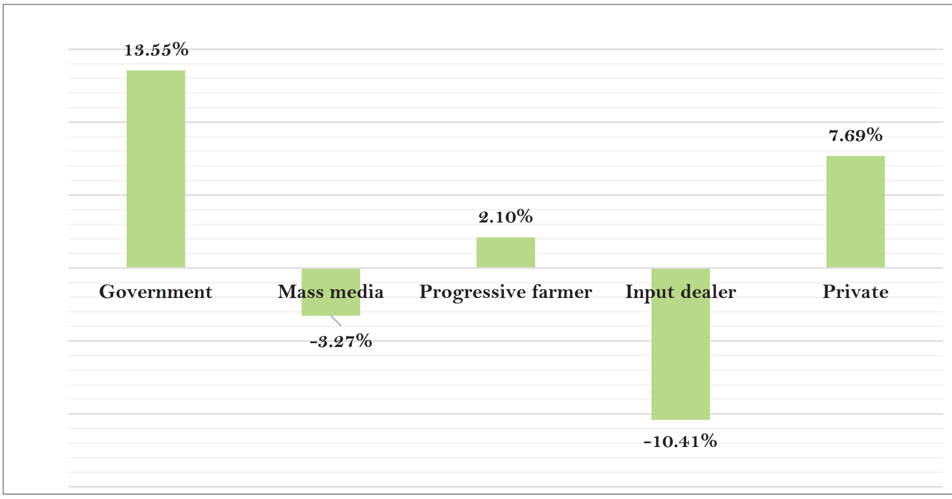
The heterogeneity in the impact of information sources could be attributed to the differences in the quality of information and the human resources and methods deployed to deliver the information. The public extension system is more effective in improving productivity, as it engages highly trained human resources capable of diagnosing the remedies and providing their effective solutions. An overwhelming majority of veterinarians (over 95%) in India are employed in the public sector.

Table 10. OLS and IV regressions for source effect

Dependent variable: Ln Milk yield	OLS regression [1]		IV regression [2]	
Household characteristics				
Family size	0.0528***	(0.0131)	0.0538***	(0.0131)
Age	0.0285	(0.0218)	0.0276	(0.0217)
Gender	−0.0035	(0.0227)	−0.0026	(0.0227)
Education level				
Below primary	0.0347	(0.0207)	0.0342	(0.0206)
Primary	0.0344	(0.0176)	0.0343	(0.0176)
Middle	0.0264	(0.0179)	0.0264	(0.0178)
Secondary	0.1098***	(0.0177)	0.1098***	(0.0176)
Higher secondary	0.0945***	(0.0223)	0.0954***	(0.0223)
Graduate and above	0.1492***	(0.0247)	0.1498***	(0.0247)
Caste				
Scheduled caste	−0.1902***	(0.0223)	−0.1894***	(0.0223)
Scheduled tribe	−0.0620**	(0.0195)	−0.0618**	(0.0194)
Other backward caste	0.0416**	(0.0131)	0.0410**	(0.0130)
Net assets	−0.0113***	(0.0018)	−0.0115***	(0.0018)
Formal training in agriculture	0.0128	(0.0426)	0.0101	(0.0425)
Non−farm business income	−0.0479*	(0.0207)	−0.0487*	(0.0206)
Wages, salary, and remittance	−0.0943***	(0.0122)	−0.0950***	(0.0122)
Farm characteristics				
Landholding size	−0.0290***	(0.0039)	−0.0294***	(0.0039)
Area irrigated	0.1016***	(0.0144)	0.1001***	(0.0144)
Herd size	0.0123	(0.0147)	0.0109	(0.0147)
Proportion of buffaloes in herd	0.0048	(0.0081)	0.005	(0.0081)
Breeding charges	0.0404***	(0.0035)	0.0403***	(0.0035)
Feed cost	0.4710***	(0.0128)	0.4696***	(0.0128)
Veterinary charges	0.0268***	(0.0024)	0.0264***	(0.0024)
Member of farmer organizations	−0.037	(0.0678)	−0.0426	(0.0678)
Information source				
Government	0.1207***	(0.0171)	0.1355***	(0.0175)
Mass media	−0.0173	(0.0158)	−0.0327	(0.0173)
Progressive farmer	0.0091	(0.0129)	0.021	(0.0139)
Input dealer	−0.1128***	(0.0137)	−0.1041***	(0.0148)
Private	0.0654***	(0.0146)	0.0769***	(0.0155)
Constant	3.1390***	(0.1398)	3.1447***	(0.1394)

District dummies are included in the regressions. Figures in parentheses are village-clustered standard errors. ***, **, and * denote significance at 1%, 5%, and 10% levels, respectively.

