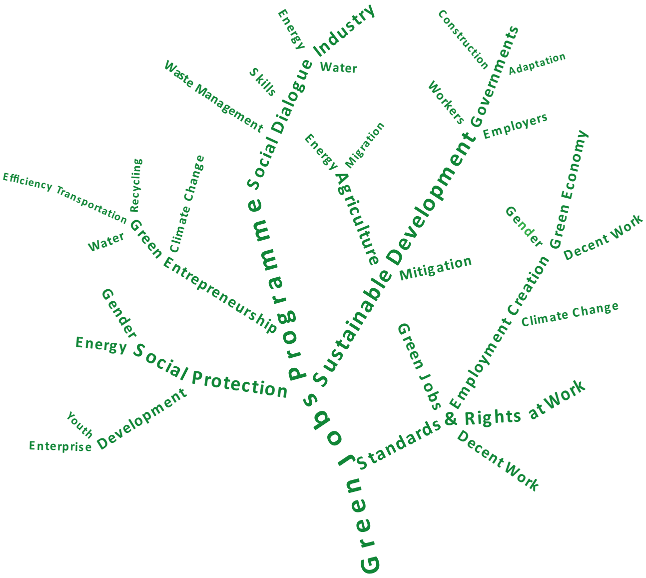

International Labour Organization

The economics of biogas

Creating green jobs in the dairy industry in India

Green Jobs Programme

ILO Country office for India

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First published 2014

ISBN 978-92-2-127428-5 (print)
ISBN 978-92-2-127429-2 (web pdf)

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Acknowledgement

This paper was developed as part of the ILO Green Value Chain Project in Jabalpur, Madhya Pradesh, India. It is the result of a close working relationship between the Green Jobs Programme in Headquarters and the Green Jobs Programme in Asia and Delhi.

The author would like to specially thank the Delhi Office and Hideki Kagohashi for the guidance provided throughout the study and the peer review of the paper. Special thanks are acknowledged to Sharad Tiwari from Development Alternative (DA)/Technology and Action for Rural Advancement (TARA) who organized all the fieldwork, interviews and discussions and provided expertise and secondary data during the entire research. Excellent feedback was given by Vincent Jugault and Merten Sievers and other colleagues from the ILO. It was edited by Xinxing Li and Anna-Maria Fyfe. Finally, great thanks to my dear friend and Green Jobs Manager Kees Van Der Ree without who the whole study would not have been realized.

Executive summary

India is the largest milk and cow dung producer in the world. With a production of approximately 120 million tonnes of milk in 2011, demand in the country is projected to grow more rapidly in the future to 200 million tonnes in ten years' time. In parallel to the growth of the milk industry, the occurrence of dung will further increase from an estimated current total output of 2 million tonnes per day to over 3 million tonnes in 2022. While policy tends to focus on milk production, dung is already driving an informal economy of national importance, which is largely overlooked.

Due to rising urbanization, milk output growth is increasingly driven by demand in cities. Consequently, the dairy industry which has traditionally been dominated by rural low productivity smallholders' farms is expanding into peri-urban areas with an increase in the number of stall-feed farms with higher productivity levels. This shift in growth poles has led to the emergence of a new phenomenon, namely a high concentration of dung available for commercial use in peri-urban dairy clusters, in addition to its continuously growing amount in rural areas. The study presented in this report has found that the productive use of total available dung could create nearly 2 million additional full-time permanent jobs in dung collection, biogas plants, electricity generation and fertilizer production in rural and peri-urban areas.

This paper analyses the economics and employment of the cow dung industry in India. It is based on a case study of the dairy cluster in Jabalpur, Madhya Pradesh. Primary data from a cluster of 40,000 buffalos is placed into the context of secondary data at national level. The analysis also considers environmental and emission aspects in light of India's National Action Plan on Climate Change.

An interesting finding from the study is that in the Jabalpur cluster, two jobs in the milk industry entail approximately one job in cow dung activities. The economic value generated by cow dung activities in Jabalpur is estimated at INR27million per month and accounts for a tenth of the value of the milk industry (INR222 million per month). The dung economy is driven by the fact that a high breed stall-fed buffalo giving 15 litres of milk per day also produces 3 litres of crude oil, which is the equivalent energetic value of approximately 30 kg of fresh dung. The number of persons who derive their primary source of income from cow dung was found to be around 1,750, which is over half of the 3,500 jobs in the milk industry. This could indicate that the dung industry is more labour intensive but provides a lower pay than the milk industry, or that the non-monetary value of cow dung activities is much higher than calculated. For example, most women working in the dung industry also produce dung cakes for their own cooking use which is not valuated in economic terms. As households have free access to dung, it is probable that its economic value is in fact much higher than the monetary value calculated. The volume of the informal economy and the income in kind that it generates is of high importance to families, dung being the basic source of cooking energy for the majority of households in Jabalpur.

Nationally, it is estimated that out of a total of nearly 400 million milk animals in India, 25 per cent are held in animal feeding operations (AFO) and confined animal feeding operations (CFAO). Another 20 per cent are kept in clusters, where dung could be collected and productively used on a large scale. Approximately 880,000 tonnes of dung is produced per day by these animals which could be commercially useable. It is estimated that currently only 50 per cent of total dung is productively processed with the remainder being applied to fields, dumped or washed away. Based on these assumptions, the removal and productive use of dung currently supports an estimated 1.5 million jobs nationally. Most of these jobs, particularly those related to cleaning and dung cake production activities, are not considered to be decent jobs. The transformation of these jobs into green and decent jobs is possible but will only occur with the support of targeted policies. Similarly, jobs could be created through untapped employment opportunities making productive use of underutilized dung.

The increased productive use of smallholders' as well as commercial dung could also lead to job creation. Regarding small-scale dung, 12 million biogas digesters could be set up all over India, creating a potential of 100,000 additional full-time permanent jobs in construction. Additional jobs could also be created by systematically collecting dung as well as building and operating community level biogas plants. The potential of biogas electricity from commercial dung is estimated at 5,000 MW, which could lead to the creation of 950,000 jobs. However, there will be repercussions on the labour market if changes are made to the current low productive use of dung cake making toward higher valued goods, such as electricity. These changes could lead to an estimated loss of 400,000 jobs in the dung cake making industry. Yet, with the right policy and because of the similarities in job profiles, most dung cake making jobs could be transformed into compost production jobs. Nonetheless, counting only direct employment, it is estimated that while 1 tonne of fresh dung in dung cake making supports approximately 1.1 jobs, a shift toward the use of dung for electricity generation combined with compost making only sustains 0.9 jobs. Job losses are, therefore, likely to occur. However, it is estimated that these losses could be offset as only 40-60 per cent of total dung is productively used. In addition, up- and- downstream employment such as the productive use of electricity could create further indirect and induced employment. The net number and quality of green jobs depend largely on policy choices and on the way a transformation is managed. If quality employment policies with a focus on substantial decent jobs and social protection perspectives were implemented (see Recommendations), a net gain is foreseeable with the generation of approximately 1.985 million new direct, permanent and full-time green jobs.

In addition to its economic and social dimension, the dung and dairy industry is responsible for significant levels of national greenhouse gas (GHG) emissions which contribute to climate change. Agriculture and livestock accounts for 50 per cent of total methane emissions (5 million tonnes per year), while the methane and nitrous oxide account for 23 and 22 per cent of India's current GHG emissions respectively (the remainder are CO_2 emissions). Emissions from anaerobic digestion are released during the rainy season when cow dung is not dried but dumped or washed directly into the rivers. Conservative estimates of the total emission reduction potential from the non-utilized dung of the livestock industry are 4.3 million tonnes of CO_2 equivalent (tCO_2e) per year. Substantial international climate funds could be leveraged for investments in biogas plants reducing GHG emissions through the Clean Development Mechanism (CDM).

Regarding policy-making, a comprehensive long-standing national policy on milk production is already in place due to the national importance of milk for nutrition and food security. From a developmental perspective, cow dung is of similar importance due to its use as a primary source of energy, particularly for cooking. Dung can also be used productively for basic energy, biogas, electricity and fertilizer and has a strong socio-economic dimension. To date, no policy has yet capitalized on the potential of dung.

Policy on cow dung is fragmented and until recently focused on small-scale biogas plants due to the large majority of cattle being held by smallholders. A number of stand-alone interventions are already in place such as the National Biogas and Manure Management Programme (NBMMP) and the Biogas based Power Generation Programme (BPGP). However, the effects of these policies have been very limited and a holistic approach which is aligned to the national policy, integrates cow dung industry into dairy industry and considers the employment aspects is lacking.

