



Dairy farming, cooperatives and livelihoods: lessons learned from six indian villages

Cédric Gaillard, Marie Dervillé

► To cite this version:

Cédric Gaillard, Marie Dervillé. Dairy farming, cooperatives and livelihoods: lessons learned from six indian villages. *Journal of Asian Economics*, 2022, 78, pp.101422. 10.1016/j.asieco.2021.101422 . hal-03483394

HAL Id: hal-03483394

<https://univ-tlse2.hal.science/hal-03483394>

Submitted on 8 Jan 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution - NonCommercial 4.0 International License

Dairy farming, cooperatives and livelihoods: lessons learned from six Indian villages

Author names and affiliations

Cédric Gaillard^{a,b}, Marie Dervillé^c

^aCIRAD, UMR MoISA, F-34398, Montpellier, France

^bMoISA, Univ Montpellier, CIRAD, CIHEAM-IAMM, INRAE, Institut Agro, IRD, Montpellier, France

^cLEREPS, Université de Toulouse, ENSFEA, IEP de Toulouse, France

Corresponding author

Cédric Gaillard

CIRAD, UMR MoISA, F-34398, Montpellier, France

Postal address : 73, rue Jean Francois Breton 34398 Montpellier Cedex 5, France

E-mail : cedric.gaillard@cirad.fr

Abstract

India's dairy sector has emerged as the world's largest dairy producer and has enabled 70 million farmers to generate income through its rapid growth. This success is linked to broad national policy support through the Operation Flood program and the emergence of an inclusive model of cooperatives. However, the informal sector is still the marketing channel most used by dairy producers, and with the liberalization of the dairy sector, the cooperative model is also facing competition from the private sector. By surveying 244 dairy farmers in two major but heterogeneous states in India, this paper examines the inclusiveness of the sector and the impact of dairy cooperative membership on farmers' income and livelihood. The originality of the paper concerns its systematic perspective on households' assets and activities. The results indicate that cooperative membership is associated with caste membership and farmers collection centers. Better incomes are associated with membership, particularly among farmers with less land and among smallholders, who are more dependent on their dairy income to lift themselves out of poverty.

Keywords: Indian dairy sector, cooperative, smallholders, livelihoods, poverty reduction.

1 Introduction

The contribution of Operation Flood (OF) and Indian policy to the dairy industry and its producers is widely acknowledged (The World Bank group, 2011; Shylendra, 2013). Operation Flood, which triggered the Indian "White Revolution" under the guidance of the National Dairy Development Board, supported the development of a vast network of cooperatives to connect rural producers to urban consumers. A total of 180,000 dairy cooperative societies were created with the aim of facilitating access to information and services and limiting transaction costs for millions of smallholders. Since the launch of OF, milk production has increased at a rate of 3.5% per annum to reach self-sufficiency and make India the world's leading dairy producer since 1998. This was made possible by turning a multipurpose herd, providing draft power and milk for home consumption into a more dairy-oriented herd providing milk for market. The production increase was supported by an increase in the number of households owning a buffalo or a cow. Sixty percent of total milk production is by landless and marginal producers (Birthal et al., 2008). The dairy sector is a major source of income for an estimated 27.6 million people (Anon, 2012).

With demand from the urban market growing at an average rate of 7% per annum (Kishore et al., 2016), the sector is expected to continue to grow, which represents an opportunity for smallholders to generate decent incomes. However, with the world's largest herds, some of the lowest milk yields in the world and the shrinking area and deteriorating quality of grazing lands, further growth in India's dairy sector is challenging. India's dairy production system needs to become more efficient. However, concealing efficiency with inclusion is a complex issue in India where land, and therefore resources to feeding the bovines, are very unequally distributed (Raj, 1971). The search for improved efficiency may lead to the capture of the benefits of the sectoral growth by landowners, enlarging their choices while restricting the one of the smallholders and landless (Raj, 1975). Can cooperatives that supported the inclusiveness of the extensive growth of the sector so far contribute to an intensive growth that remains inclusive?

The role of dairy cooperatives in the development of the sector is not straightforward. On the one hand, it valorized only 9% of the production in 2015, with informal marketing channels remaining dominant and competition from private dairies increasing. Since market liberalization in 2003, private dairies have indeed competed with cooperative models, especially among farmers with large herds and high production capacities (Staal et al., 2006). However, cooperatives have a structural role that extends beyond their market share, as they contribute to regulating the conditions of access to the dairy market (NDDDB, 2019). First, they are at the origin of the technical and organizational innovations that spread throughout the sector. Second, cooperatives' prices are used as a reference. Cooperatives have also been reported to have a positive impact on producers. Several studies have reported positive impacts of Indian cooperatives on their members in terms of milk yield, margins and food security (Khumar et al., 2018; Khumar et al., 2019).

More precisely, to support an inclusive intensification of production, one needs to understand how milk production intensification contributes to poverty reduction and, more widely, to the livelihoods of the poor. However, the benefits of dairy intensification in terms of poverty reduction are not always straightforward. If poorer households, such as landless and marginal farm households, improve their living conditions through dairy activities (Singh et al., 2013), it is at the cost of a higher dependence on bovines for their livelihoods (Kishore, 2016) and of a relatively low valorization of their labor (Aubron et al., 2015; Aubron et al., 2020). In addition, smallholders and farmers with large plots of land take advantage of dairy activities to diversify their income, benefit from fertilization and, at the same time, use their crop production to reduce costs for animal feed, which can be high

(Hemme et al., 2003). This suggests comparative advantages for dairy farmers who have access to irrigated land.

It is therefore fundamental to consider the household as a whole system of activities and to capture the different income sources (Chandrasekhar & Mehrotra, 2016) to assess the contribution of dairy income to rural household livelihoods. Income from off-farm labor in particular (and its compatibility with dairy activities) requires attention, as it constitutes an important adaptive strategy for Indian farmers to spread risk, stabilize salaries, reduce income inequalities to cope with income differentials (Subramanian et al., 2018; Himanshu et al., 2011) and contribute to food insecurity reduction (Rahman & Mishra, 2020).

In this context, we relied on a multidimensional analysis based on the livelihood analysis framework (Scoones, 1998) to measure the different contributions of dairy household strategies. The objectives of this study are (i) to describe the assets, resources and practices of rural dairy households and to relate them to the share of dairy activity in household income strategies and (ii) to test the relationships among cooperative membership, dairy income and poverty reduction.

In this regard, we relied on a household survey in two districts of two major Indian dairy states, Gujarat, considered the cradle of the White Revolution, and Andhra Pradesh, which has also benefited from the White Revolution but where the cooperative framework was liberalized the earliest with the MACS act in 1995 and where the competition from the private dairy sector is fierce. The influence of dairy cooperatives on income was considered, both in terms of understanding their degree of inclusiveness and their consequences for household levels of poverty, by considering dairy income among other sources of income.

Thus, after a description of the specificities of the dairy industry in the two districts studied and a description of the household investigation methodology, we designed an econometric model to estimate the different impact pathways of cooperatives. These econometric results will be discussed in light of existing recent work.

2 Context of the study

The Dairy Producer Household Survey is part of a multidisciplinary project on the transformation of the Indian dairy sector. This study, the Indian Milk Project (2015-2019), combines disciplines and scales of analysis to shed light on the way agricultural development contributes to poverty alleviation in different parts of the country. In particular, the districts where the household surveys were conducted were chosen based on the presence of dairy activities (Figure 1), supply chains and agrarian diagnoses previously carried out in Gujarat and Andhra Pradesh as part of the project in 2016 and 2017. Both approaches provide a systematic long-term perspective that allows for light to be shed on the historical and spatial structuring of economic processes. The first results of the Indian Milk Project are combined with a literature review to shed light on the context in which the dairy households investigated in 2018 operate.