Figure 8. Impact of sources of information on milk yield (%)



Studies have shown a positive and significant impact of information from social networks and mass media on the returns from crop farming (Feder and Slade 1986; Foster and Rosenzweig 1995; Birol et al. 2015). Our findings, however, show no significant effect of these sources on dairy productivity. This can be expected. Animals have a complex biological system, a sound understanding of which is a prerequisite for diagnosing an ailment or disorder. Only a qualified veterinarian can, upon physical examination of the animal, diagnose the ailment and suggest remedial measures. Further, social networks and mass media often acquire information from the public extension system; hence, the probability of loss of information and miscommunication in the dissemination process is relatively high.

5 Conclusion and Implications

Utilizing data from a nationally representative farm survey and applying the instrumental variable method, this study has assessed the impact of information on the productivity of dairy farming in India. Important conclusions are:

Using the information in farming decisions can enhance dairy productivity by 15%. Farmers' information needs are diverse; the impact on dairy productivity, therefore, differs by the information type—information on livestock management has a more significant effect than information on feeding, breeding, and health. The payoff of using different information types is larger than using any one type of information in isolation. The impact of information is also differentiated by the source dispensing it—information from public sources has a significantly larger impact than from private sources, social networks, mass media, and input dealers.

In the past few decades, there has been increasing recognition of livestock's contribution toward sustaining agricultural growth, reducing income inequality, poverty, and malnutrition, and empowering rural women. However, when public resources are allocated, the livestock subsector is under-appreciated and inappropriately funded. The livestock subsector shares approximately 10% of the total public spending on agriculture and allied activities (Birthal and Mishra 2021). The delivery of livestock services, including extension services, is grossly lacking, despite the country having an extensive veterinary infrastructure (i.e., hospitals, polyclinics, and dispensaries) engaging over 80,000 trained veterinarians. The findings of this study reveal that the government extension or service delivery system reaches only 14% of livestock farmers. A few important implications emerge from this study.

First, given the maximum impact of the public extension system on dairy productivity, the need for extending its outreach cannot be undermined. India has a large number of veterinarians and para-veterinarians primarily employed in the public sector, yet the delivery of livestock services has remained poor. The question is: Should the governments utilize the existing human resources and infrastructure or evolve new institutional arrangements to strengthen the livestock information and service delivery system?

Second, India has a strong network of dairy cooperatives and an equally strong presence of the private dairy processors in some states. How can the policy facilitate leveraging the potential of such value chains for delivering livestock information and services?

Third, depending on the ease of their adoption, some of the livestock services, particularly those not complex and difficult to understand by the farming communities, can be considered for privatization. However, the relatively small impact of the private information sources points towards building/enhancing their capacities.

Finally, since farmers' information needs are diverse, and given the more significant impact of the joint use of information, the need for providing bundled information cannot be undermined. It also means adopting a single-window approach for the effective delivery of livestock services.

References

Adams, R. H. J and J. J. He. 1995. *Sources of income inequality and poverty in rural Pakistan*. Research Report 102. International Food Policy Research Institute, Washington, D.C. https://pdf.usaid.gov/pdf_docs/PNABW967.pdf

Aker, J. C. 2011. Dial "A" for agriculture: a review of information and communication technologies for agricultural extension in developing countries. *Agricultural Economics* 42(6): 631–47. https://doi.org/10.1111/j.1574-0862.2011.00545.x

Akter, S, J. Farrington, P. Deshingkar, L. Rao, P. Sharma, H. A. Freeman, and J. Reddy. 2008. *Livestock drought and unreliability in India: targeting and innovation*. ILRI Discussion Paper 9. International Livestock Reseach Institute, Nairobi, Kenya. https://hdl.handle.net/10568/278

Ali, J. 2012. Factors affecting the adoption of information and communication technologies (ICTs) for farming decisions. *Journal of Agricultural & Food Information* 13(1): 78–96. https://dx.doi.org/10.1080/10496505.2012.636980

Alvarez, J and P. Nuthall. 2006. Adoption of computer based information systems: the case of dairy farmers in Canterbury, NZ, and Florida, Uruguay. *Computers and Electronics in Agriculture* 50(1): 48–60. https://dx.doi.org/10.1016/j.compag.2005.08.013

Anderson, J. R and G. Feder. 2007. Agricultural extension. In *Handbook of Agricultural Economics*, vol 3.ed. Evenson R. and P. Pingali, 2343–78. Elsevier. https://www.sciencedirect.com/handbook/handbook-of-agricultural economics/vol/3/ suppl/ C