In light of these findings, this paper argues for an integrated Energy-Dairy Policy which would align dung management strategies to the national dairy industry policy. For example, the establishment of milk processing and chilling factories could simultaneously include the constructions of adjacent biogas power plants which are conceptually similar to the synergies in Combined Heat and Power (CHP) plants. The collection of milk could be organized jointly with the collection of dung. Institutionalized skills training to enable such investments would need to be enhanced. Taking such a holistic approach is expected to lead to the creation of millions of new green jobs while making existing jobs in cow dung more decent. At the same time, such a policy would increase the performance of the dairy industry as a whole. It would also address the most pressing bottlenecks in milk production, namely the quantity and quality of the product. Reduced energy expenditures and increased farmers' income could lead to increased investment and a higher *quantity* of milk production whereas biogas based processing and sterilization could improve the *quality* of milk.

1. Introduction

India's milk production increased from approximately 20 million tonnes in 1968 to 122 million tonnes in 2011, making it the largest milk producing country in the world. It is estimated that demand in India will further increase to 200 million tonnes in 2022 (National Dairy Development Board, 2011). Should exports and imports remain limited, domestic milk production will need to grow at an even faster pace in the future in order to meet this demand. Over the last 15 years, 2.5 million tonnes of milk were produced yearly. A 4 per cent annual growth is necessary to achieve an incremental addition of approximately 5 million tonnes of milk per year over the next 15 years. The Indian dairy industry is already changing to meet this growing demand while fending off international competition. In addition to its mostly traditional small rural milk producers, clustered and commercial farms in peri-urban areas are beginning to emerge.

In the past, the growth of the milk industry was achieved through the Operation Flood Programme and the Anand Model which was initiated in the 1970s to achieve the objectives of self-sufficiency and food security. The model is based on the promotion of cooperatives through financial and technical support from the government for their creation and development. Strong cooperatives were created as a result, supporting the growth and linking millions of smallholder farmers to rear dairy animals. The uniqueness of the Anand Model lies in its focus on very small individual producers owning one to three milk animals. Nowadays, approximately 75 million smallholders are engaged in low productivity dairying activities, predominantly in rural areas (NMCC, 2010). Seventy per cent of the Indian population still resides in rural areas and depends primarily on agriculture and, to an increasing extent, on dairying for their livelihoods. The *rural* dairy industry is, therefore, likely to remain dominated by smallholders in the foreseeable future. Radical transformation on a par with developed dairying nations to turn the industry into a productive-oriented, technology-driven and profit-making business sector is unlikely. In some years to come the rural dairy market will probably still be dominated by labour-driven smallholder enterprises with low productivity and low input-output cost ratio, adopting low cost home-grown technologies.

However, with fast growing demand in urban areas and the liberalization of the Indian dairy industry, which started in 1991 and accelerated in the 2000s, the emergence of larger and more productive farms and dairy clusters has been observed. Having to deal with a competitive business environment in a globalized world, growth poles in the dairy industry are transitioning from small to large farms and from rural to *peri-urban* areas. In addition, increasing consumer demand for quality milk provides strong incentives for investing in larger farms with the necessary safety equipment and hygienic standards. Milk producers are clustering and further developing into private or cooperative-owned processing plants to centrally collect and pasteurize milk. Following the opening up of the Indian dairy industry, the number of processing facilities has grown significantly. There are approximately 700 registered dairy units which process nearly 15 per cent of the milk produced (Banerjee, 2008).

In light of these trends, the future growth of the Indian dairy production is likely to be driven by (i) a continued growth of smallholders in rural areas, coupled with (ii) new and accelerated growth of larger farms in peri-urban centres. The Indian dairy industry which was in the past dominated by rural smallholders, is now developing into a two-tier industry with smallholders and industrial farms existing in parallel. Although very different in their structures, both types of farms share a common objective, namely to increase the production and quality of milk in order to improve the income and food security of both rural and peri-urban households and farmers.

To achieve this objective of quantitative high quality growth, a new dairy strategy and policy will need to broaden the focus away from solely milk production towards integrated farm management. In an increasingly competitive environment, productivity should not only consider milk in terms of output per animal, but also as a total farm output in relation to total input. Value should be maximized along the dairy chain from storage facilities for fodder input to the productive use of dung for energy and fertilizer. Importantly, the current and future growth of the dairy industry will not only increase the milk output growth. It will simultaneously lead to a massive increase in dung production, a phenomenon which is often overlooked.

This phenomenon occurs differently in rural and peri-urban settings. With an increasing growth of peri-urban dairy clusters, a massive amount of concentrated dung from Animal Feeding Operations (AFO) is generated. Technology advancement in large scale bio-digesters create opportunities for the productive use of dung occurring on an industrial scale. Conversely, in rural areas, although the collection of dung from roaming animals poses a challenge, decreasing prices for family-size biodigesters is also creating opportunities for smallholders.

In addition to the industrial occurrence of dung and increasingly affordable biogas technology for smallholders, the economic context is also changing. While in the 1970s food security was the main developmental concern in India, nowadays the focus is placed on energy which is seen as a principal impediment to fostering socio-economic development. In the wake of soaring and volatile energy prices and diminishing energy sources, rural families and the poor are likely to suffer the most. With 72 per cent of the population still relying on traditional use of biomass, the local production of biogas for cooking, lighting and fertilizer for farming could significantly improve income and energy availability for the rural poor. With 25 per cent of the Indian population still living without access to electricity – thus hindering economic and social development – electricity generation for rural mini grids could significantly improve their access to energy. In peri-urban areas, large biogas electricity plants could also feed into the national grid adding to much needed total generating capacity.

An integrated Dairy-Energy Policy is needed to turn these potential benefits into a reality. Although policies, such as the National Biogas and Manure Management Programme (NBMMP), already exist alongside the National Dairy Plan (NDP), these policies do not seem to be well coordinated nor aligned. While the NBMMP specifically targets the promotion of dung and biogas, the NDP focuses on milk production. Neither of them offers an integrated approach in promoting both the dairy and dung industries jointly or linking one industry to the other (MNRE, 2009a; MNRE, 2010c; National Dairy Development Board, 2011).

Aligning dairy and energy policies to the productive use of dung for biogas, electricity generation, milk processing, pasteurization and fertilizer is a promising way to (i) increase farm productivity, (ii) improve milk quality, (iii) address energy poverty, and (iv) create employment. In addition, such an integrated Dairy-Energy Policy would alleviate environmental pressure emanating from deforestation, greenhouse gas emissions and dung pollution. Locally, dung pollution is a new phenomenon whereby water becomes polluted when large amounts of dung waste are disposed into rivers and the surrounding areas.

In accordance with the two-tier structure of the industry, the design of such a policy should take into account five determinant differences between large commercial peri-urban farms and self-sufficient rural smallholders:

1. Difference in farm size, structure and location: dispersed small rural farmers with one to eight grazing animals *versus* large commercial farms of 50 to 1,000 animals clustered in peri-urban areas in confined animal feeding systems;
2. Difference in organization: individual self-organized rural smallholders based on the Anand Model *versus* large commercial farms privately managed or in loose business associations;
3. Difference in availability of dung: small quantities of 20-50 kg/day in small rural farms *versus* 1-30 tonnes/day concentrated in large peri-urban farms;
4. Difference in available milk and dung collection systems and infrastructure: non-collected dung from roaming animals in rural areas *versus* contracted dung intermediaries in commercial farms who clean and transport the dung to biogas plants or for final disposal. The difference also applies to milk collectors in peri-urban milk clusters who transport milk to central processing plants *versus* non-organized settings where milk is not collectively transported;
5. Difference in terms of energy and fertilizer needs: non-electrified rural areas where access to electricity is difficult *versus* modern cooking fuel and fertilizer, electrified in peri-urban centres which are also partly equipped with liquefied petroleum gas (LPG) for cooking and have access to chemical fertilizer.

Regarding peri-urban dairy clusters, the integrated Dairy-Energy Policy should incentivize ‘combined investment’ in both milk processing facilities and large biogas plants simultaneously. The example of Combined Heat and Power (CHP) plants in the energy sector could be followed, where power plants generate electricity for the processing plant or the national grid.

Market-based policy instruments such as feed-in tariffs, tax incentives and rebates for green capital investment, and access to clean development financing should be coupled with capacity development, institution building, as well as technical and vocational training for engineers and management training for investors. Global evidence suggests that feed-in tariffs, in particular, have proven to be very successful in the promotion of renewable energies. While such tariffs have been introduced in India, biogas is often not eligible at the state level and/or does not reflect real power generating cost. Adjusting the price of power purchasing agreements for biogas on a par with other renewables would be essential to make biogas investments commercially attractive.

Market-based approaches could be complemented with regulatory measures, such as mandatory requirements for ‘Combined Milk Processing and Electricity Generation’ units where biogas plants are set up simultaneously to processing plants. These policy instruments should be designed jointly by the Ministry of Energy and the National Dairy Development Board and aligned to the NDP, the NBMMP and the Remote Village Electrification Programme (RVE) (MNRE, 2010a; 2009b). For example, a feed-in tariff policy could be combined with institutionalized capacity building, technical and vocational training and enterprise development strategies in the dairy industry. Furthermore, the organization of dung collection, transportation and productive use of slurry, such as organic fertilizer, could be incentivized. Specific attention needs to be paid to potential job losses in less productive dung activities, such as dung cake making. Cooperation with the Ministry of Labour should thus be sought. Social dialogue and just transition frameworks would create opportunities to relocate redundant dung cake workers into similar jobs such as vermicomposting production from slurry in biogas plants.