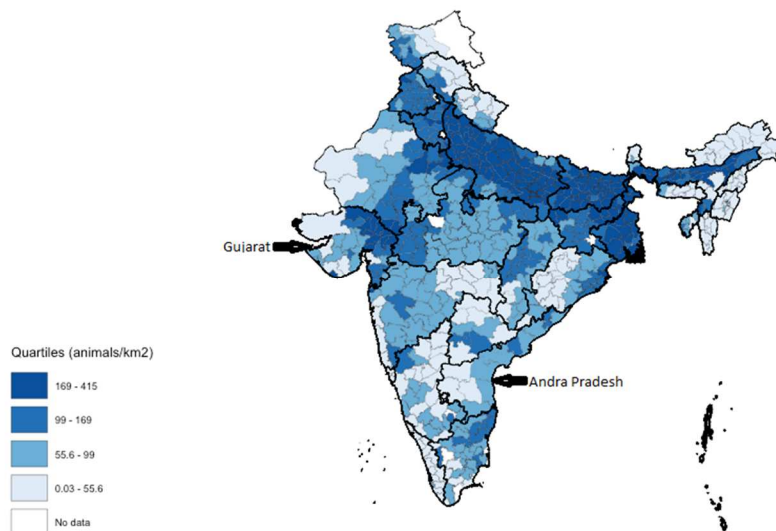


Figure 1: Density of bovines, head/km² (Livestock census 2019, mapped using R)

2.1 Dairy in Gujarat

Gujarat is a state in northwestern India and is considered the cradle of the White Revolution. Gujarat is one of the fastest growing states in the country (World bank group, 2017). Growth is driven mainly by industry and services, and Gujarat is less rural than the rest of India (57% of Gujarati people live in rural areas compared to nearly 69% nationally). Gujarat agriculture is among the most industrialized in India: mechanization is important (9% of Indian tractors), and fertilizer consumption is higher (144 kg/ha) than the national average (133 kg/ha) (Indian Ministry of agriculture, cooperation & farmers welfare, 2019). Agriculture accounted for 19% of the state's GDP in 2016-2017 (PRS Legislative Research, 2018). Livestock accounts for 21.2% of cash receipts in the agricultural sector, with milk and dairy products accounting for 82.2%. Livestock income is a source of income for approximately 4.3 million households in Gujarat (NDDDB, 2014).

The Gujarati dairy cooperatives have been instrumental in the Indian White Revolution, as it is the Gujarati business model that the National Dairy Development Board has replicated throughout India from Operation Flood phases I, II and III (1965-1995) to the present (National Dairy Plan I 2011-2019). Funded in 1946 in Anand as a village cooperative, the cooperative extended gradually with the development of a processing unit at the district level and a state-level marketing and apex body, The Gujarat Cooperative Milk Marketing Federation Ltd. (GCMMF, popularly known as Amul). This three-tier organizational innovation, referred to as the Anand pattern, favored the combination of scale economies at the processing and marketing stages while favoring social inclusion through the development of numerous village cooperative societies at the collection level (Shah, 1996). Amul is India's largest food product marketing organization, with an annual turnover of \$5.1 billion in 2019—2020 and 23 million liters per day from 3.6 million milk producer members (Amul, 2020).

The Rajkot district is located in the Saurashtra Peninsula. Despite its harsh semiarid climate, the Rajkot district managed to develop both its industry and agriculture over the last 20 years. The district is rather urbanized (58% urban, and Rajkot city, with 1.5 million people, is the 4th largest city in Gujarat). Most agricultural land belongs to the Patel caste, who employ agricultural labor to conduct the work. The development of infrastructures for irrigation in the 1970s allowed farmers to change from rain-fed agriculture based on cereals to irrigated cotton and groundnut production (Shah et al. 2009; Furlan, 2016). The dissemination of the Green Revolution's technical package went hand in hand with the development of input and credit cooperative societies, which are now present

in almost every village. Rajkot Dairy (*in full, the Rajkot District Cooperative Milk Producers Union Ltd.*) started in 1956 but joined the state cooperative federation (GCMMF) only in 1991. Collection developed quickly from the 2000s onwards. In 2016, the Rajkot Union federated approximately 500,000 farmers. In parallel to these cooperative channels, the dynamism of the district's cities, Rajkot and Gondal in particular, has sustained vivid informal channels for dairy milk sales and sweets processing. In a state marked by the strength of the Amul cooperative, the vitality of informal channels is noteworthy and particularly interesting for the analysis of farmers' marketing choices. This feature and the existence of preliminary works on farming systems and dairy chains as part of the Indian Milk Project justify the choice of this mandal for livelihood analysis.

2.2 Dairy in Andhra Pradesh

Andhra Pradesh is a state in southern India that emerged from the partition of the former state of Andhra Pradesh in 2014. It currently consists of 13 mainly coastal districts. The former Andhra Pradesh was characterized by a strong dependence on the agricultural sector. Two-thirds of the population lived in rural areas (Chandramouli et al., 2011), and 62% of households depend on agriculture, which is 7% more than the rest of India according to the Central Statistical Office (CSO). The contribution of the primary sector amounts to 27.68% of GDP (Raitu Kosam, 2015). Following the Green Revolution in the 1970s, rice, tobacco and cotton are the state's predominant crops. The proportion of farms with less than 2 hectares is high: 86% of households, not counting those that do not own any land (Chandramouli et al., 2011). In these conditions, milk production often plays a role in securing income.

Operation Flood was deployed in the state between 1970 and 1987. The Andhra Pradesh Dairy Development Cooperative Federation (APDDCF) was set up in 1981. Andhra Pradesh is also marked by the adoption in 1995 of a 'parallel act' to the Cooperative Act: the 'Mutually Aided Cooperative Societies (MACS) Act 1995' aimed to revive the cooperatives' principles and free them from public influence. The partition in 2014 has had important implications for the structure of the milk value chain, as it has led to a partition of the AP Federation (APDDCF) as well as to conflicts over specific assets (ownership of the Viyaha brand in particular). Recently, the state experienced consecutive dry spells and drought. The growth of the sector is due to a pragmatic policy of the state government that supplies silage, rations and fodder to farmers at subsidy prices so that the profit from dairy production remains high (NDDDB, 2018).

In the studied Mandal of Vinukonda, most land belongs to the Kamma and Reddy families; the dalit community is employed mainly as daily labor. The mandal benefited from the establishment of a dam in the 1970s, providing access to gravitational irrigation. It attracted investors and farmers from neighboring districts and favored the development of paddy cultivation (Marblé, 2019). With the development of irrigation, the area available for animal grazing shrank, partially substituted by paddy straw. However, in recent decades, Vinukonda mandal, located at the tail end of the dam canal network, has been facing disruptions in its access to irrigation. This has led to a decrease in the irrigated area in most villages and pressure on crop choices. Regarding milk production, the Guntur district cooperative, Sangham Dairy, was founded in 1972 and is currently one of the five leading dairy districts in AP, collecting 200 000 liters per day (Jenin and Dervillé, 2019). The Sangam dairy first followed the three-tier Anand pattern and then adopted the more autonomous MACS structure. To encourage an increase in milk yield, it promoted animal insemination (crossbreeding with the more productive buffalo Murrah breed) and concentrates to supplement the natural herbaceous plants and paddy straw diet. Recently, it has also promoted the cultivation of patches of green grasses on irrigated land. Private formal dairies are developing fast in the district, some competing with Sangham Dairy and others developing new milksheds (Marblé, 2019).

3 Data collection and methodology

3.1 Sampling

The choice of villages was based on the agrarian diagnostics previously carried out as part of the Indian Milk Project. In each state, the villages belong to districts where a high diversity of marketing channels was found and where milk production coexists with other farming systems. In Andhra Pradesh, villages were selected in the Guntur district and in Gujarat, in villages of the Rajkot district (Table 1). The villages were chosen for the diversity of their marketing channels in relation to their moderate distance from the city (10 - 40 min; 4-22 km), soil and access to irrigation, and limited size (a few hundred households were needed to achieve a systematic, representative sampling of the population). Within each village, households were randomly selected according to a spatial grid to obtain a representative sampling of the dairy farmer population. For time and budget constraints, the number of surveys to be conducted in each district was set at between 120 and 130, and the number of interviews conducted per village is proportional to the size of the living areas. The number of interviews per village is proportional to the size of the settlement area. Based on the census of the local population, the proportion of surveys per village is very close to the proportion of households per village, while respecting a minimum of 20 households interviewed per village (UN, 2010). Given the lack of a sampling frame that records the number of milk-producing households, we cannot accurately calculate our margins of sampling error. However, even assuming that all households are producers, we estimate the margin of error to be a maximum of 5.84% with a confidence level of 95% according to the usual calculation (Daniel, 2011).

Interviews were conducted with the individual in the household in charge of farm-related decisions. Some questions may have required the intervention of another member of the household to obtain accurate answers. Interviews were conducted face-to-face with the help of a local translator and lasted an average of 2.5 hours.

Table 1: Distribution of households interviewed by village

State	Village	Number of households interviewed
Rajkot district (Gujarat)	Village 1 : Ghoghavadar	31
	Village 2 : Shivrajgad	62
	Village 3 : Kholipad	35
Guntur District (Andhra Pradesh)	Village 4 : Venkupalem	20
	Village 5 : Naragayanipalem	26
	Village 6 : Peda Kancharla	70
Total		244

3.2 Theoretical framework

Chambers and Conway (1991) define livelihoods as "what people can do or be based on their rights". Their assets, both tangible and intangible, including "social resources, organizations and institutions",

enable them to deploy strategies through their practices and activities. Livelihoods then refer to the assets (and the capacity of individuals and groups to use them—their 'capabilities'), and the activities and practices required for a livelihood are considered sustainable when they enable individuals and households to cope with stress and shocks while maintaining or improving their endowments and their capacity to access them without damaging the natural resources (Scoones, 1998). In this approach, sustainability is broken down into the three dimensions usually used: environmental, economic and social.