Babu, S. C, C. J. Glendenning, K. Asenso-Okyere, and S. K. Govindarajan. 2011. *Farmers' information needs and search behaviours: case study in Tamil Nadu, India*. IFPRI Discussion Paper 1165, International Food Policy Research Institute, Washington, DC. https://ebrary.ifpri.org/digital/collection/p15738coll2/id/126836

Bandiera, O and I. Rasul. 2006. Social networks and technology adoption in northern Mozambique. *Economic Journal* 116(514): 869–902. https://dx.doi.org/10.1111/j.1468-0297.2006.01115.x

Bardhan, D, S. Kumar, G. Anandasekaran, M. Meraj, M. Chilambarasan, R.K. Singh, G. Singh, R. Pal, Y.P. Singh, M.R. Verma, and D. Kumar. 2020. Economic losses due to haemorrhagic septicaemia in India. *The Indian Journal of Animal Sciences* 90(3): 341–46. https://doi.org/10.56093/ijans.v90i3.102320

Bardhan, D, S. Kumar, G. Anandsekaran, J. K. Chaudhury, M. Meraj, R. K. Singh, M. R. Verma, D. Kumar, P. T. N. Ahmed, S. Lone , V. Mishra, B. S. Mohanty, N. Korade, and U.K. De. 2017. The economic impact of peste des petits ruminants in India. In *The economics of animal health* (J. Rushton, ed.). Revue scientifique et technique (International Office of Epizootics) 36 (1): 245-63. https://doi.org/10.20506/rst.36.1.2626

Batte, M. T and M. W. Arnholt. 2003. Precision farming adoption and use in Ohio: case studies of six leading-edge adopters. *Computers and Electronics in Agriculture* 38(2): 125–39. https://dx.doi.org/10.1016/S0168-1699(02)00143-6

Bhagat, G. R, M. S. Nain, and R. Narda. 2004. Information sources for agricultural technology. *Indian Journal of Extension Education* 40(1–2): 109–10.

Bijla, S. 2018. Dynamic poverty processes in rural India and the role of livestock. *Agricultural Economics Research Review* 31(conf): 9–16. https://dx.doi.org/10.5958/0974-0279.2018.00017.4

Birol, E, A. Munasib, and D. Roy. 2015. Networks and low adoption of modern technology: the case of pearl millet in Rajasthan, India. *Indian Growth and Development Review* 8(2): 142–62. https://dx.doi.org/10.1108/IGDR-07-2014-0025

Birthal, P. S and D. S. Negi. 2012. Livestock for higher, sustainable and inclusive agricultural growth. *Economic and Political Weekly* 47: 89–99.

Birthal, P. S and J. P. Mishra. 2021. *India: Status report*. Presented at the Regional Expert Consultation Meeting on Harmonizing the Guidelines and Policies for Enhancing Regional Trade of Livestock and its Products, July 27-28, SAARC Agriculture Center, Kathmandu, Nepal.

Birthal, P. S and V. K. Taneja. 2012. Operationalizing the pro-poor potential of livestock: Issues and strategies. *Indian Journal of Animal Sciences* 82(5): 441–47. https://epubs.icar.org.in/index.php/IJAnS/article/view/17669

Birthal, P. S, D. S. Negi, A. K. Jha, and D. Singh. 2014. Income sources of farm households in India: determinants, distributional consequences and policy implications. *Agricultural Economics Research Review* 27(1): 37–48. https://dx.doi.org/10.5958/j.0974-0279.27.1.003

Birthal, P. S, S. Kumar, D. S. Negi, and D. Roy. 2015. The impacts of information on returns from farming: evidence from a nationally representative farm survey in India. *Agricultural Economics* 46(4): 549–61. https://doi.org/10.1111/agec.12181

Birthal, P. S. 2008. *Making contract farming work in smallholder agriculture*. ICAR-National Institute of Agricultural Economics and Policy Research, New Delhi. https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=6e60f935224c704df289388853174f7b01efb8fa

Birthal, P.S and D. S. Negi. 2012. Livestock for higher, sustainable and inclusive agricultural growth. *Economic and Political Weekly* 47(26/27): 89-99. https://www.jstor.org/stable/23251727

Birthal, P.S and M. K. Singh. 1995. Structure of rural income inequality: a study in western Uttar Pradesh. *Indian Journal of Agricultural Economics* 2(30): 168-75. https://doi.org/10.22004/ag.econ.275016

Birthal, P.S and V.K. Taneja. 2006. *Livestock sector in India: opportunities and challenges*, presented at the ICAR-ILRI workshop on 'Smallholder livestock production in India' held during January 24-25, 2006 at ICAR-NIAP, New Delhi.