Concerning dairy smallholders, an integrated Dairy-Energy Policy could benefit from past experiences in Indian dairying. The very successful Anand Model of cooperative dairy development could be used as a basis for a new Anand/Shakti Energy Model which would integrate milk production and dung collection. It could be designed to foster milk output growth at the same time as the productive use of dung. The 13 million smallholders already connected with the dairy cooperative institution could benefit from an upgraded support. Aggressive outreach to combat energy poverty, low productive subsistence farming and food insecurity could further increase the number of smallholders organized in cooperatives. Financing, training, capacity building and direct support in construction and maintenance of biogas digesters and production of organic fertilizer could be part of this support. Smallholders are able to supply milk twice a day (in the morning and in the evening) and are guaranteed payment based on the quality of the milk supplied. The same model could be applied to dung. As part of the package, benefits provided by the cooperatives to its producer members, smallholders could receive services related to the productive use of dung. Such services could include microfinance for investment into a family biogas digester, the provision of a certified mason to build and maintain the plant, and training and capacity building in operating the plant. These services should include and be based on a thorough assessment and selection process for the installation of small biogas plants in order to avoid failures and discouragement by non-functional plants. An ILO manual has been developed in this regard.[1] In addition, cooperation with the dairy education institutions as well as the private sector is crucial. If after a thorough assessment and selection process, it emerges that conditions at the farm are not favourable for family-size biogas plants, a centrally built medium-size village plant could be set up and run by cooperatives. Dung could then be collected at the same time as milk and processed centrally. Village plants would also provide electricity or gas to the households. Beyond individual members, the village community would also reap benefits as a whole. In certain progressive cooperatives which would fully adopt the Anand/Shakti Energy Model, financing could be provided for investments in electricity generating plants and mini grids supplying electricity to the village. The Anand Shakti Energy Model would, therefore, use dung in addition to milk as a tool for socio-economic development.

In order to form such an integrated Dairy-Energy Policy, this study aims to provide evidence on the current size of the dung economy in terms of employment and output. From the baseline, a scenario is projected which assumes the productive use of total available dung. The potential for job creation and value added is then assessed. Policy recommendations are made on the basis of the findings.

[1] *Green Value Chain Development for Decent Work – A Guidebook for Development Practitioners, Government and Private Sector Initiatives* (forthcoming) offers a practical guide to assess value chains by integrating green opportunities as well as environmental impacts of the value chain into the analysis.

It is difficult to estimate employment at the national level due to the lack of available official data. Employment in dung activities and the structure and size of farms is not well known. Knowledge on the size of herds and farms, and specifically on the number of animal feeding operations (AFO) and confined animal feeding operations (CAFO), would help to determine the number of persons working in these farms in dung activities as well as the amount of dung produced. This is due to the fact that AFO and CAFO farms produce dung on a commercial scale and hence create additional labour to cleaning of the stalls and in dung cake making, compost and electricity generation. Small household farmers who only keep a few animals work primarily on their own and thus do not generate additional employment, while small biogas plants create employment for masons and maintenance workers.

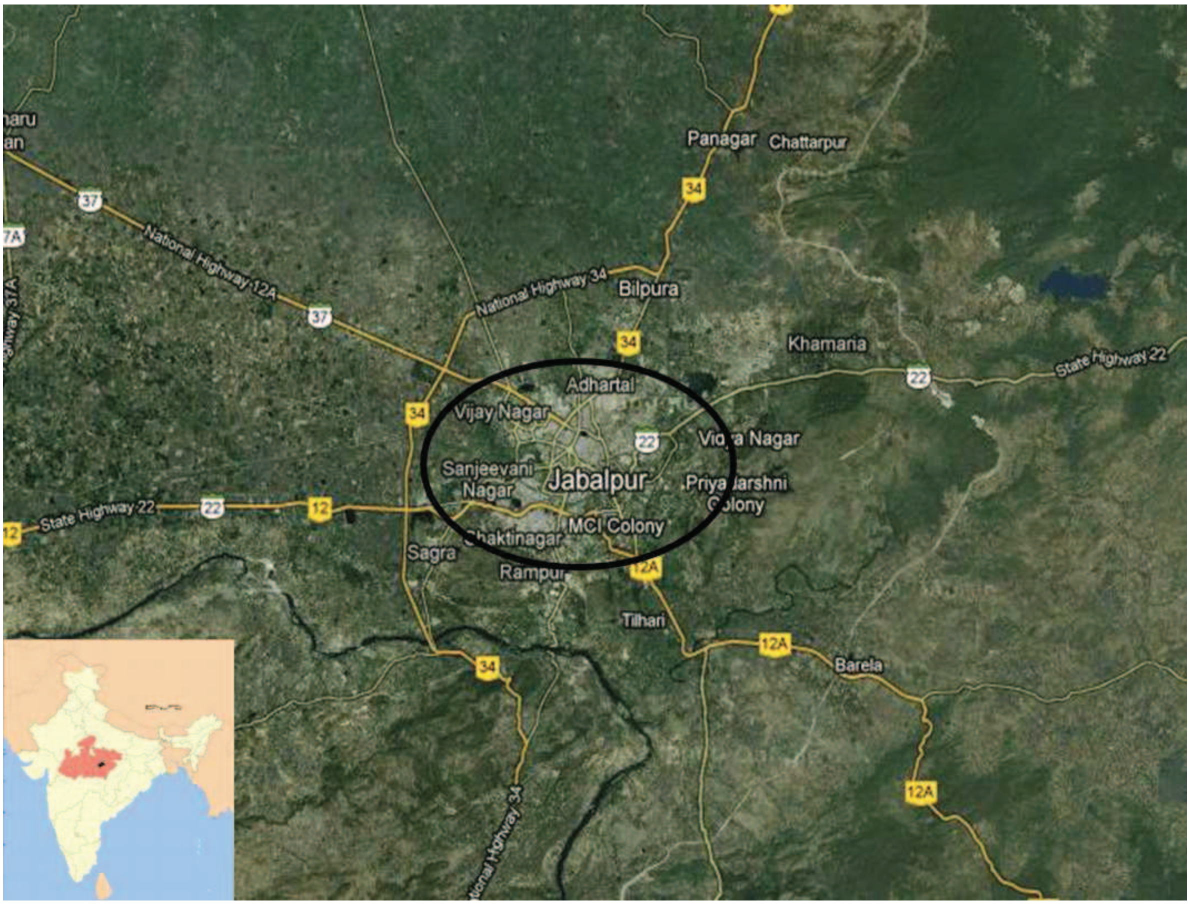
To fill the data gap, this study has derived its employment estimations from the total population of dairy animals as indicated in the latest national livestock census from 2007. The national estimations are based on the employment-dung ratio found in the case study of the dairy cluster in Jabalpur, Madhya Pradesh, India. Based on the consolidated figures for the Jabalpur cluster, extrapolations have been made for the Indian dairy and dung economy as a whole. The total available dung has been derived from the total cattle population. Employment at the national level has been calculated on this basis. These estimations have been supplemented with academic literature and official reports on the Indian dairy and biogas industry.

Primary quantitative data was collected in November 2011. The range of data covers employment, wages, quality of work, prices of milk, dung, compost, biogas and electricity. The data was collected through a questionnaire designed specifically for dairy farmers and dung contractors of large, medium and small farms. Structured interviews were held with government officials, academics from university, dairy associations and cooperatives. Private sector companies engaged in activities including milk, compost and biogas, as well as other stakeholders such as brick kiln owners were also interviewed with the support of a similar questionnaire. Meetings and discussions were held with women's associations, informal worker groups and dung cake makers.

Due to the small sample size of the interviews, and the difficulties faced in the collection of rigorous data on output and employment at the national level, the estimations on the Jabalpur dung economy and the national extrapolations should be treated with care. In light of the aforementioned limitations on the robustness of the findings, the data should be interpreted as trends and indications rather than as hard facts. All assumptions are detailed in the Appendix.