In our study, we operationalize this framework with a cross-sectional approach. Thus, dairy farmers' allocations are observed and compared by district. A specific sustainable livelihood index (SLI) for poor rural households is developed to describe the resources owned by farm households. The index is then designed following Hahn et al. (2009). Indicators are identified, and each indicator is assumed to have equal weight in the individual groups of livelihood assets. Each of the variables describing the assets are normalized to be between 0 and 1.

The index is then designed following Hahn et al. (2009). Each asset index is computed with 3 to 5 variables (figure 2) with equal weight for each variable. Each of the variables describing the assets are normalized to be between 0 and 1. Three situations are possible: (i) The dichotomous variables are coded 1 for yes and 0 for no or 1 for presence and 0 for absence ;(ii) Variables with several modalities are ordered so as to classify them between 0 and 1 according to their number of modalities (if there are 3 modalities, we use 0 for the "low" modality, 0.5 for the intermediate modality and 1 for the "high" modality);(iii) The quantitative variables were normalized as follows:

$$X_i = \frac{X_i - X_{min}}{X_{max} - X_{min}} \quad (1)$$

where i represents a household in our sample, $i \in [1, 184]$, X_i is the value for the quantitative variable observed for individual i , X_{min} is the minimum value of the quantitative variable in the sample, X_{max} is the maximum value of the quantitative variable in the sample, and X_i is the new value of the variable between 0 and 1 for individual i .

For each asset, the variables (transformed for quantitative variables and recoded for qualitative variables) describing that asset are summed and divided by the number of variables. The score for each asset is also between 0 and 1 for each individual in the sample.

In addition to household assets, other socioeconomic variables, such as the age and gender of the head of the farm or, given the Indian context, caste, were used in the quantitative analyses. Furthermore, the social hierarchy of castes still plays a decisive role in the organization of Indian society. A grouping of the different castes present in the two districts follows:

- Scheduled caste or scheduled tribes (only in Guntur, Andhra Pradesh)
- Other backwards class (Yadava, Vishnu Brahmins, Muslim and Rajikas in Guntur; Bharvar and Koli in Rajkot)
- Other caste, also called forward class (mainly Patel in Rajkot and Chowdari and mainly Naidu and Reddy in Guntur)

As shown in Figure 2, the objective was first to determine the relationship between household assets (a) and household membership (b) in a dairy cooperative (c), as well as the effects of cooperative membership on the dairy incomes of herders (d) and the consequence of these effects on the poverty level of farm households (e) through their different livelihoods (f).

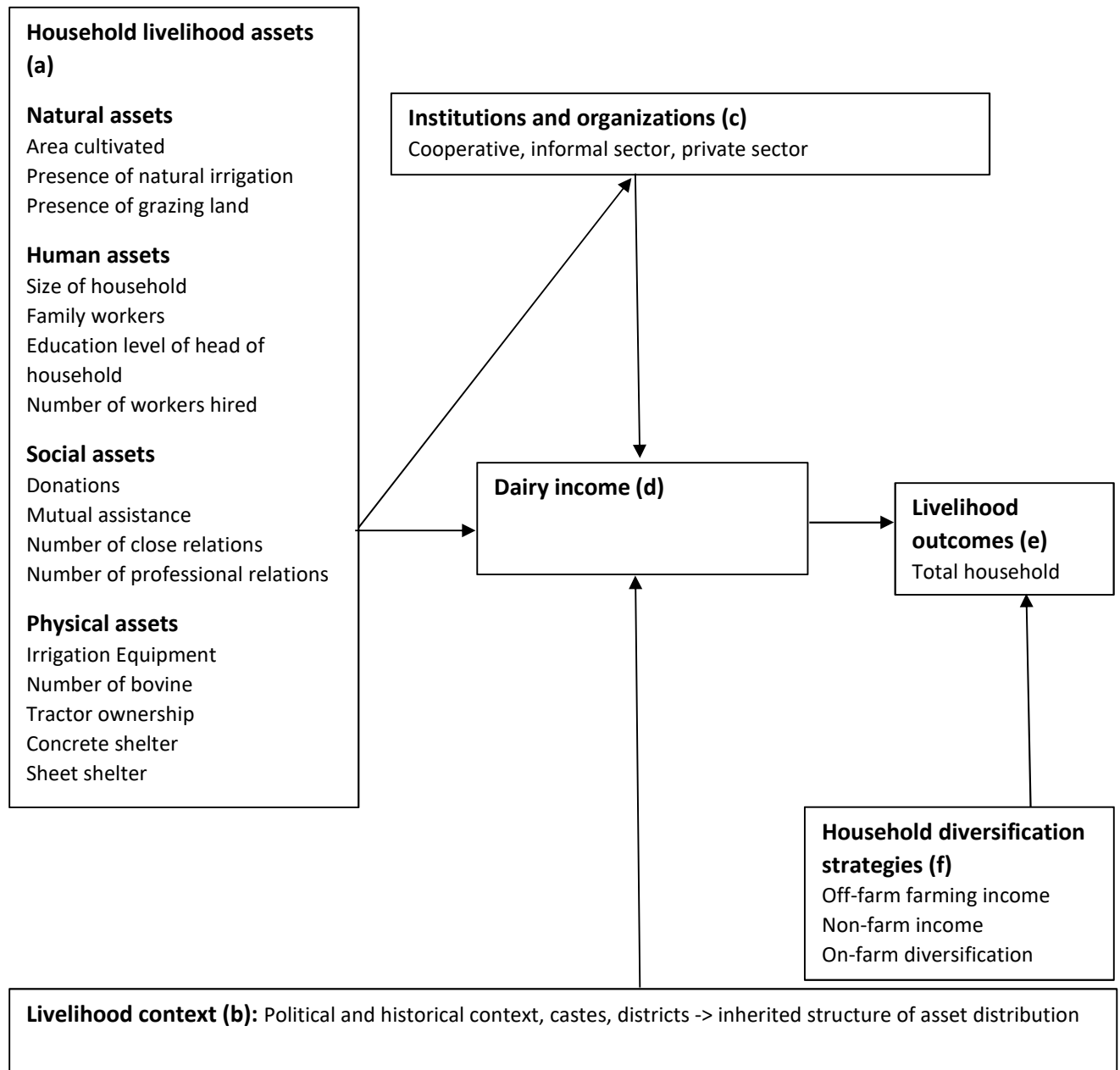


Figure 2: Theoretical framework of the study

Source: Authors

3.3 Statistical and econometric approaches

The analyses were carried out in Stata. Different resources and assets, the choice of marketing channel, and agricultural practices were compared between the two states using nonparametric Wilcoxon tests.

Selection bias in farmer participation in dairy cooperatives is possible for various reasons, such as geographic locations, thereby making participation decisions endogenous in nature. Therefore, a probit–2SLS model was estimated using the Stata command ‘ivtreatreg’ (developed by Cerulli, 2014). In the first step, a probit regression generating the predicted probability of a farmer’s decision to join a cooperative (Y_1) is estimated. Y_1 is a binary variable taking the value ‘1’ if a given household is a member of a cooperative and ‘0’ otherwise. The predicted probability of participation is generated

by the probit selection regressions (2) and (3) on the explanatory variables and the instrumental variable.

$$\text{Probit}(Y_1) = \Pr(Y_1 = 1 \mid X_i, Z_j) \quad (2)$$

The second step involves performing a two-stage least squares (2SLS) regression. 2SLS runs two OLS regressions. We ran a first OLS of Y_1 on the predicted values from the previous step with the exogenous variables. Finally, we estimated second OLS of the outcome variable Y_2 , household dairy income, using the fitted values generated in the first OLS regression (equation (4)) (Cerulli, 2014). According to Cerulli (2014), probit-2SLS is the most efficient model for estimating the treatment effect (in the current case, the effect of belonging to a dairy cooperative) among the other possible models. The model also allows for the estimation of heterogeneous treatment effects with the use of idiosyncratic variables. Given that cooperatives provide services such as the sale of cattle feed and mineral mixtures and disseminate knowledge on better animal management practices, it is likely that participation impacts households differently according to a range of land holding size of land potentially providing animal feed through the production of fodder or crop by product. The impact of cooperative membership can also be moderated by the functioning of the local dairy market. Therefore, the model estimates the average treatment effect (ATE) with idiosyncratic or heterogeneous effects by adding regressors. The introduction of heterogeneous effects therefore generates average treatment effects on the treated (ATET) and average treatment effects on the untreated (ATENT), which are different from the ATE.

$$Y_1 = \alpha_0 + \sum_1^k \alpha_i X_i + \sum_{k+1}^l \alpha_j Z_j + \varepsilon_1 \quad (3)$$

$$Y_2 = \beta_0 + \beta_1 Y_1 + \sum_2^3 \beta_i H_i + \sum_4^{k+1} \beta_j X_j + \varepsilon_2 \quad (4)$$

where Y_1 is the dummy variable for belonging to a dairy cooperative and Y_2 is household dairy income. X_i is an exogenous vector of household and farmer variables, Z_j is a vector of instrumental variables, H_i is a vector of the determinants of the heterogeneous effects of Y_1 . α_i and β_i are the parameters to be estimated. In particular, β_1 is the average treatment effect (ATE) of belonging to a cooperative on dairy income. ε_1 and ε_2 are the respective error terms for each estimation.