Carter, B. R and M. T. Batte. 1993. Identifying needs and audiences in farm management outreach education. *Review of Agricultural Economics* 15 (3): 403–15. https://dx.doi.org/10.2307/1349477

Choudhary, B. B and S. Sirohi. 2019. How sensitive are buffaloes (Bubalus bubalis) to heat stress? *Journal of Dairy Research* 86(4): 399-40. https://doi.org/10.1017/S0022029919000773

Choudhary, B. B. 2017. *Climate sensitivity of agricultural production system in trans- and upper-gangetic plains of India: potential economic impact and vulnerability*. Ph.D. thesis, National Dairy Research Institute, Karnal, India.

Conley, T. G and C. R. Udry. 2010. Learning about a new technology: pineapple in Ghana. *American Economic Review* 100(1): 35–69. https://dx.doi.org/10.1257/aer.100.1.35

DAHD. *Annual Report 2021-22*. Department of Animal Husbandry and Dairying, Ministry of Fisheries, Animal Husbandry and Dairying, Government of India, New Delhi. https://dahd.nic.in/document/annual_report/

Das, S. R and C. Krishna. 2018. Household food insecurity and malnutrition in an urban field practice area of a medical college. *National Journal of Community Medicine* 9(12): 869-74.

Delgado, C, M. Rosegrant, H. Steinfeld, S. Ehui, and C. Courbois. 1999. *Livestock to 2020: the next food revolution*. IFPRI Food, Agriculture, and the Environment Discussion Paper 28, International Food Policy Research Institute, Washington, D.C. https://hdl.handle.net/10568/333/

Evenson, R. E and G. Mwabu. 2002. The effect of agricultural extension on farm yields in Kenya. *African Development Review* 13(1): 1–23. https://dx.doi.org/10.1111/1467-8268.00028

FAO. 2018. *World livestock: transforming the livestock sector through the sustainable development goals*. FAO, Rome.

FAO. 2020. *Livestock solutions for climate change*. FAO, Rome. https://www.fao.org/3/i8098e/i8098e.pdf

Farrin, K. and M. J. Miranda. 2015. A Heterogeneous agent model of credit-linked index insurance and farm technology adoption. *Journal of Development Economics* 116: 199-211. https://doi.org/10.1016/j.jdeveco.2015.05.001

Feder, G and R. Slade. 1986. A comparative analysis of some aspects of the training and visit system of agricultural extension in India. *The Journal of Development Studies* 22(2): 407–28. https://dx.doi.org/10.1080/00220388608421987

Fontaine, X and K. Yamada. 2011. *Envy and hope: relevant others' consumption and subjective well-being in urban India*, GCOE Discussion Paper 212, Osaka University, Suita, Japan.

Foster, A and M. Rosenzweig. 1995. Learning by doing and learning from others: human capital and technical change in agriculture. *Journal of Political Economy* 103(6): 1176–209. https://dx.doi.org/10.1086/601447

Glaeser, E. L, D. Laibson, and B. Sacerdote. 2002. An economic approach to social capital. *Economic Journal (London)* 483:437–58. https://doi.org/10.1111/1468-0297.00078

GoI. 2005. *Household assets holding, indebtedness, current borrowings and repayments of social groups in India 2002-03*, NSS Report No. 503, National Sample Survey Office, Government of India, New Delhi.

GoI. 2014. *Income, expenditure, productive assets and indebtedness of agricultural households in India 2013*, NSS Report No. 576, National Sample Survey Office, Government of India, New Delhi.

GoI. 2017a. *Report of the committee on doubling farmers' income, Volume IV.* Department of Agriculture, Cooperation and Farmers' Welfare, Ministry of Agriculture & Farmers' Welfare. Government of India, New Delhi.

GOI. 2017b. *Report of the committee on doubling farmers' income, Volume VI*. Department of Agriculture, Cooperation and Farmers' Welfare, Ministry of Agriculture & Farmers' Welfare. Government of India, New Delhi. http://farmer.gov.in/imagedefault/DFI/DFI%20Volume%2011.pdf

GOI. 2019. *2Oth Livestock Census*. Department of Animal Husbandry and Dairying, Ministry of Fisheries, Animal Husbandry and Dairying, Government of India, New Delhi.

GoI. 2021a. *Basic animal husbandry & fisheries statistics*. Department of Animal Husbandry and Dairying, Ministry of Fisheries, Animal Husbandry and Dairying, Government of India, New Delhi.

GoI. 2021b. *Situation assessment of agricultural households and land and livestock holdings of households in rural India 2019*, NSS Report No. 587, National Sample Survey Office, Government of India, New Delhi.