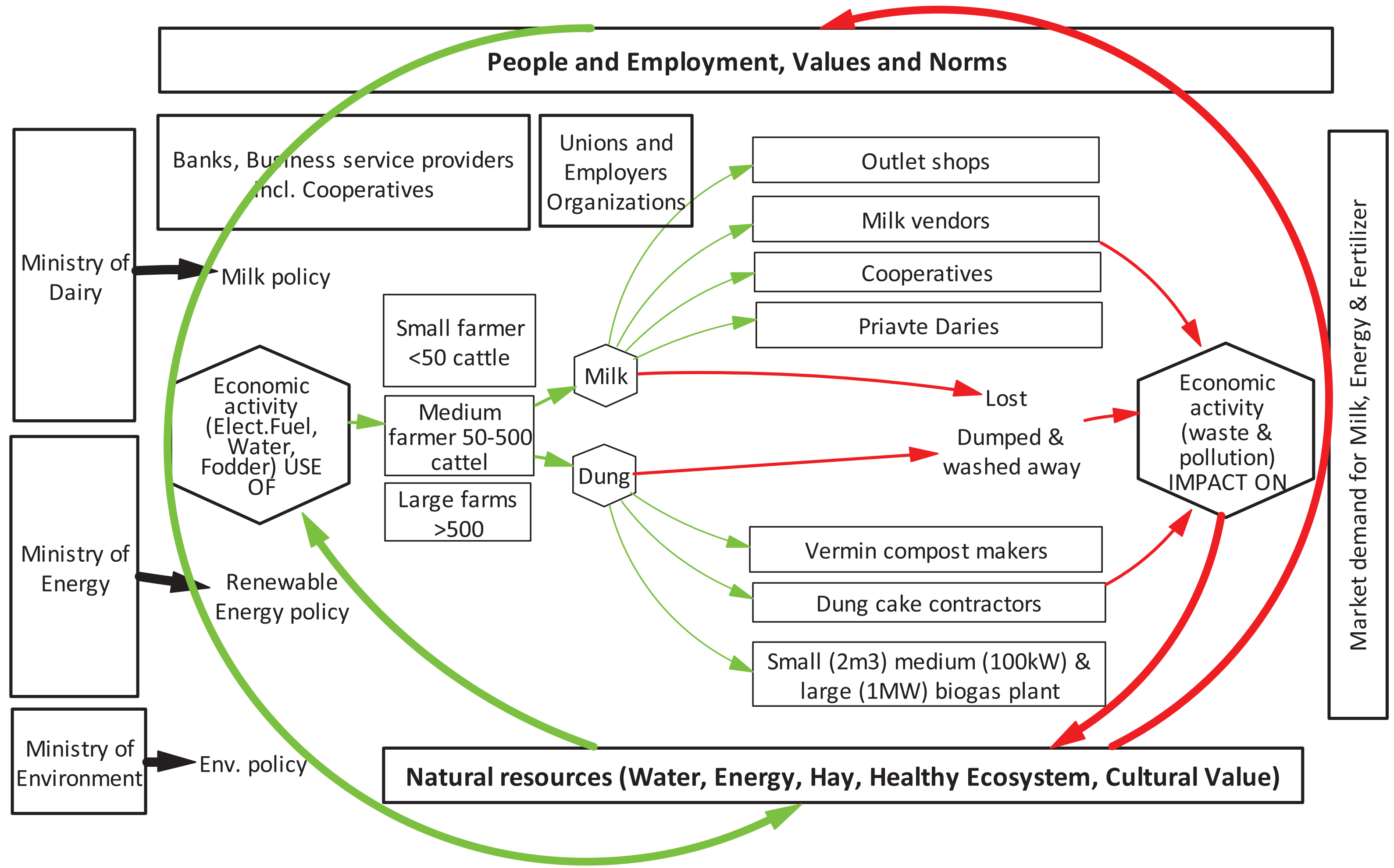
The term 'Jabalpur cluster' refers to a geographical area of dairy farms in a radius of 7-10 km around the city of Jabalpur along the Paryat and the Gaur Rivers (see Figure 1). Approximately 40,000 buffalos are held primarily in large commercial farms and animal feeding operations (31,000 at Paryat River, 6,700 at Gaur River and 2,000 by smallholders). Specifically, the cluster contains a total of 210 commercial farms (50-1,000 buffalos) and 90 small-holder farms (2-50 buffalos or cows).

Figure 1. Jabalpur cluster



The analysis follows a system dynamics approach as developed by the ILO's Green Jobs Programme for value chain development. Value chains are mapped as circular material flow systems from and to the natural environment embedded in the policy context. Positive and negative feedback loops on social and economic outcomes are assessed, with a particular focus on employment (ILO, forthcoming) (see Figure 2).

Figure 2. System dynamics analysis of the dairy industry in India for Green Value Chain Development for decent work



2. The economic and employment dimension of dung

It is difficult to estimate dung employment at the national level, as there is no official data available on this specific area of employment. Information on the structure and size of farms is also limited. Data on the size of herds and farms would help to estimate the total amount of concentrated dung in peri-urban centres versus scattered dung in rural areas. Data on the number of animals in animal feeding operations (AFO) and confined animal feeding operations (CFAO), as well as clusters where dung is concentrated, are also necessary to estimate employment in peri-urban areas. Only larger farms with animal feeding operations or farms in clusters produce dung on a commercially usable scale and, therefore, create additional labour for cleaning, the collection of dung, dung cake making and the generation of compost and electricity. Farmers who only keep a small number of animals in scattered rural areas do not usually employ additional labour and have, therefore, a limited impact on downstream activities. However, small farms could create employment in the construction sector if investments were made in small biogas installations.

This study bases its national estimations on the total dairy animal population and employment dung ratios derived from the Jabalpur cluster. Data comes from the 18th Indian livestock census (2007). Commercial dung refers to dung from dairy animals in clusters or animal feeding operations where dung can be, or has the potential to be centrally collected. Total dung production is derived from the total number of dairy animals in clusters and animal feeding operations, based on the assumption that 5 kilogramme of dung are produced per animal per day.

To determine the number of animals in clusters and feeding operations, it is first assumed that the total buffalo population (105,342,000) is found in clusters or animal feeding operations because of its high breed. Poorer rural smallholders on the other hand are likely to have cows or cross-bred animals. Secondly, out of the total remainder of dairy animals (282,718,000 cattle or cross breed), it is known that approximately 75 per cent are being held by small farmers in rural areas in herds of one to eight animals. Accordingly, the total dairy animal population producing commercially useable dung is estimated at 176,021,500 animals, which is equivalent to 45 per cent of the total. The production of dung comes to approximately 880,000 tonnes per day (MAHDF, 2007) (see Table 1).

Table 1. Total Indian buffalo and cattle population and tonnes of commercial dung

Type of animals	Population
Cattle exotic/ cross bread	
Male	6 844 000
Female	33 060 000
Total cattle exotic cross bread	39 904 000
Cattle indigenous	
Male	76 799 000
Female	166 015 000
Total cattle indigenous	242 814 000
Total cattle	**282 718 000**
Out of total cattle 25% are found in larger farms producing commercial usable dung	70 679 500
Buffalo	
Male	19 597 000
Female	85 745 000
Total buffalo[1]	**105 342 000**
Total animals producing dung on commercial scale	**176 021 500**
Total commercial dung produced per day	**880 000 tonnes**

[1] Assuming that because of the higher breed, 100 per cent are either in clusters or in larger commercial farms.
[2] Assuming a conservative 5 kg of dung per animal. According to the Ministry of New and Renewable Energy (MNRE, 2009b), the occurrence of dung is of 10 kg/day for a cow, 5 kg/day for a calf and 15 kg/day for a buffalo. Furthermore, it was estimated in 1997 that 200 million tonnes of dung were available from a total cattle population of 289 million. For the purpose of this study conservative figures have been used, assuming a dung production of 880,000 per day for a commercial cattle population of 176 million.
Source: Author's own estimation based on the 18th livestock census India (2007)

Using estimates on the employment-dung ratio from Jabalpur, a total of 1.5 million jobs are supported by commercially available dung and 85,000 jobs by dung in rural areas in the biogas digesters construction industry (see Table 2). As in the case of Jabalpur, the calculation indicates that approximately 50 per cent of dung is not used productively and is instead applied to fields, dumped or washed away .[2]

[2] The assumptions as detailed in table 2 are based on the shares as found in the Jabalpur cluster.

Table 2. Estimated current jobs in the dung industry in India removing and productively using 400,000 tonnes of dung per day[1]

Type of job in dung industry	Assumption of number of jobs per tonne and day	Share of total of 880 000 tonnes dung used	Total number of jobs
Cleaners and collectors (half -time jobs in combination with other dairy activities)	1 cleaner or collector for 45 buffalos	50% of dung from the 176 million animals in clusters or animal feeding operations is collected (440 000 tonnes)	1 900 000 part-time jobs Equal to 950 000 full-time jobs
Dung cake makers	1 worker per 1 tonne	46% (400 000 tonnes)	400 000
Compost makers	1 worker per 0.625 tonne	3% (26,000 tonnes)	41 000
Transport and management	1 dung transporter/ manager per 12 tonnes	Only 50% of dung (440 000 tonnes) is transported and managed	37 000
Electricity generation	70 workers in 1MW plant and 120 in fertilizer production (200 tonnes)	1% (8 800 tonnes)	8 800
Small biogas construction[2]	30 man days for the construction of a 2m3 size plant, 5 man days per year for maintenance (assuming 40 kg of dung per digester per day giving 80 000 tonnes)[3]	Construction of 700 000 biogas plants in 5 years	85 000
Total		**50% (440 000 tonnes)**	**1 538 million**

[1] Representing 50 per cent of total available 880,000 tonnes of dung in 2007. Estimates based on the Jabalpur shares.
[2] According to the Ministry of New and Renewable Energy (MNRE) and the Confederation of Indian Industry (CII), 2010
[3] Figure by MNRE

Some of these existing jobs are part-time jobs, combining dairy activities with dung collection and farm cleaning. However, most of these jobs, and particularly those in cleaning and dung cake making jobs, are not decent jobs as they are mostly informal and often entail hazardous working conditions. Nevertheless, with the right policy these jobs can be transformed into green jobs.