The vector of explanatory covariates was composed of the calculated asset score variables detailed in the Results section, the duration of dairy activity in the household and the participation of a household member in an off-farm income-generating activity (a dummy variable).

The instrumental approach is used in this type of model to control for confounding and measurement error in observational studies so that causal inferences can be made. It allows us to identify or isolate the ATE on the outcome independent of unobserved sources of variability.

In other words, instrumental variables are assumed not to have any direct effect on the outcome. Instead, the instrumental variable is thought to influence only selection into the treatment condition. That is, the effect of the instrumental variable on the dependent variable is entirely mediated via its effect on treatment assignment. In our case, we hypothesize that caste membership, already used in similar studies (Kumar et al., 2019), impacts membership in a cooperative without directly influencing the dairy income of the household. Proximity to the collection center can also change the decision to join a cooperative, so we have used the location variable 'Villages' as an instrumental variable. The success of this strategy rests on the quality of the instrument. Tests were thus implemented to measure whether the instruments are "relevant", meaning correlated with the endogenous regressors (captured by rejection of the underidentification test of Anderson) and

uncorrelated with the error term in the final equation, and that the excluded instruments are correctly excluded from the final equation (captured by a failure to reject the overidentification test of Sargan).

Given that cooperatives provide services such as the sale of cattle feed and mineral mixtures and disseminate knowledge on better animal management practices, it is likely that participation impacts households differently according to the ownership of land potentially providing animal feed through the production of fodder or crop waste. Therefore, we introduced a variable that differentiates between landless farmers, those with land less than 2 ha (called marginal farmers) and those with land greater than 2 ha (reference group). The impact of cooperative membership can also be moderated by the functioning of the local dairy market and the heterogeneity in agronomic conditions. A variable for the district was also introduced to estimate these heterogeneous effects.

Finally, the results of this probit-2SLS selection model were complemented by analyses to better understand the correlations between the variables. Thus, to enhance the discussion, linear regressions are used to estimate the correlations between other outcomes (margin per liter of milk, productivity per animal) and explanatory variables (index of assets).

4 Results: Dairy as a source of livelihood enhanced by cooperatives

4.1 Description of households

Table 2: Distribution of castes by district

Castes	Vinukonda Mandal (Andhra Pradesh)	Gondal Mandal (Gujarat)	Total
Other Caste (OC)	52	111	163
Backward Caste (BC)	38	17	55
SC/ST (OBC)	26	2	26
Total	116	128	244

Rural households in the three villages in Andhra Pradesh were composed of many castes without the presence of a majority caste (Table 2), while rural households in Gujarat were predominantly Patel. The average age of respondents was 44 old years in Andhra Pradesh and 46 old years in Gujarat. Farmers from Andhra Pradesh have been involved in dairy activities for an average of 17 years and for more than 20 years in Gujarat, with less than 10% having been involved in dairy activities for fewer than 5 years.

Most of the variables describing household assets had significantly different means (Table 3). On average, the rural Gondal households in our sample were far better endowed with human and physical capital. The differences were particularly significant, especially for the level of education. Less than half of the heads of farms in the 3 villages in Andhra Pradesh had had access to education, while 87.5% of heads in the villages of Gujarat had had access ($p < 0.01$). Tractor ownership was rare in the Vinukonda mandal, while more than one-third of farmers in the Gondal mandal had access to motorized equipment (rejection of equality, $p < 0.01$). These elements also pointed to strong

heterogeneity between the 2 mandals in arable land availability, where the differences in the averages, again in favor of the Gondal households, were very clear (9.53 acres vs. 1.51 acres, $p < 0.001$). As a partial compensation, in the study area in Vinukonda, more than one-third of the farmers benefit from natural irrigation and the presence of communal grazing. With regard to social capital, the results were more balanced between households in the 2 mandals, though the networks were mobilized differently. Donations and the number of close relationships were higher in Vinukonda, while households in Gondal benefited from more frequent self-help practices (the village cooperative inherited from the Green Revolution; cf. section 2.1).

Table 3: Assets of farm households by district (n = 244)

	Variables	Vinukonda (Andhra Pradesh)			Gondal Mandal (Gujarat)			Difference in score
		Mean/Freq	SD	Score	Mean/Freq	SD	Score	
Human Asset	Size of household	3.6	1.19	0.186	5.555	2.29	0.258	-0.072***
	Family workers	2.31	0.56	0.202	2.805	1.33	0.588	-0.386***
	Education level (with education Y/N)	48.30%		0.483	87.50%		0.875	-0.392***
	No. of workers hired	0.01	0.03	0.001	2.373	2.65	0.148	-0.148***
Social asset	Freq gift	0.655	1.42	0.109	0.438	0.5	0.072	0.037*
	Mutual assistance (Y/N)	12.10%		0.121	50.80%		0.508	-0.387***
	No. of close relations	0.664	0.95	0.132	0.344	0.59	0.068	0.064***
Score for Human & Social Assets				0.227			0.381	-0.164***
Physical asset	Presence of infrastructure irrigation (Y/N)	5.20%		0.052	86.70%		0.867	-0.815***
	No. of bovine	3.12	1.69	0.062	3.359	5.04	0.069	-0.007**
	Tractor (Y/N)	1.70%		0.017	35.10%		0.351	-0.334***
	Concrete shelter (Y/N)	27.60%	0.45	0.276	60.20%		0.602	-0.326***
Natural asset	Sheet shelter (Y/N)	12.10%		0.121	16.40%		0.164	-0.043
	Presence of natural irrigation (Y/N)	34.50%		0.345	21.10%		0.211	0.134**
	Presence of grazing land (Y/N)	38.80%	0.49	0.388	21.90%		0.219	0.169***
Score for Physical & Natural Assets				0.179			0.307	-0.128**

***: $p < 0.01$, **: $p < 0.05$, *: $p < 0.10$

All these differences are also clearly visible in the diagram presented (Figure 3).

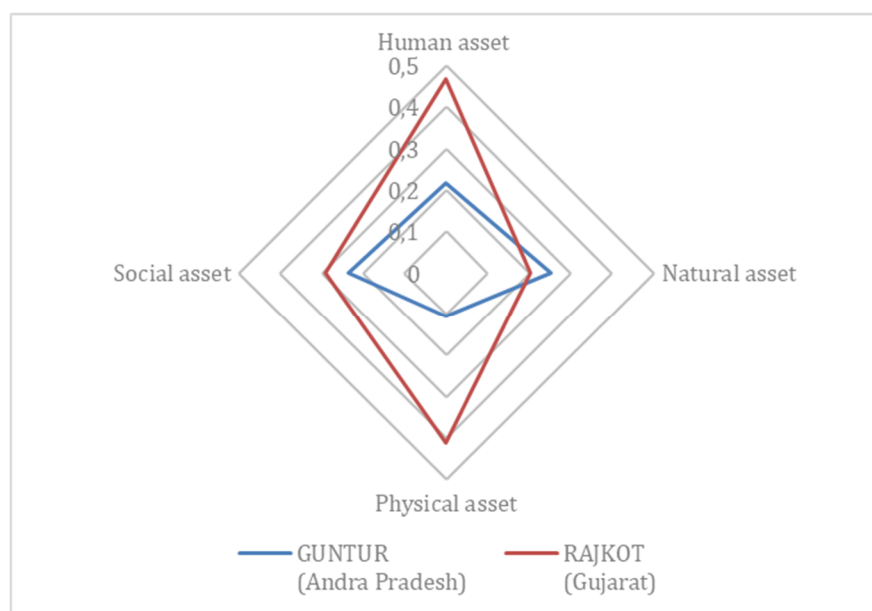


Figure 3: Mean of farm household assets by district

4.2 Dairy practices, performance and production costs

Interestingly, despite contrasting land availability, the average herd size (three animals) is comparable across the two mandals. However, the types of animals bred differ: in Vinukonda, almost all bovine bred are buffalo (95%), with more than half of them being crossbred with the improved buffalo breed Murrah ($n=65$); in Gondal, there are more cows (70% of the total), mostly of the local breed, Gir. The other bovine populations encountered in the survey include crossbred cattle (jersey or Prim'holstein crossbreeds), crosses of local breeds and improved local breeds.