GoI. 2022. *Annual Report 2021-22*. Department of Animal Husbandry and Dairying, Ministry of Fisheries, Animal Husbandry and Dairying, Government of India, New Delhi.

Govindaraj, G, K.B. Ganesh, A. Krishnamohan, R. Hegde, S. Nandakumar, K. Prabhakaran, M. Vinay, N. Kakker, T. Lokhande, K. Sharma, A. Kanani, A. Limaye, K. Natchimuthu, T.A. Khan, J. Misri, B.B. Dash, B. Pattnaik, and H. Rahman. 2020. Economic impact of FMD in cattle and buffaloes in India. *The Indian Journal of Animal Sciences* 90(7): 971-76. https://doi.org/10.56093/ijans.v90i7.106662

Hamshere, P, Y. Sheng, B. Moir, C. Gunning-Trant, and D. Mobsby. 2014. *What India wants: analysis of India's food demand to 2050*? ABARES Research Report No. 14.16, Canberra. https://doi.org/10.13140/RG.2.2.18626.94406

Heffernan, C. 2004. Livestock and the poor: issues in poverty-focused livestock development. *BSAP Occasional Publication* 33: 229–45. https://dx.doi.org/10.1017/S1463981500041777

IGFRI, 2011. *Vision 2030*. Indian Grassland and Fodder Research Institute, Jhansi, U.P., India.

IGFRI. 2013. *Annual Report 2013-14*. ICAR-Indian Grassland and Fodder Research Institute, Jhansi, U.P., India. https://www.igfri.res.in/pdf/AR-13-14/AR-13-14.pdf

ILRI. 2019. *The women's empowerment in livestock index: Vital progress towards gender equality*. ILRI Solution Brief 3. ILRI. Nairobi, Kenya.

IPCC. 2001. *Climate change 2001: the scientific basis*. Contribution of working group I to the third assessment report of the intergovernmental panel on climate change [Houghton, J.T, Y. Ding, D. G. Griggs, M. Noguer, P. J. van der Linden, X. Dai, K. Maskell, and C.A. Johnson (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Kanwal, V. 2018. *Analysis of risk and vulnerability of rural farm households to natural disasters in Rajasthan.* Ph.D. Thesis, National Dairy Research Institute, Karnal.

Kumar, A. 2010. Exports of livestock products from India: performance, competitiveness and determinants. *Agricultural Economics Research Review* 23(1): 57–67. https://doi.org/10.22004/ag.econ.92095

Kumar, P, A. Kumar, S. Parappurathu and S.S. Raju. 2011. Estimation of demand elasticity for food commodities in India. *Agricultural Economics Research Review* 24(1): 1-14. https://doi.org/10.22004/ag.econ.109408

Kumar, P, P. K. Joshi, and S. Mittal. 2016. *Demand vs supply of food in India-futuristic projection*. Proceedings of the Indian National Science Academy 82: 1579-86. http://dx.doi.org/10.16943/ptinsa/2016/48889

Liu, E. M. 2013. Time to change what to sow: risk preferences and technology adoption decisions of cotton farmers. *Review of Economics and Statistics* 95(4): 1386–403. https://dx.doi.org/10.1162/REST_a_00295

Mellor, J. W. 2004. Agricultural growth and poverty reduction: the rapidly increasing role of smallholder livestock, In *Livestock and livelihoods: challenges and opportunities for Asia in the emerging market environment*, National Dairy Development Board of India and FAO of the United Nations. 372. https://ci.nii.ac.jp/naid/10027886356/#cit

Morton, J and R. Matthewman. 1996. Improving livestock production through extension: information needs, institutions and opportunities. *Natural Resource Perspectives* 12: 112-16.

Mwabu, G. 2001. Health status in Africa: a regional profile. *South African Journal of Economics* 69(2): 319–35. https://dx.doi.org/10.1111/j.1813-6982.2001.tb00015.x

Nardone, A, B. Ronchi, N. Lacetera, M.S. Ranieri, and U. Bernabucci. 2010. Effects of climate changes on animal production and sustainability of livestock system. *Livestock Science* 130(1): 57-69. https://doi.org/10.1016/j.livsci.2010.02.011

NDDB. 2021. *Annual Report 2020-21*. National Dairy Development Board, Anand, India.

NITI. 2018. *Demand & supply projections towards 2033: crops, livestock, fisheries and agricultural inputs*. The Working Group Report. NITI Aayog, New Delhi.