Should the share of collected dung increase, additional green jobs could be created by promoting the productive use of the currently underutilized dung. It is estimated that commercially available dung increased from 880,000 tonnes in 2007 to 1 million tonnes in 2012, along with a 2 per cent annual growth of the dairy industry (conservative estimation). Accordingly, for 2012 it is deduced that 200 million dairy animals will produce 1 million tonnes of dung per day available for commercial use. The potential power generation from this amount of dung is estimated at 5,000 MW. Assuming that this potential is tapped into by 1–1.2 MW plants which support around 70 jobs in their operation, 350,000 jobs could be created. In addition, because 120 jobs are needed to turn slurry into compost, the total job creation potential is estimated at 950,000. If this potential is realized, jobs will be required to clean, collect and transport the additional 660,000 tonnes of dung (it is assumed that currently only 440,000 tonnes are collected). This would entail approximately 1.2 million full-time jobs for the handling of dung produced by 124 million animals.

However, jobs in the dung cake making industry will be lost if there is a shift of dung use toward electricity generation. It is assumed that if the full potential of 5,000 MW is realized, the total available commercial dung coming from clusters and animal feeding operations will be absorbed by biogas power plants. The current 400,000 jobs in dung cake making would, therefore, be lost. Nevertheless, feeding the 660,000 tonnes of dung which are currently under-utilized into the productive economy would lead to a net gain of over half a million new jobs. This calculation only counts jobs in large electricity generation plants, in comparison to former jobs in dung cake making. Due to the similar job profiles of dung cake makers and slurry compost care takers, it would be possible to compensate job losses through a transition toward employment in biogas and compost facilities (MNRE, 2009b). However, the right policies should be developed and implemented in order to ensure a just transition of the workforce.

Additional employment could be created from non-commercial dung through the construction of small biogas plants and the maintenance of 12 million potential digesters all over India (out of the 4 million existing plants, 2 million are functional, totalling to 10 million plants to be constructed or rebuilt). It is assumed that 30 man-days are needed to build a $2m^3$ plant and 5 man-days are required for proper maintenance. Assuming that a total of 1 million plants could be constructed per year over the next 10 years, 140,000 full-time permanent jobs could be created in construction and maintenance (GoI, 2002). This would require a large and ambitious increase of the targets in the current 11th and upcoming 12th Five Year Plan. The target number for small biogas plants should be increased to 5 million plants for the next five years and an additional 5 million plants in the consecutive years, to reach the target of 10 million plants by 2022.

Summing up the net employment gains, the dung industry could potentially lead to the creation of 1,985 million additional full-time permanent green jobs. However, the majority of workers are unskilled labourers in dung cleaning, collection (1.24 million), transportation (55,000) and low-skilled jobs in fertilizer production (600,000 jobs). A number of skilled workers are required in large biogas and electricity generation plants (350,000) and the construction of small biogas digesters (140,000) (see Table 3).

Table 3. Potential of green jobs creation in India in biogas and electricity generation from an estimated available commercial dung of 1 million tonnes in peri-urban areas and 750,000 tonnes in rural areas

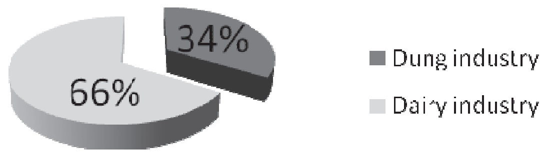
Potential green jobs creation	Dung absorbed from rural and urban (cluster) areas	Estimation
Electricity generating plants of 1 MW capacity each, with a total of 5 000 MW including fertilizer production from slurry	1 million tonnes (200 tonnes per 1 MW) from urban clusters	950 000
Transport and dung management in urban clusters for 660 000 tonnes (in addition to 444 000 tonnes which have already been transported)	660,000 tonnes (1 manager /contractor manages 12 tonnes)	55 000
Construction and maintenance of 10 million small biogas plants (in addition to 2 million existing and functioning plants)	750,000 tonnes (60 kg dung per plant and day) from rural areas	140 000
Dung collectors and cleaners for the additional 124 million animals	100% of commercial dung in peri-urban areas is collected, assuming one full-time job for 100 animals[1]	1.24 million
Total		**2.385 million**
Jobs lost in dung cake making due to the absorption of dung by 5000 MW in electricity generation		-400 000
Total net employment gain		**1.985 million**

[1] Figures from the Jabalpur cluster indicate that one woman collects and cleans dung from 45-50 animals. While these are often part-time jobs and to remain on the conservative side, it is estimated that one full-time jobs consists of collecting and cleaning dung from 100 dairy animals.

2.1 Employment in dung

The national estimations of the employment creation potential in the dung industry are based on the findings from the Jabalpur milk cluster. In this cluster, it was estimated that 34 per cent of the total number of jobs in the dairy industry are full-time jobs in the cow dung industry alone. The main activities consist of stalls cleaning, manure transportation, dung cake making, marketing and sales, compost production and retailing, operation of small biogas plants for cooking gas and medium to large biogas plants for electricity generation. A total of 1,730 persons are estimated to be employed in the cow dung industry in Jabalpur versus 3,500 in the milk industry (see Figure 3).

Figure 3. Employment in dairy and dung industries



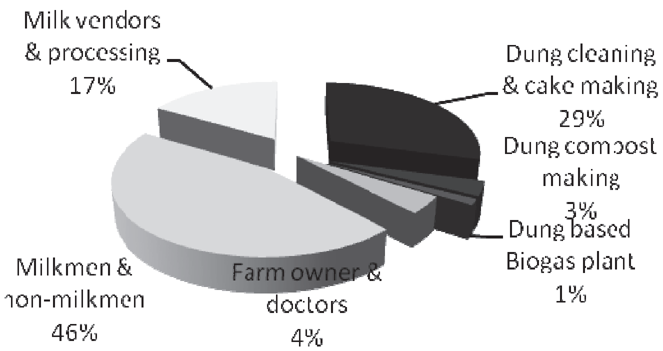
Most of these jobs are related to the milk and dung produced by 40,000 buffalos in the cluster (31,000 in small to large farms at Paryat River and 6,700 at Gaur River, and an additional 2,000 buffalos belonging to smallholder farmers). The farms are located in the peri-urban area of Jabalpur, within a 5 to 7 kilometre radius (see Figure 1 and Table 4).

Table 4. Structure and farm size of the dairy cluster in Jabalpur

Type of farm and number of animals	Number
Large farms (800-1 000)	12
Large to medium farms (500-800)	8
Medium farms (200-500)	75
Small farms (50-200)	115
Non-commercial farms (5-50)	90
Total commercial farms (50-1 000 buffalos)	210

The majority of jobs are low skilled jobs in stall cleaning, dung cake making and composting. Over 90 per cent of workers in this segment are women. A few technicians, managers and highly skilled workers run the biogas plants, manage the compost and dung cake production and oversee the sales and distribution of the various dung cake products (see Figure 4 and Table 5).

Figure 4. Employment in dairy disaggregated by industry



The monthly income ranges from approximately INR1,500 for women cleaning the farms and making the dung cakes, to up to INR50,000 for managers in the dung cake business.