Dairy production costs also reflected differences in practices between the 2 districts. While one could have made the hypothesis of fewer food purchases in Rajkot district, where agricultural areas are much larger and favor intra-consumption, the average animal food expenditures by farmers there (mean=101,323 rupees, $SD=138,047$) are higher than those observed in Vinukonda district (mean=66,725 rupees, $SD=40,445$), suggesting a higher degree of intensification in dairy production. Proportionally, it is mainly through the purchase of concentrates that households in Gondal district differentiate themselves (63% of food expenditures vs 32% in Guntur). Households in Gondal also had higher investments in other animal husbandry costs (7,874 rupees vs 3,070 rupees in Guntur). However, these extra costs were largely compensated for by higher milk productivity, leading to lower production costs per liter in Gondal (Table 4). In short, average dairy income is nearly 2.5 times higher in households in Gondal than in households in Vinukonda.

Table 4: Mean of indicators of dairy performance by district (standard errors in parentheses)

	Vinukonda (Andhra Pradesh)	Gondal (Gujarat)
Margin per liter of milk produced	10.28 (9.56)	13.78 (11.63)
Production per bovine	904 (314)	2,409 (1,253)
Number of bovines	3.12 (1.69)	3.36 (5.08)
Dairy Income	36,838 (68,711)	94,039 (173,121)

4.3 Marketing channels

Table 5: Number of farms by marketing channel and district

	Vinukonda (Andhra Pradesh)	Gondal (Gujarat)	Total
Member of cooperative	31	77	108
Non-member of cooperative	85	51	136
Including informal channel	51	34	85
Private channel	34	0	34
Exclusive self-consumption	0	17	17

The results presented in Table 5 show strong heterogeneity in the choice of farmers' marketing channels between the two districts in the two different states. In Gondal (Gujarat), the cooperative channel dominates. This can be explained by the strength of the Gujarati cooperative Amul as well as by the fact that there is no competition from private formal dairies. In Vinukonda (Andhra Pradesh), only 25% of the households delivered their milk to a cooperative. Another 27% delivered to private formal dairies. Forty percent of the households delivered their milk through informal channels. The share is the same in Gondal, but there, one-third—13% of the households—engaged in dairy activities for self-consumption only. The rest of the households sold part of their production (80% sold at least half of what they produced) but consumed part of it.

Prices vary greatly according to marketing channels. The price of milk sold through informal channels (Mean=39.5, SD=11.0) was slightly higher than that of milk sold through the cooperatives (Mean=38.5, SD=9.9) and was even higher than that sold through private channels (Mean= 34.5, SD=3.4). The difference in terms of production costs per liter was also in favor of the members of a cooperative (23.4 rupees vs 25.3 for private dairies and 26.0 for the informal channel). Thus, the margin per liter was slightly higher for cooperative members (Table 6). The lower production costs for cooperative members may be related to a better access to inputs on one side and to a better animal productivity on the other side. The cooperative membership benefits are indeed even higher when considering the animal productivity and the overall dairy income (10,000 rupees higher for co-op members on average). Nevertheless, as results displayed in table 6 are not corrected for selection effect, the highest animal productivity for cooperative members may be partly related to the place. The rate of cooperative membership is indeed higher in Gujarat where the endowment of resources is also the higher. It is likely that better resources to feed the animals and maybe also better breed explain part of this higher animal productivity for cooperative members.

Table 6: Dairy performance by cooperative membership (standard errors in parentheses)

	Member of cooperative	Non-member of cooperative
Margin per liter of milk produced	12.35 (10.44)	11.85(11.03)
Production per bovine	2,078 (1,439)	1,381 (874)
Number of bovines	3 (2.75)	3.17 (4.05)
Dairy income	71,758 (106,472)	61,691 (152,071)

4.4 Income and diversification

The average total income per household was 94,378 rupees (95% CI=[78,083; 110,674]) or US \$1,260 for the households surveyed in Vinukonda (Andhra Pradesh) and 501,084 rupees (95% CI=[411,000; 591,171]) or US \$6,690 per year in Gondal (Gujarat).

The majority of rural households implement a varied system of activity (Figure 4). By construction, all households were engaged in dairy activities. More than half were engaged in crop cultivation (n=144). Ninety-five had income from off-farm activities: forty-eight received income from agricultural labor outside the family farm, mainly in Vinukonda, and thirty received income from nonagricultural activities, mainly in Gondal. Fifteen households combined dairy with agricultural and nonagricultural jobs.

In Gondal, family farms provided most of the income earned. In accordance with the agrarian diagnosis, cotton and ground nut rotation (n=108) was practiced by most of the households. Most of the households also cultivated green fodder (n=110). Cereals (n=45), horticulture (n=35), chili (n=26) and pulses (n=20) were also cultivated but less frequently. Dairy income accounted for 20% of household income, ranking before that from nonagricultural jobs (16%).

In Vinukonda, dairy was the main source of income. With a dairy income 2.5 times less than that in Gondal, it accounted for 40% of total household income. Despite their apparently limited efficiency, dairy activities made critical contributions to household income in Vinukonda. Agriculture, mainly based on the cultivation of rice (n=26), pulses (n=12) and tobacco (n=5), accounted for only 23% of the income earned. With the limited land endowment of rural households in Vinukonda, livestock activities accounted for more than 50% of total income on average. Income from off-farm agricultural activities (15%) and income from nonfarm activities (7%) represented additional income for a weak share of households.

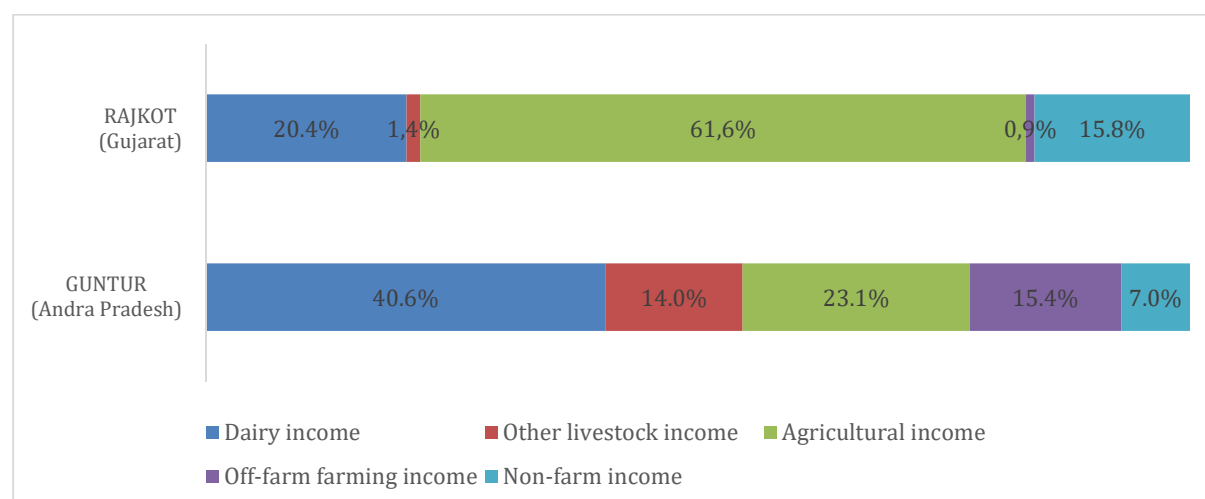


Figure 4: Distribution of income by activities by district

Less than 10% (n=21) of dairy producers were specialized, with significant heterogeneity in income and herd size but with overall margins per liter of milk (mean=8.1, SD=14.1) tighter than average. Ninety-two percent of households consumed part of their own milk production (85% of households in Gondal and all of those in Vinukonda), with an average consumption of 0.88 liters per person (SD=0.46) in Gondal and 0.27 liters (SD=0.14) in Vinukonda. A total of 9.3% of total production was self-consumed in Vinukonda and 20.2% in Gondal, with a higher but more variable average consumption per person in Gondal. Eighteen households, mostly with high total incomes, used milk only for consumption.

4.5 Determinants of cooperative membership and their impacts on dairy income

The results of the various tests show that the instrumental variables approach used was valid. Indeed, the instruments fulfilled the exclusion restriction assumption, i.e., the instruments were correlated with the treatment variable (here, membership in a cooperative) with $p < 0.05$ and were uncorrelated with the outcome variable (here, the log of milk income) and uncorrelated with the residuals of the final equation ($p > 0.05$).