Nyamushamba, G. B, C. Mapiye, O. Tada, T. E. Halimani, and V. Muchenje. 2017. Conservation of indigenous cattle genetic resources in Southern Africa's smallholder areas: turning threats into opportunities-a review. *Asian-Australasian Journal of Animal Sciences* 30(5): 603-21. https://doi.org/10.5713/ajas.16.0024

Okwu, O. J and S. Dauda. 2011. Extension communication channels' usage and preference by farmers in Benue State. *Nigerian Journal of Agricultural Extension and Rural Development* 3(5): 88–94.

Putnam, R. D. 2001. *Bowling alone: the collapse and revival of American community*. Simon and Schuster. New York.

Rao, C.K, F. Bachhman, V. Sharma, P. Venkataramaiah, J. Panda, and R. Rathinam. 2014. *Smallholder dairy value chain development in India and* *selected states (Assam and Bihar): situation analysis and trends*. ILRI Project Report. ILRI. Nairobi, Kenya. https://hdl.handle.net/10568/35469

Saxena, R, N. P. Singh, B. B. Choudhary, S. J. Balaji, R. K. Paul, U. Ahuja, D. Joshi, R. Kumar and M. A. Khan. 2017. Can livestock sector be the game changer in enhancing the farmers' income? reinvesting thrust with special focus on dairy sector. *Agricultural Economics Research Review* 30: 59-76. https://doi.org/10.5958/0974-0279.2017.00022.2

Sendhilkumar, G, K. N. Selvakumar, M. Prabu, A. S. S. Pandian, C. Valli, and P. Thilakar. 2019. Livestock as a source of income equity- an evidence from rural Tamil Nadu. *International Journal of Livestock Research* 9(1): 111-18. https://doi.org/10.5455/ijlr.20180510090015

Singh, B, R. S. Narwal, and J. S. Malik. 2003. Communication sources used by extension personnel and farmers. *Indian Journal of Extension Education* 39 (1–2): 26–30.

Solano, C, H. Leon, E. Perez, and M. Herrero. 2003. The role of personal information sources on the decision-making process of Costa Rican dairy farmers. *Agricultural Systems* 76(1): 3–18. https://dx.doi.org/10.1016/S0308-521X(02)00074-4.

Srivastava, A. K, J. B. Patel, K. J. Ankuya, H. D. Chauhan, M. M. Pawar, and J. P. Gupta. 2019. Conservation of indigenous cattle breeds. *Journal of Animal Research* 9(1): 1-2. https://doi.org/10.30954/2277-940X.01.2019.1

Thornton, P. K, V. D. Steeg, A. Notenbaert, and M. Herrero. 2009. The impacts of climate change on livestock and livestock systems in developing countries: a review of what we know and what we need to know. *Agricultural systems* 101(3): 113-27. https://doi.org/10.1016/j.agsy.2009.05.002

Upton, M. 2004. *The role of livestock in economic development and poverty reduction*, PPLPI Working Paper No. 10, Prop Poor Livestock Policy Initiative, FAO, Rome. https://www.fao.org/3/bp224e/bp224e.pdf

World Bank. 2011. *Demand-led transformation of the livestock sector in India: achievements, challenges, and opportunities.* The World Bank, Washington, DC.

Appendix

Table A1. Frequency distribution of households by number of information and information sources used

No. of Information	No. of information sources					Total
	One source	Two sources	Three sources	Four sources	Five sources	
One type	1225	957	665	168	24	3039
Two types	118	382	274	121	33	928
Three types	4	54	79	37	26	200
Four types	0	0	6	3	5	14
All	1347	1393	1024	329	88	4181

Notes: Different kinds of information include information on breeding, feeding, health and management The different sources of information include government, private, progressive farmer, mass media and input dealer.

Table A2. Sources of information by caste of information users

	Scheduled caste	Scheduled Tribe	Other backward caste	Upper or other caste	Total
Progressive farmer	9.28 14.60 [211]	9.54 10.69 [217]	48.33 11.73 [1099]	32.85 12.25 [747]	100 12.01 [2274]
Input dealer	8.22 14.95 [216]	9.13 11.82 [240]	46.94 13.17 [1234]	35.72 15.40 [939]	100 13.88 [2629]
Mass media	7.30 26.57 [384]	10.99 28.47 [578]	50.43 28.32 [2653]	31.29 26.99 [1646]	100 27.77 [5261]
Government	7.30 22.77 [329]	11.10 24.63 [500]	48.56 23.34 [2187]	33.04 24.40 [1488]	100 23.78 [4504]
Private	7.14 21.11 [305]	11.58 24.38 [495]	51.38 23.44 [2196]	29.90 20.96 [1278]	100 22.56 [4274]
All	7.63 100 [1445]	10.72 100 [2030]	49.46 100 [9369]	32.19 100 [6098]	100 100 [18942]

Notes: Upper rows contain row percentage; lower rows contain column percentage, and frequencies are shown in square brackets.