Table 5. Employment in the dung economy in Jabalpur

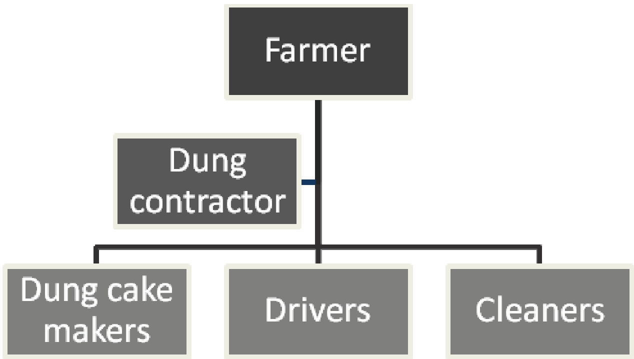
Type of Employment	Assumption on workers employed	Workers employed	Monthly income over the year in INR[1]
Women cleaning dung in the dairy farm	1 women cleans dung from 1 row of buffalos (40-50 animals)	890 women	1 600
Tractor drivers/owners transporting dung	1 male contractor employs/hires 1 male driver	50 male tractor drivers	3 500
Contractors which are contracted by dairy to dispose of cow dung	60% of farms have contractors with on average 1 contractor working for 2 farms	50 male contractors	50 000
Women dung cake makers	1 woman for 1 tonne of fresh dung/day	551 women	1 590[2]
Operator small biogas generator (50 kW)	1 male electrician	1 male electrician	4 500
Cleaner/feeder of small biogas digester	1 male labourer	1 male labourer	3 500
Women employed in commercial vermicomposting business	2 women for 1.25 tonnes of cow dung/day (25-30 trolleys a day)	50 women vermicomposting maker	3 500
Workers in big biogas plant 1.2 MW	70 skilled and unskilled workers, mainly men	70	4 000
Workers in compost making of big biogas plant 1.2 MW	120 women	120	3 500
Total	n.a.	**1 730**	**1 600-50 000**

[1] The monthly salaries are averages which can vary quite significantly depending on the farm, the location, the years of experience and the exact nature of the job (notably for contractors whose income depends on the size of the rented land).

[2] The calculation is as follows (see also Box 1): INR85 per day x 7 = INR595 per week. 595 x 8 months = INR19,040. 19,040 / 12 months = INR1,590

Women perform hard physical work, carrying out tasks such as cleaning the farms, loading the tractor trolleys and forming the dung cakes by hand. While there are certain forms of semi-regular contracts for women cleaning the farms, dung cake making is a performance-based job which pays INR35 per 1,000 cakes. Dung cake makers work mainly without contracts, job security, the opportunity to unionize and job guarantees (see Box 1).

Figure 5. Workers in the dung industry



Box 1

Dung cake workers in Kandra Kheda village (dairy cluster Jabalpur)

In the Kandra Kheda village, approximately 250 women workers earn their primary source of income from the dung cake making business. Some of these women have been working in this industry for 20 years, providing the main source of income for their families.

Types of jobs and contracts: While 50 per cent of the women work in the cleaning of the dairy farm as well as dung cake making, the other 50 per cent only work in dung cake production. Daily tasks consist of cleaning the stalls, removing the dung, washing the farm and loading the tractor trolleys. In the area, no women running their own dung cake business have been identified. Some of them have a semi-formal contract with the farmer which guarantees their employment throughout the year. Most of them depend on jobs allocated by contractors who have a formal contract with the farms.

Working hours: Most of the cleaners work typically between 5-9 a.m. and 4-6 p.m., while half of them sometimes work in between those hours. For dung cake makers, the typical working hours are between 9 a.m. and 1 p.m., and 3-6 p.m,. Unlike farm cleaning jobs, the dung cake business only runs eight months per year due to the rainy season where dung cakes cannot be dried and used. Nevertheless, during those eight months, jobs are mainly considered to be on a full–time basis, seven days a week.

Salary: For cleaners, the weekly salary is approximately INR400 for cleaning one line of 50 buffalos; with other benefits including half a litre of milk every day and a Sari (cloth) worth INR400 once a year. For dung cake makers, their salary is mainly based on performance depending on the number of cakes produced per day. Usually one woman can make approximately 3,000 cakes per day out of an estimated 1 and 1.5 tonnes (or one trolley) of fresh dung. Generally up to INR700 can be earned per week.

Occupational safety and health: Most of the work for dung cake makers requires strong physical movements, for example when carrying heavy loads when loading and offloading the trolleys. Most of the workers form fresh dung cakes by hand without adequate protection. In addition, the squatting working position is frequently reported to lead to backache.

Social security and workers' rights: Workers in the dung cake business have no job security, no possibility to unionize, no bargaining power and no social benefits or security.

The contractor is typically a businessman or woman who holds a contract with a farm owner to allow them to remove the dung, lease a plot of land, oversee dung cake making and retail the finished product. A contractor usually has yearly contracts with one farm. The contractor pays the farm based on the estimation that the dung from 100 buffalos cost the contractor INR10,000 per year, which translates into approximately 1-2 trolleys a day with one trolley costing INR100 (see Box 2).

Box 2

Indira, a female dung cake contractor

Indira is a female dung contractor who has had a contract with one dairy farm of 300 buffalos for the past 20 years. She usually buys approximately three tractor trolleys of around 1.25 tonnes of dung per day for INR100,000 from the farm, where she has to collect the dung herself from a central stocking place. She hires three women to work on the making of dung cakes, which take approximately 10 to 25 days to dry (depending on the sun) and ready to sell. The three employees are paid on a performance basis in line with the sector-wide standard of INR35 per 1,000 cakes. Total costs vary around INR370,000 per year while the income is INR600,000. This leaves the women with a net benefit of 230,000 per year or approximately INR20,000 per month. This represents a much higher salary than what is typically found in the dairy industry which ranges from INR1,200 for women cleaners to INR15,000 for skilled labour in processing and management. The dung cake making business can only operate for eight months out of the year as production has to halt during the rainy season. Indira usually sells one trolley of 7,000-8,000 dung cakes for INR2,500 per day during the dry season. The dung cakes are mainly sold to brick kilns. The transportation costs include the rental costs for a tractor (INR10,000 per month) and the payment of a driver (INR 3,500 per month) and an additional monthly cost of INR6,000 for the diesel. She has to lease 1.5 acres of land which costs INR30-40,000 per year to the business.

This represents a typical contracting model where a farmer sells dung to a contractor (such as Indira) and gives contract for him/her to collect the dung. The contractor leases land or is allocated a piece of land for his/her own business. While 75 per cent of the contractors work under this arrangement, 25 per cent of contractors work directly on the farm. The contractors' preferred arrangement is said to be the one where a piece of land is rented, reducing the level of dependence on the farmer.

Another profitable business is the production of vermicomposting, which requires relatively small initial investment and is highly labour intensive. The only capital investment that is necessary is the construction of pitches under which to spread the dung. Once the worms are introduced to the ground, the process of vermicomposting happens automatically. Approximately 50 workers are needed, mostly women, to regularly sprinkle and air the compost and to transform 35 tonnes of fresh dung into 13 tonnes of vermicomposting per day (see Box 3).

Box 3

Hari OM vermicomposting business

Mr Brajesh Vishwakarma started his vermicomposting business in 2008. He constructed 30 pits of 27x100 feet on 10 acres of land costing INR50,000-60,000 each. The total investment excluding the rental of the land was approximately INR1.5 million with an additional INR80,000 for trolleys of worms which turn the dung into vermicomposting.

A total of 40-50 workers are employed for the business, excluding tractor operators and dung transporters. Out of the total number of employees, 60 per cent are women. Mr Brajesh Vishwakarma has contracted out the transportation of dung to deliver 25-30 trolleys of dung per day which equals approximately to 34 tonnes of manure per day (1.25 tonnes per trolley). He pays INR400 per trolley out of which the transport businessmen earns INR250 as the real cost of transportation is approximately INR100-150 per trolley.

It takes nearly four months to transform manure into vermicomposting. Out of the raw manure only 60 per cent of the weight will be kept as most of the moisture evaporates, thus reducing the total production of compost to approximately 12.5 tonnes per day. It is estimated that 2,000–3,000 tonnes of vermicomposting can be produced in a year, taking into account a break during the winter season. Sales prices vary between INR2-4 per kilogramme with a production cost estimated at INR1.85 per kilogramme, the difference providing net profit.

In addition, the business sells 500 kilogrammes of Wormy Worsa (a mix of washed worms) per year at a price of INR25,000. Water used to wash the worms (approximately 100 litres per year) is sold as concentrated fertilizer at INR100 per litre. The main customer for this compost is from outside Madhya Pradesh where Mr Brajesh Vishwakarma sells 80 per cent of his own labelled compost while the remainder is sold locally.

The biggest challenge which the business faces is to retain a stable workforce as workers may leave to attend festivities for up to four months. This challenge is addressed by taking on labour force from villages which are located more than 150 kilometres away. An additional problem comes from the competition from chemical fertilizer which is highly subsidized, although the demand for compost is growing. With a growing recognition that organic fertilizers outperform chemical fertilizers due to the improved nutrient value and moisture in the soil after a 2-3 years transition while chemical fertilizers drain the soil from nutrients which increases costs for farmers, it is hoped that the consumption of vermicomposting will be enhanced.

Due to the high level of dung locally concentrated in the Jabalpur cluster, a cosmetics corporation called Ayur has invested INR170 million in a 1.2 MW biogas plant. Local farmers supply a total of 200 tonnes of dung at a price of INR100-150 per tonne per day. To operate the plant, 70 workers ranging from simple labour to highly skilled engineers are required, and 120 jobs are planned to be created to make compost. The cost for economically viable power generation stands at approximately INR6 cents per kWh. However, Ayur faces several challenges. Only a feed-in tariff of INR3.36 cents is accorded, which does not suffice for the plant to cover costs which as a result faces insolvency. An additional challenge comes from the load shedding which is limited to eight hours per day. Power generation has to stop as it is not possible to feed into the grid when it is down. Consequently, generators can only run for approximately 12 hours a day while the rest of time the gas is flared which jeopardizes accessed finance from the Clean Development Mechanism (see Box 4).