Table 7: Econometric results for probit–2SLS model model

		Cooperative membership (Y/N)	Log Income from dairy activities
Treatment variables	Cooperative membership (Y/N)		0.346*
	Landless/Large farm		0.461**
Treatment heterogeneity variables	Smallholder/Large farm		0.885***
	District (Rajkot/Guntur)		0.439**
	Score for human assets	0.814*	-0.230
	Score for social assets	0.692	0.603**
	Score for physical assets	0.241	0.482**
Covariates	Score for natural assets	-0.234	-0.156*
	Duration of dairy activity (in years)	0.022***	-0.011***
	Participation in off-farm activities	-0.091	-0.241**
	Village 2(/Village 1)	0.213	
	Village 3(/Village 1)	0.426*	
	Village 4(/Village 1)	-1.750***	
Instrument introduced in the selection equation (equation 1)	Village 5(/Village 1)	-0.559**	
	Village 6(/Village 1)	-0.267*	
	Caste OBC (/OC)	-1.053***	
	Caste BC (/OC)	-0.706***	
Constant		-0.379*	11.623***
Model Statistics		LR Chi2 (13)=60.63 and p= 0.00	F(10, 222)=4.36 and p= 0.00
Test of underidentification			p=0.004
Test of overidentification			P=0.249

***: p<0.01, **: p<0.05, *: p<0.10

Determinants of membership in a cooperative

The results (Table 7) show that an increase in human capital is significantly associated with an increase in the probability of being a member of a cooperative ($p < 0.10$). In particular, households opting for this marketing channel have hired labor and the education level of farm head was in average, higher.

Membership in the BCs and OBCs was associated with a lower probability of joining a cooperative than membership in the OCs given the other covariates. Finally, an increase in the duration of dairy activity was linked to an increase in the chances of being a member of a cooperative. As already observed in the descriptive statistics, location also plays a role in the choice of dairy farmers to join a cooperative. In particular, households in village 4 (Venkupalem), where no cooperative was present at the time of survey, have a lower propensity to rely on a cooperative to sell their milk. The propensity to join cooperatives is also lower in the other villages of Vinukonda and in particular in the village of Peda Kancharla where the vast majority of farmers opting for the private network are present.

Determinants of dairy income

The effect of cooperative membership, used here as a treatment variable, on the logarithm of milk income was significant and positive. The average treatment effect should be read as the exponential of 0.346; i.e., cooperative membership is associated with a 41% increase in milk income.

The results (Table 8) also show that the effect of membership in a cooperative on those who were not members at the time of the survey would have been greater than the effect on those who actually joined (if they had not joined). Figure 5 confirms this, with the modal value of the distribution of the ATET being below that of the ATE, approximately 0.25, suggesting that the majority of members would have had a more measured decrease in their milk income if they had not been members. The impact on nonmembers is more homogenous, as shown by the ATENT curve.

Table 9 shows how cooperative membership affected different types of farmers in each district. This indicates that first landless farmers and then smallholders benefit more from cooperative membership than farmers with more agricultural land.

Table 8: Average effects of membership in a cooperative on the log of dairy income

ATE	ATET	ATENT
0.346	0.294	0.388

Table 9: Average effects of membership in a cooperative on the log of dairy income by type of farm and district

	Rajkat	Guntur
Landless farmers	1.092	0.654
Marginal farmers	0.669	0.230
Large farmers	0.208	-0.231

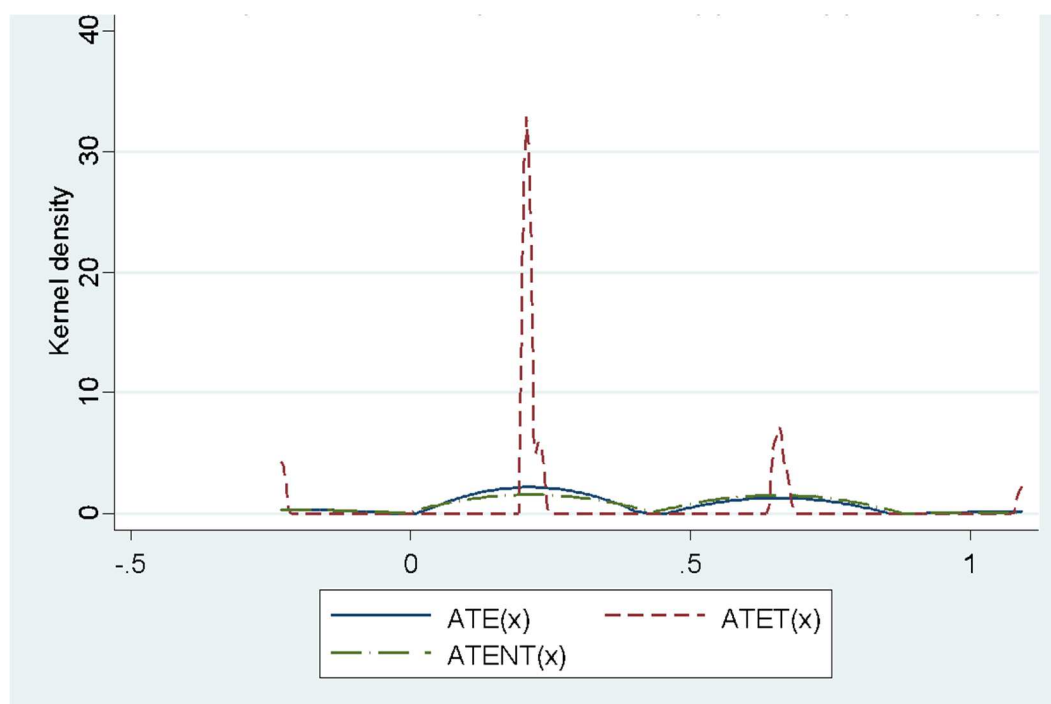


Figure 5: Comparison of ATE, ATET and ATENT on the log of dairy income

The estimations (Table 7) also show that an increase in physical assets is associated with an increase in milk income ($p < 0.05$), whereas the association of natural assets with income is negative. Similarly, a greater duration of dairy activity is slightly but significantly associated with a decrease in income ($p < 0.05$). While the effects of human capital on income are negative and insignificant, an improvement in social capital is significantly linked to an improvement in dairy income.

Table 10: Correlation between assets and dairy performance

	Score for human assets	Score for social assets	Score for natural assets	Score for physical assets
Margin per liter of milk produced	-1.17	1.24	-1.38	7.45**
Production per bovine	-221.6	7664.9***	-701.1	6250.1**

***: $p < 0.01$, **: $p < 0.05$, *: $p < 0.10$

Table 10 provides detailed information on the correlations between assets and the dairy performance indicators. The results show that the margin per liter of milk is only positively and significantly correlated with the physical asset index, including in particular the size of the herd. This positive association is also found with the presence of irrigation infrastructure favoring the production of green fodder. In this respect, we observed that farmers who owned crops that could be used for animal feed had a significantly higher gross margin per liter (12.1 vs. 10.6).

Animal productivity is positively related to social capital and physical capital and negatively correlated—but not significantly so—with the natural and human assets indexes. Finally, for the other covariates tested (Table 7), the duration of dairy activities and participation in off-farm activities were significantly and negatively correlated with the dairy income of farm households.

4.6 Impact of dairy cooperative membership on poverty

The impacts of cooperative membership on the poverty of households in their situation at the time of the survey, in a hypothetical situation in which all farm households are members, and one in which none are members were observed (Table 11). The impact on milk income and ultimately on total household income if all households were cooperative members reduced the share of households below the poverty line (less than 36,000 rupees per capita annually) by more than 10% relative to the current situation, linked to an average increase of more than 16,000 rupees.

Table 11: Consequences of membership in a cooperative for dairy households

	Mean of dairy income (Std dev.)	Median of dairy income [1st quartile; 3rd quartile]	% below the poverty line
In current situation	63,315 (126,918)	32,850 [12,080; 75,555]	49.8%
Situation where no dairy producers are cooperative member	54,846 (117,496)	30,244 [11,212; 61,187]	54.1%
Situation where all dairy producers are cooperative member	79,729(162,636)	38,750 [15,444; 92,447]	39.1%

The share of poor households was also higher among landless households (76.6%) than among those with land (31.6%). The share of households below the poverty line that had diversified their activity with agricultural labor (83%) outside the family farm was higher than that among those households that had diversified into nonagricultural jobs (18.4%).

5 Discussion

We examined the impact of membership in a dairy cooperative on the income of the dairy producers in six villages located in two mandals in two contrasting Indian states. While this question has already been explored in a large body of literature, to our knowledge, no study has differentiated these impacts according to the type of farm while measuring the effects of the assets and livelihoods of households. Our study, which considers the household activity system, examined a variety of activities and their tensions and synergies and jointly assessed the microeconomic determinants of joining a cooperative, the impact of membership on dairy income and the consequences on total household income and poverty. The integration of a household survey into a wide, comprehensive project on the transformation of the Indian dairy system favors a relevant interpretation of the correlations among the variables.