Table A3. IV regressions for number of information used

Dependent variable: Ln milk yield	One type of information [1]		Two types of information [2]		Three or more types of information [3]	
Household characteristics						
Family size	0.0586***	(0.0136)	0.0624***	−0.0145	0.0552***	(0.0149)
Age	0.026	(0.0225)	0.0223	−0.0241	0.0296	(0.0250)
Gender	0.0005	(0.0239)	0.005	−0.0245	0.0036	(0.0260)
Education level						
Below primary	0.0279	(0.0216)	0.0111	−0.0228	−0.0013	(0.0240)
Primary	0.0255	(0.0183)	0.0214	−0.0197	0.0251	(0.0206)
Middle	0.0247	(0.0184)	0.0126	−0.0197	0.0158	(0.0205)
Secondary	0.1028***	(0.0184)	0.0926***	−0.0196	0.0886***	(0.0205)
Higher Secondary	0.0987***	(0.0230)	0.0776**	−0.0245	0.0807**	(0.0251)
Graduate and above	0.1521***	(0.0255)	0.1531***	−0.0273	0.1421***	(0.0281)
Caste						
Scheduled caste	−0.1947***	(0.0228)	−0.2151***	−0.0241	−0.2164***	(0.0241)
Scheduled tribe	−0.0652**	(0.0200)	−0.0604**	−0.0212	−0.0697**	(0.0217)
Other backward caste	0.0435**	(0.0136)	0.0339*	−0.0145	0.0372*	(0.0149)
Net assets	−0.0121***	(0.0019)	−0.0120***	−0.0021	−0.0128***	(0.0021)
Formal training in agriculture	0.0389	(0.0464)	0.0431	−0.0493	0.0813	(0.0522)
Non−farm business income	−0.0368	(0.0215)	−0.0486*	−0.0234	−0.0431	(0.0243)
Wages, salary, and remittance	−0.1040***	(0.0127)	−0.0882***	−0.0135	−0.0838***	(0.0139)
Farm characteristics						
Landholding size	−0.0263***	(0.0042)	−0.0202***	−0.0046	−0.0177***	(0.0050)
Area irrigated	0.0956***	(0.0148)	0.0783***	−0.0157	0.0704***	(0.0161)
Herd size	0.0016	(0.0159)	−0.0164	−0.017	−0.0219	(0.0179)
Proportion of buffaloes in herd	0.0098	(0.0087)	0.0191*	−0.0088	0.0230*	(0.0094)
Breeding charges	0.0395***	(0.0038)	0.0430***	−0.0038	0.0475***	(0.0041)
Feed cost	0.4612***	(0.0131)	0.4544***	−0.0137	0.4551***	(0.0139)
Veterinary charges	0.0251***	(0.0026)	0.0235***	−0.0029	0.0268***	(0.0031)
Member of farmer organizations	−0.1694	(0.1018)	−0.1114	−0.0955	−0.0113	(0.1146)
Information						
Any information	0.0974***	(0.0165)	0.2769***	−0.0246	0.4572***	(0.0505)
Constant	3.2321***	(0.1442)	3.3106***	−0.1526	3.3257***	(0.1527)

Notes: District dummies are included. The figures in parentheses are village-clustered standard errors. ***, **, and * denote significance at 1%, 5%, and 10% levels, respectively.