Box 4

Ayur's 1.2 MW biogas plant

Ayur – an Indian cosmetic corporation – has invested INR170 million in a 1.2 MW biogas plant in Jabalpur. Out of this investment, INR60 million have come from a loan with an 11 per cent interest rate. INR36 million were a subsidy from the government (through a policy which fixes the subsidy at 30 million per MW). In addition, international funds were leveraged through the Clean Development Mechanism (CDM) by getting credits for reduced emissions from the dairy industry and its renewable electricity. Furthermore, the possibility to depreciate over two years makes the investment economically sound.

For the operation of a biogas plant, a total of 200 tonnes of dung is required per day costing an estimated INR100-150 per tonne. Approximately 70 workers are employed with wages ranging from INR110 per day to INR4,500 per month for a low skilled worker and INR20,000 for a skilled worker. In order to make vermicomposting, 120 women will be employed. Arrangements have already been made which set up ten village societies each with 12 women who will run the compost facility and supply it with slurry through a buy-back agreement. Ayur will sell the compost through the existing vermicomposting maker's name. A Memorandum of Understanding was signed for this purpose between the women societies, the vermicomposting maker and Ayur.

With an estimated 70 per cent utilization ratio, effective electricity generated stands at 7,567.00 MWh per year. Economically viable generation costs stand approximately at INR6 cents per kWh which is of great concerns, as currently only INR3.36 cents are paid by the authorities for the electricity supplied to the grid. The INR6 cents would mean an income stream of INR4,540,200 per year which would allow for operation and maintenance with a small profit margin. In addition to the urgent need to adjust the prices and subsidies, technical problems are also overwhelming: upgrading the four 333 kW generators to ones which can automatically switch electricity from feeding into the grid in case of malfunction will cost INR24 million. Although recognizing that the economic costs would be enormous without feed-in if the grid is down, due to a difficult financial situation, there are currently no plans for such investments.

An additional problem comes from the process of dewatering the slurry to be able to make compost. The slurry is too liquid for the automatized dewatering machines which are already installed and need to be fixed.

Technicians were trained for installation although specialists are still brought in from Europe for specific problems. The installation was done by a Dutch firm with the engines coming from Germany. Spare parts are from European companies but can be supplied by a service centre in Bangalore.

Source: UNFCCC, 2006

Aside from large-scale biogas plants, small-scale biogas plants for power generation are also an economically beneficial investment option for farmers. The initial total investment costs in a 100 kW biogas plant for a farm of 1,000 buffalos is estimated at a relatively small 3.5 per cent of total costs. Excluding land but including stalls, workers' housing, farm equipment and 1,000 buffalos, the cost of the individual investment for the dairy farm is estimated at around INR100 million (see example of the Reliable Dairy farm in Box 5). The investment cost in a 100 kW biogas plant to absorb over 50 per cent of the dung and generating electricity which would be more than sufficient for the farm, is estimated at INR3.5 million with a payback period under seven years. These estimations are based on past investments by Reliable Dairy, a buffalo farm in Jabalpur (see Box 5).

Box 5

Reliable Dairy farm owner Mr Hitesh Patel

The total investment for the 100kW biogas plant was INR3.5 million in 2000 but is estimated to double in 2012. Out of this total, the digesters cost INR2.5 million (four digesters of 85 cubic metres each), while the generator cost 1 million. There was a subsidy of 10 per cent of the total investment from the government, while 65 per cent came from a loan with an interest rate of 12 per cent per year (Biogas based Power Generation Programme (BPGP) and the Remote Village Electrification (RVE) Programme). Operation and maintenance cost approximately INR10,000 per month. As a broad principle, the dung of one buffalo (approximately 30 kilogrammes per day) is required to fill one cubic metre. For the two digesters that the farmer is currently running (two times 85 cubic metres), 10,000 kWh are generated per month on average. The slurry from the digester can be sold as organic manure, which provides an additional earning of INR40,000 per month. The rest of the slurry (50 per cent) is applied to their own fields. The profit cycle is approximately seven years.

The electricity generated from the biogas plant is used to light the stalls, run small engines, a water pump, and machinery for fodder processing and to supply workers' housing with electricity. Feeding power into the grid is not possible due to load shedding and fluctuations of the generators. Bigger machines cannot be run either as they could be damaged by these fluctuations. This is the reason why the adjacent milk processing plant belonging to the farm is connected to the grid. The milk processing plant consumes approximately 20,000 kWh per month. Theoretically, the existing biogas capacity would be sufficient to provide the electricity for the plant but this is not done due to technical reasons and the risk of damaging the machines. Furthermore, subsidies are as low as INR4.8 cents per kWh, which is not sufficient to cover the electricity costs.

There is one full-time employee to operate and maintain the generator and two part-time employees to clean the automatic digester and dissolve the dung. Mr Hitesh Patel also hires 15 women for the removal of the dung and 40 employees to take milk and/or take care of the animals in the farm. Semi-skilled labour is paid approximately INR5,000 per month, while the electrical officer earns INR7,000 per month.

Seventy per cent of Sudana (concentrated food) is sold as fresh milk directly to households through retailers which receive a INR2 commission per litre. The price per litre sold to the retailers is INR36 for a fat content of 7.5 per cent (2011 prices). However, the farmer has to pay an income tax of 10-30 per cent of the profits. Deducting total costs from the turnover, a net benefit between 10 and 15 per cent remains for the farm owner.

The total initial investment for the establishment of the dairy farm was approximately INR100 million, comprising of the purchase of 1,000 buffalos, the construction of stalls, warehouses food storage and water tanks, housing for workers and farm equipment but excluding land rental. The rents for land vary greatly, in the range of INR1-1.5 million per hectare in peri-urban areas and INR4-5 million in urban areas. For an integrated farm management model for 1,000 buffalos, approximately eight hectares are required while five hectares are sufficient to keep buffalos and focus solely on milk production.

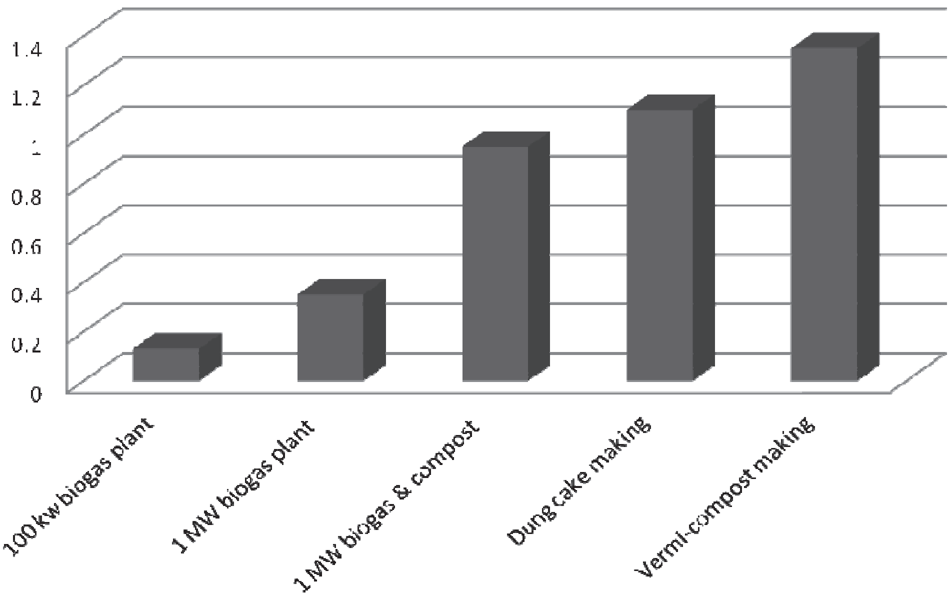
Putting the investment cost of the digester and biogas generator (INR3.5 million) in relation to the total cost of the farm investment (INR100 million), it only represents a fraction of 3.5 per cent. This means that an integrated energy dairy farm would require only a 3.5 per cent additional resource as a percentage of the total farm investment. This is a relatively small amount and the payback could be quick depending on the use and substitution of previously used cooking and lighting sources.

Although value added in the dung industry is at a maximum where technology is most developed and investment highest, such as in large biogas electricity generation, assessing the number of people employed in the various dung industrys reveals a different picture.