Several results were highlighted: (i) significant differences in asset endowments between households living in Vinukonda (in the district of Guntur in the state of Andhra Pradesh) and those living in Gondal (in the district of Rajkot in the state of Gujarat); (ii) the endowments of human and natural assets, duration of activity, geographic situation and caste were associated with cooperative membership; (iii) a better dairy income is associated to the cooperative channels. Landless and marginal farmers, although they less frequently utilize this channel, have a greater economic benefit from joining a cooperative than farmers with a larger amount of farmland; and (iv) although dairy activity is rarely the main activity of households, an improvement in dairy income related to the decision to join a cooperative could contribute to a partial reduction of rural poverty in India.

5.1 Positive impacts of cooperatives on dairy incomes

Our results show an association between membership in a cooperative and higher dairy income. These results are in line with those of numerous studies conducted in India, where Kumar et al. (2018) in the state of Bihar, Ravishankara et al. (2019) in the state of Karnataka, and Mahida et al. (2018) in the state of Gujarat showed the improved performance of and higher incomes for farmers opting to use the cooperative channel to sell their products.

Our study also found that landless and smaller farmers benefit most from cooperatives in terms of increases in their income. The cooperatives play a role in compensating landless people and smallholders for their lack of autonomy as far as on-farm animal feed is concerned. Cooperatives facilitate access to concentrates and fodder that have been highlighted as instrumental in raising dairy income. Dairy producers with land, irrigation facilities and synergies between agriculture and livestock farming obtain the highest dairy income.

While the services of cooperatives can mitigate a lack of natural and physical capital resources, the networks they develop can also compensate for a lack of social capital. As our results suggest and as has already been observed in other studies (Tenzin et al., 2016), social assets are considered to be an important determinant of dairy income. This is all the more the case in stratified society as India where intra caste exchanges limit the capacity of marginal caste to benefit from value added market.

Overall, our study demonstrates that increasing dairy producers' cooperative membership is a lever for reducing rural poverty. These results support Indian public policies to support cooperatives (traditional, MACS or producer companies) to reduce poverty through dairy production.

However, before adjusting for selection effects, the benefits of the cooperative channels compared to the informal and private ones are very heterogeneous. While farmers marketing their milk through cooperatives performed better in terms of income than those choosing the informal channel, the dairy incomes of farmers choosing the private channel were similar to the ones of cooperative members despite lower milk prices. Comparisons already made in the literature even show that in certain context, better margins per liter of milk produced for farmers choosing the private channel (Chaudhary et al., 2019). In addition, this positive outcome of cooperative is place dependent: it depends first on the presence of a cooperative in the producers surrounding and second on the cooperative maturity and efficiency (price paid and service provision to dairy producers) (Punjabi 2009; NDDDB 2019).

5.2 Strengthening the inclusiveness of cooperatives

Our results are based on a cross-sectional survey. Thus, it is difficult to extrapolate the results of the selection equation by evoking causal links, given that dairy farmers who opted for the cooperative channel may have acquired certain characteristics after joining the cooperative. However, the associations obtained may provide interesting insights into the degree of inclusiveness of the cooperative marketing channel.

The purchase price policy of cooperatives is based on transparency, with payment per liter related to the fat content of the milk, which is not the case for the other marketing channels (private and informal) that pay a fixed rate per liter of milk. Conversely, to benefit from this transparency, dairy producers have to transport their milk to the collection center twice daily and take part in collective decision making, which requires additional time and labor.

Considering milk payments based on fat, one might have expected that farmers whose livestock is mainly buffalo would have been more inclined to join cooperatives. This was not the case in our

study, but this effect was largely mitigated by the overwhelming majority of buffalo in Andhra Pradesh, where buffalo satisfy the farmers' preferences for breeding and consumption. Conversely, in Gondal (Gujarat), the interviews revealed the producers' attachment to the Gir cow breed, native to the neighboring district of Junagadh, the milk of which is reputed to be healthy by the inhabitants (Esteban 2016).

Our results highlight the importance of proximity to collection centers in the choice to use the cooperative channel. While cooperatives have an important territorial network in Gujarat and are therefore present in all the villages studied in Gondal mandal, this is not the case in Vinukonda, where the absence of cooperative in Venkupalem village led to a lower incidence of cooperative membership. A twice-daily milk delivery imposes location specificity requirements and potentially extra work. Human assets, in particular the hiring of outside workers, were also a factor in cooperative membership. The importance of human assets in the choice of membership was also reported in Kenya (Fischer and Qaim, 2012) and in Ethiopia (Abebaw and Haile, 2013; Chagwiza et al., 2016).

Another factor determining the choice for cooperative membership was experience in the dairy sector, with older farmers indicating a desire to reduce risk and a willingness to secure income in a more contractual way, irrespective of their physical capital and land endowments.

However, the inclusive character of cooperatives is particularly challenged in our study when we observe the link between caste membership and choice of marketing channel. While studies have reported that access to cooperatives is indifferent to caste membership (Kumar et al., 2013; Kumar et al., 2018), our study is related to some work, such as Ravichandran (2020), that reports difficulties among lower caste members, as well as among women, who had limited access to leadership roles and training opportunities. This may be explained by the fact that most cooperatives have been formed by members of dominant castes with enough assets and time to invest in collective action (Shah, 1996). Members of lower castes living near the collection center benefit secondarily from the establishment of this marketing channel.

5.3 Dairy: contrasting diversification strategies

Dairy is rarely the sole activity of a household. By analyzing the complexity and diversity of household activities, this study makes a breakthrough in shedding light on the dairy activity contribution to rural household income.

Dairy is complementary to agriculture for those who own land. Dairy activity is more lucrative for households with land and physical assets and that have access to good genetic materials and inputs and can take advantage of synergies between crops and livestock. Our results show that the synergies between crop and livestock production increase as households' land and physical resources increase, increasing inequality even though dairy income contributes to less than one-third of household income in these systems. In addition, these households can access well-paid nonagricultural jobs.

Dairy, as has been observed elsewhere in India (Das et al., 2017), is complementary to agricultural jobs for landless and marginal farmers. Dependent on purchased inputs and/or extensive labor for the collection of natural grasses, dairy activities are critical for household income despite limited animal productivity. Dairy income does not offer better remuneration than agricultural jobs (150 rupees, i.e., \$2, per day of work in the study area) (Aubron, al. 2020), but it complements off-farm incomes that are seasonal.

Our results show that even if dairy activities are more inclusive than crop cultivation, as landless farmers can access dairy activities and dairy markets, the productivity of dairy activities is related to physical assets and landholding size. This suggests that the search for an intensive growth could exclude the poor less productive producers. This would have dramatic social outcomes as despite its limited productivity, dairy is a key complementary income for these poor households. This point was already highlighted by K.N. Raj (1971, 1975). Fortunately, households with more assets have alternative employment opportunities, leaving room for the poor. In a context where distributional issue is acute, cooperative have a large role to play in compensating for the lack of assets among the landless producers and in enabling them to tap into part of the benefits of the growing demand for dairy.

6 Conclusion

The dairy sector ensures a source of livelihood for 70 million farmers in India. While the informal sector remains the most common marketing channel used by dairy farmers, the cooperative model emerged as largest scheme to the development of the sector.

Our results, based on a survey of dairy farmers in two states with significantly different historical contexts for the development of dairy cooperatives, showed that farmers who have opted for the cooperative channel generate higher incomes than others. The benefits of joining a cooperative are most pronounced among the least resourced households. Thus, it is a plebiscite for India's pro-cooperative dairy policy to keep up with the growing demand on dairy products. However, the inclusiveness of the cooperative channel is questioned by an access issue for backward castes and farmers far from the cooperative collection centres. Cooperatives have to enhance their collection network upstream so as to provide opportunities to as many smallholders as possible. Towards this end, the development of milk producers' companies as supported by the National dairy services may be synergetic.

Examining the capacity of dairying to enhance smallholders' livelihood in a broader set of locations across India or over different period of time would strengthen our findings. Seasonal variations of market prices can be an important factor that could reduce or improve the margins of dairy farmers and significantly change the strengths and weaknesses of different marketing channels. This is all the more the case that cooperative milk price is reported to be more stable. As for the different study locations, it is important to consider places where presence of private channels is more important than in our study in order to compare the results of farmers opting for this marketing channel, whose functioning is often closer to that of cooperatives than to the informal channel.