Notes

Notes

Notes

NIAP Publications

Policy Papers

21. Dastagiri,M.B.2004.Demand and Supply Projections for Livestock Products in India.
22. Bhowmick, B.C., B.C. Barah,S. Pandey, and N. Barthakur. 2005. *Changing Pattern of Rice Production Systems and Technology in Assam.*
23. Jha, D., and S. Kumar. 2006. *Research Resource Allocation in Indian Agriculture.*
24. Kumar, A. 2009. *India's Livestock Sector Trade: Opportunities and Challenges.*
25. Chand, R., P. Kumar, and S. Kumar. 2011. *Total Factor Productivity and Contribution of Research Investment to Agricultural Growth in India.*
26. Chand, R., S.S. Raju, S. Garg, and L.M. Pandey. 2011. *Instability and Regional Variation in Indian Agriculture.*
27. Raju, S.S., P. Shinoj, R. Chand, P.K. Joshi, P. Kumar, and S. Msangi. 2012. *Biofuels in India: Potential, Policy and Emerging Paradigms.*
28. Shinoj P., A. Kumar, S. Kumar, and R. Jain. 2014. *Commodity Outlook on Major Cereals in India.*
29. Birthal, P.S., S. Kumar, D.S. Negi, and D. Roy. 2016. *The Impact of Information on Returns from Fanning.*
30. Birthal, P.S., D.S. Negi and D. Roy 2017. *Enhancing Farmers' Income: Who to Target and How?*
31. Saxena, R., N.P. Singh, Balaji S.J.,Usha R. Ahuja and Deepika Joshi. 2017. *Strategy for Doubling Income of Farmers in India.*
32. Singh, Naveen P., Arathy Ashok, Pavithra S.,Balaji S.J., Bhawna Anand and Mohd. Arshad Khan. 2017. *Mainstreaming Climate Change Adaptation into Development Planning.*
33. Saxena, Raka, Ramesh Chand. 2017. *Understanding the Recurring Onion Price Shocks: Revelations from Production-Trade-Price Linkages.*
34. Saxena, Raka, Ranjit Kumar Paul, Pavithra S, Naveen P Singh and Rohit Kumar 2019, *Market Intelligence in India Price Linkages and Forecasts*
35. Singh, Naveen P., Anand, B and Singh, S. 2020*. Impact of Climate Change on Agriculture in India: Assessment for Agro-Climatic Zone.*
37. Subash, S.P., A. Jhajharia, and S. Pal. 2020. *Trade and Investment Policy for Overseas Acquisition of Fertilizers and Raw Materials: Role of the Government*.

Policy Brief

34. Kumar, S., PAL. Prasanna, and S. Wankhade. 2010. *Economic Benefits of Bt Brinjal-An Ex-Ante Assessment.*
35. Chand, R., A. Gulati, P. Shinoj and K.Ganguly. 2011. *Managing Food Inflation in India: Reforms and Policy Options.*
36. Shinoj. P., S.S. Raju, R. Chand, P.Kumar, and S.Msangi. 2011. *Biofuels in India: Future Challenges.*
37. Ramasundaram, P., A. Suresh, and R. Chand. 2011. *Maneuvering Technology for Surplus Extraction: The Case of Bt Cotton in India.*
38. Chand, R., and J. Jumrani. 2013. *Food Security and Undernourishment in India : Assessment of Alternative Norms and the Income Effect.*
39. Chand, R., and P.S. Birthal. 2014. *Buffer Stock Norms for Foodgrains during Twelfth Five Year Plan.*
40. Chand, R., and S.K. Srivastava. 2014. *Changing Structure of Rural Labour Market: Trends, Drivers and Implications for Agriculture.*
41. Birthal, P.S., D.S. Negi, Md. Tajudding Khan, and S. Agarwal. *2015. Is Indian Agriculture Becoming Resilient to Droughts ? Evidence form Rice Production.*
42. Singh, N.P., and J.P. Bisen. 2017. *Goods and Services Tax: What it holds for Agricultural Sector?*
43. Subash, S.P., Chand P., Pavithra S., Balaji S.J. and Pal S. 2018. *Pesticide Use in Indian Agriculture: Trends, Market Structure and Policy Issues.*
44. Singh, N.P., S.Singh and B. Anand, 2019. Impact of Climate Change on Indian Agriculture: *An Agro-Climatic Zone Level Estimation.*
45. Pal, S., R. Saxena and Balaji, S.J. 2020. *Market and Innovation-led Agricultural Transformation.*
46. Roul, C., Chand, P. and Pal,S. 2020. *Developing Agricultural Sustainability Index for the Indo-Gangetic Plains of India.*
47. Birthal, P.S., J. Hazrana, D.S. Negi, and A. Mishra. 2022. *To Insure or Not to Insure: What Explains Low Uptake of Crop Insurance?*
48. Birthal, P.S. 2022. *Managing Climate Risks in Indian Agriculture: What do We Need to Know?*
49. Balaji S. J., P. Sharma, P. Venkatesh, and K. Shreya. 2022. *Technology and Policy Options for Reducing India's Import Dependence on Edible Oils.*
50. Saxena, R., R. K. Paul, Balaji S. J., and R. Kumar. 2022*. India's Agricultural Exports during the Covid-19 Pandemic.*

भाकृअनुप–राष्ट्रीय कृषि आर्थिकी एवम् नीति अनुसंधान संस्थान
ICAR - NATIONAL INSTITUTE OF AGRICULTURAL ECONOMICS AND POLICY RESEARCH
(Indian Council of Agricultural Research)
Dev Prakash Shastri Marg, Pusa, New Delhi - 110 012, INDIA
Ph: +91(11) 2584 7628, 2584 8731 Fax: +91 (11) 2594 2684
Email : director.niap@icar.gov.in, Website : www.niap.icar.gov.in