Finally, future studies should continue to explore how different cooperative services have led to impacts on farmers. These investigations are essential to target the poorest farmers and improve the competitiveness and sustainability of the sector,

References

- Abebaw, D., & Haile, M. G. (2013). The impact of cooperatives on agricultural technology adoption : Empirical evidence from Ethiopia. *Food policy*, 38, 82-91.
- Amul (2020). <https://amul.com/m/organisation>
- Anon. (2012) Statistical Handbook 2012. Directorate of Economics and Statistics, Government of Odisha, Odisha, India.
- Aubron, C., Bainville, S., Vigne, M., Philippon, O., Dervillé, M., Daviron, B., Dorin, B. (2020). Milk and dairy in India's development path: Lessons from a multi-location research. VKCoE Digest (Vergese Kurien Center of Excellence),. Anand, India. Volume-I, Issue-II: pp. 9-10.
- Aubron, C., et al. (2015). "Pauvreté et inégalités en Inde rurale. Réflexion à partir de deux diagnostics agraires dans l'État du Gujarat." *EchoGéo*(32).
- Birthal, P. S., Jha, A. K., Tiongco, M. M., & Narrod, C. (2008). Improving farm-to-market linkages through contract farming: a case study of smallholder dairying in India. *Intl Food Policy Res Inst.*
- Chagwiza, C., Muradian, R., & Ruben, R. (2016). Cooperative membership and dairy performance among smallholders in Ethiopia. *Food Policy*, 59, 165-173.
- Cerulli, G. (2014). *ivtreatreg: A command for fitting binary treatment models with heterogeneous response to treatment and unobservable selection*. *The Stata Journal*, 14(3), 453-480.
- Chambers, R., & Conway, G. (1992). *Sustainable rural livelihoods: practical concepts for the 21st century*. Institute of Development Studies (UK).
- Chandramouli, C., & General, R. (2011). Census of india 2011. Provisional Population Totals. New Delhi: Government of India, 409-413.
- Chandrasekhar, S., & Mehrotra, N. (2016). Doubling farmers' incomes by 2022: What would it take. *Economic & Political Weekly*, 18, 10-13.
- Daniel, J. (2011). *Sampling essentials: Practical guidelines for making sampling choices*. Sage Publications.
- Das, V. K., & Ganesh-Kumar, A. (2019). Off-the-farm livelihood choice of farm households in India (No. 2019-032). Indira Gandhi Institute of Development Research, Mumbai, India.
- Esteban, T. (2016). La pluralité des modèles de coopération en soutien à la diversité des producteurs laitiers du Gujarat. Quel accès au marché et inclusion dans cette ère post-libéralisation? Développement Agricole et Rural au Sud (DARS). Montpellier, Montpellier SupAgro. Master: 109 p.
- Fischer, E., & Qaim, M. (2012). Linking smallholders to markets: determinants and impacts of farmer collective action in Kenya. *World development*, 40(6), 1255-1268.

Furlan, T. (2016). Accès à l'eau d'irrigation et ses conséquences sur le développement des systèmes de production dans une région semi-aride du Nord de l'Inde. Diagnostic agraire du taluka de Gondal dans la péninsule du Saurashtra, Gujarat. Ressources, Systèmes Agricoles et Développement (RESAD). Montpellier, Montpellier SupAgro. Master Degree: 164 p.

Hahn, M. B., Riederer, A. M., & Foster, S. O. (2009). The Livelihood Vulnerability Index: A pragmatic approach to assessing risks from climate variability and change—A case study in Mozambique. *Global environmental change*, 19(1), 74-88.

Hemme, T., Garcia, O., & Saha, A. (2003). A review of milk production in India with particular emphasis on small-scale producers (No. 855-2016-56223).

Himanshu, H., Lanjouw, P., Mukhopadhyay, A., & Murgai, R. (2011). Non-farm diversification and rural poverty decline: A perspective from Indian sample survey and village study data

Indian Ministry of agriculture, cooperation & farmers welfare, 2019. Department of fertilizers. <https://urvarak.nic.in/getStateWiseStockAsOnMapToday>

Jenin, L. and M. Dervillé (2019). Milk Producers Companies: an institutional innovation to face liberalisation and save smallholder's ownership? Milk and Dairy in India's Development Path. Lessons, challenges and perspectives, Indian International Center, New Delhi.

Kishore, A., Birthal, P. S., Joshi, P. K., Shah, T., & Saini, A. (2016). Patterns and drivers of dairy development in India: insights from analysis of household and district-level data. *Agricultural Economics Research Review*, 29(1), 1-14.

Kumar, A., Shinoj, P., & Jee, S. (2013). Do dairy co-operatives enhance milk production, productivity and quality? Evidences from the Indo-Gangetic Plain of India. *Indian Journal of Agricultural Economics*, 68(902-2016-66835), 457-468.

Kumar, A., Saroj, S., Joshi, P. K., & Takeshima, H. (2018). Does cooperative membership improve household welfare? Evidence from a panel data analysis of smallholder dairy farmers in Bihar, India. *Food Policy*, 75(C), 24-36.

Kumara Charyulu D, Moses Shyam D, Wani SP and Raju KV. 2016. Rythu Kosam: Andhra Pradesh Primary Sector Mission. Rayalaseema Region Baseline Summary Report. Research Report IDC-15. Patancheru 502 324. Telangana, India: International Crops Research Institute for the Semi-Arid Tropics. 32 pp. ISBN 978-92-9066-587-8 <http://idc.icrisat.org/idc/wp-content/uploads/2018/01/IDC-Report-No-15-Rythu-Kosam.pdf>

Mahida, D., Sendhil, R., Sirohi, S., Chandel, B. S., Ponnusamy, K., & Sankhala, G. (2018). Potential impact of dairy cooperatives on sustainable milk production: Evidence from Gujarat, India. *Indian journal of Economics and Development*, 14(1a), 402-409.

Marblé, Y. (2019). Analyse de la contribution des systèmes laitiers au développement durable des territoires Etude de deux micro territoires contrastés en Inde du Sud-est et à l'Île de La Réunion. Sciences Humaines et Sociales. Réunion, Université de la Réunion. **PhD Thesis**: 302 pages.

NDDDB (2018). Dairying in Andhra Pradesh a statistical Profile 2018, National Dairy Development Board: 107 p.

NDDDB (2019). Annual Report 2018-2019: 52 p.

Punjabi, M. (2009). "India: Increasing demand challenges the dairy sector." Smallholder dairy development: Lessons learned in Asia 2. <http://www.fao.org/3/i0588e/i0588E00.htm>

- PRS Legislative Research (2018). Gujarat Budget Analysis 2018-2019. New Delhi, Institute for Policy Research Studies: 6
[p.https://prsindia.org/files/budget/budget_state/gujarat/2018/Gujarat%20Budget%20Analysis%2018-19.pdf](https://prsindia.org/files/budget/budget_state/gujarat/2018/Gujarat%20Budget%20Analysis%2018-19.pdf)
- Rahman, A., & Mishra, S. (2020). Does non-farm income affect food security? Evidence from India. *The Journal of Development Studies*, 56(6), 1190-1209.
- Raj, K. N. (1971). "India's sacred cattle: Theories and empirical findings." *Economic and Political Weekly*: 717-722.
- Raj, K. N. (1975). "Agricultural development and distribution of land holdings." *Indian Journal of Agricultural Economics* 30(902-2018-1916): 1-13.
- Ravichandran, T. (2020). Comparison of institutional arrangements for inclusive dairy market development in India.
- Ravishankara, K. M., Dixit, A. K., Datta, K. K., & Singh, S. P. (2019). Effect of Cooperative Dairy Society on the Performance of Dairy farms in Mandya District of Karnataka. *Indian Journal of Economics and Development*, 15(4), 580-585.
- Scoones, I. (1998). Sustainable rural livelihoods: a framework for analysis.
- Shah, T., Gulati, A., Shreedhar, G., & Jain, R. C. (2009). Secret of Gujarat's agrarian miracle after 2000. *Economic and Political Weekly*, 45-55.
- Shylendra, H. (2013). "Microfinance and the Cooperatives in India: Can the Poor Gain from Their Coming Together?" *International Journal of Rural Management* 9(2): 151-181.
- Singh, S. R., & Datta, K. K. (2013). Future of Smallholders in the Indian Dairy Sector—Some Anecdotal Evidence. *Indian Journal of Agricultural Economics*, 68(902-2016-66708), 182-194.
- Staal, S. J., Baltenweck, I., Njoroge, L., Patil, B. R., Ibrahim, M. N., & Kariuki, E. (2006, August). Smallholder dairy farmer access to alternative milk market channels in Gujarat. In IAAE Conference, Brisbane, Australia.
- Subramanian, S., & Lavani, M. (2018). Poverty, growth, inequality: some general and India-specific considerations. *Indian Growth and Development Review*.
- Tenzin, G., & Natsuda, K. (2016). Social capital, household income, and community development in Bhutan: a case study of a dairy cooperative. *Development in Practice*, 26(4), 467-480.
- United Nations (2010). Guide pratique pour la conception d'enquêtes sur les ménages, Département des affaires économiques et sociales, division statistique.
- The World Bank group (2011). Demand-Led Transformation of the Livestock Sector in India: Achievements, Challenges, and Opportunities. S. A. A. a. R. Development. Washington: 176.
- World bank group (2017). Gujarat, Poverty, growth and inequality: 5 p.