Calculating the number of jobs per tonne of fresh dung, the largest number of employment is found in vermicomposting followed by dung cake making. Compost and dung cake making are both highly labour intensive whereas large-scale biogas is more capital intensive. The 1.2MW plant in Jabalpur cost INR170 million to build and currently employs 70 workers, a number which is set to rise to 190 workers once composting is operational. For dung cake making the only invesment required is the rental of one hectare of land for approximately INR100,000 per year employing 5-6 full-time workers (see Figure 6).

An investment of INR400,000 in land for dung cake making creates one job over 20 years while around INR2.5 million are required in the case of large biogas plant to sustain one job for the same period and an additional INR900,000 in cases where biogas is combined with compost.

Figure 6. Employment per tonne of fresh dung in different dung activities



Consequently, if the dung which is currently being used was totally absorbed by future investments into large biogas plants, jobs would be lost, particularly in dung cake making activities. Accordingly, a transformation from the current lower productive use of dung cake making into higher valued goods such as electricity, cooking gas and fertilizers would entail changes in the labour market. By managing these changes with the right policy choices, most of these jobs could be transformed, for example, from dung cake making to compost production. The slurry from biogas plants could be used for high nutritional compost requiring significant labour which could be recruited from among the current dung cake makers. Nonetheless, counting only direct employment, it is estimated that while 1 tonne of fresh dung in dung cake making supports roughly 1.1 jobs, using the dung for electricity generation combined with compost making would only sustain 0.95 jobs, which signifies job losses. As estimated, only 40-60 per cent of total dung is productively used. There is, therefore, a growth potential in terms of jobs and economic value to offset potential losses. Particularly, during the four monsoon month, the dung cake making and compost activities are intermittent, meaning that the dung from these activities is mostly lost. In addition, using electricity downstream, if well planned, could create further indirect and induced employment.

Job creation is possible but will only occur with adapted policy interventions which would prepare the labour force and market for such structural changes. The net number and quality of green jobs will, therefore, depend on the way a transformation is managed. This applies particularly to untapped opportunities which could arise by making productive use of the underutilized dung to create new green jobs.

Although the prospects for milk demand is said to be very optimistic in Jabalpur, the key challenge for dairy farmers is the availability of skilled labour and the growing pressure to lower prices, while increasing the quantity and quality of milk due to national and international competition. Probably one of the most promising ways to improve competitiveness is through integrated farm management: running farms as modern businesses and upgrading value along the whole dairy chain from fodder cultivation to biogas production and compost making. The example in Box 6 shows that increased income or cost reduction could result in further investment and quantitative growth while biogas could be used for pasteurization/sterilization to improve quality.

Box 6

Major challenges for dairy farms in urban areas

Labour: Lack of skilful labour force, especially milkmen, poses a major challenge for the running of a dairy farm in urban areas. On one hand, the numbers of milkmen in urban areas in India are not sufficient, as a qualified professional milkman has to have at least two years on-job experience and most of the citizens in the urban areas are not in favour of working for the farms because milking is considered a 'dirty job'. On the other hand, machinery for milking has proven to be ineffective and less productive in comparison to milkmen, not only because cows are not familiarized with the machines, but also because the investment for machines is too costly.

Increased competition: With soaring prices for fodder and strong competition from international milk producers offering cheaper prices, the increasing cost of feed poses a challenge for the dairy farms, which lose their price advantage in the indigenous market.

Rearing of calves: Due to low milk consumption, calves are mismanaged. There is also a shortage of skilled labour to care for the calves. As a result, 40-50 per cent of these animals die before they are fully grown. The majority of farms therefore prefer to buy buffalo from an advanced dairy cluster in the state of Haryana.

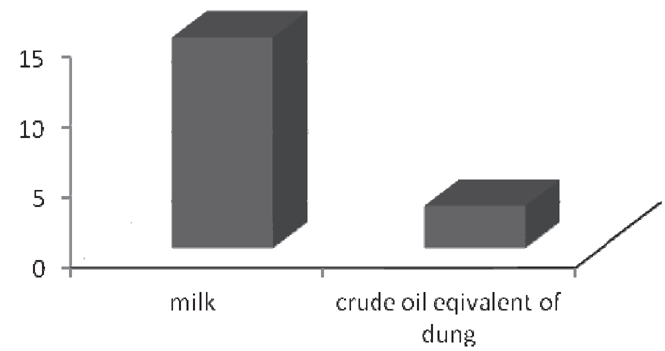
Organic milk: In India, there are no large commercial organic milk production companies, due to a lack of demand and high marketing costs, although in some cities, such as Mumbai, organic milk is sold with prices which are double that of conventional milk (INR60 per litre). However, animals are reported to be extensively fed with Oxytocin, a hormone derived from a banned drug, which poses significant health threats to consumers.

Integrated farm management as a solution to the challenges: Milk consumption is increasingly fuelled by the expansion of an urban middle class with a vegetarian diet. Nevertheless, notable labour shortages and increased competition still pose a challenge to dairy farms for further growth. The key to success in dairy farming is to link the core business of milk production with other businesses within the value chain and to establish an integrated farm management system. This requires further cultivating animal feed, building fodder storage facilities, outlet shops or milk processing plants, and establishing a dung management system with a biogas plant attached.

2.2 The economics of dung

Although cow dung is often perceived as an unintended by-product of dairy farming, it has a high energetic and consequently economic value. While 1 kilogramme of crude oil contains 9,800 kilocalories (kcal), 1 kilogramme of fresh cow dung holds around 1,000 kcal. Stall-fed animals with a daily intake of approximately 20 kilogramme of fodder and 50-70 litres of water produce at maximum of approximately 30 kilogramme of wet cow dung a day, which is equal to 30,000 kcal. Accordingly, a good breed buffalo in one day gives nearly 15 litres of milk and the same energy capacity as 3 litres of crude oil (see Figure 7).

Figure 7. Buffalo milk and dung production per day in litres



In addition to its calorific value, fresh cow dung contains 0.25 per cent Nitrogen, 0.15 per cent Phosphorus and 0.25 per cent Potassium, which are the main ingredients of industrial fertilizers.[3]

Due to cow dung's high energetic and nutrient value, the industry has developed into a large informal economy of significant socio-economic importance in India. The monetary value of the dung industry in Jabalpur is estimated at INR27 million per month, although a large percentage of dung cake is not monetized (see Table 6).

[3]At the time of deposition, cattle dung is approximately 80 per cent water with the remainder being plant material with high energetic value that at the same time is rich in nutrients and microorganisms. By dry weight (DW), dung contains about 0.8 per cent K, 0.4 per cent Na, 2.4 per cent Ca, 0.7 per cent P, and 0.8 per cent Mg while levels of nitrogen in dung DW range from 2.5 to 4.0 per centbeing highly valuable as fertilizer. *Floate, K. D. 2011: Arthropods in Cattle Dung on Canada's Grasslands* In: *Arthropods of Canadian Grasslands (Volume 2): Inhabitants of a Changing Landscape.*

Table 6. Dung activities and attached value

Economic cow dung activity in Jabalpur dairy cluster (40 000 buffalos)	Use of fresh cow dung out of a total 1 215 tonnes produced per day	Total production per day	Economic value by sales price per day in INR
Large farms directly applying fresh dung to their fields or dumping it	324 tonnes (27%)	324 tonnes fresh dung	40 500
Small and medium size farms directly applying dung to their fields or dumping it	88 tonnes (7%)	88 tonnes fresh dung	11 000
Dung cake making (large scale)	495 tonnes (41%)	165 tonnes dry cow dung cake	412 500
Dung cake making (small scale)	56 tonnes (5%)	19 tonnes dry cow dung cake	57 000
Vermicomposting producer	37 tonnes (3%)	12 tonnes compost	36 000
1.2 MW plant (21 019 kWh/day)	200 tonnes (16%)	21019 kWh/day	126,114 (Sales price at INR6 /kW1)
		67 tonnes compost	201 000
50 kW plant (333 kWh/day)	15 tonnes (1%)	333kWh/day	1 998
		5 tonnes compost	15 000
Total	**1 215 tonnes (100%)**		
Total economic value per day			**901 112**
Total economic value per month			**27 million**
Total economic value per year			**324 million**

[1] According to Ayur company (undated). The price of viable production is estimated at around INR6/kWh.

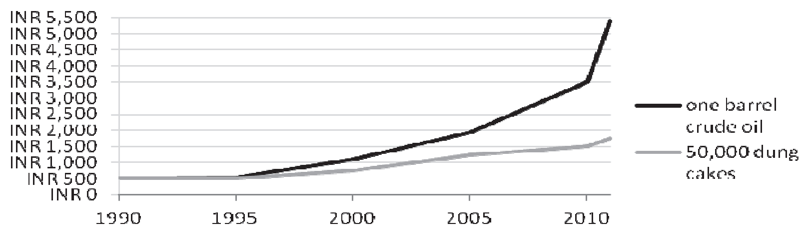
In comparison, the monetary value of the dung cake economy is estimated at INR222 million per month. Although dung represents a significant portion of the dairy industry, the actual value of dung is estimated highly as dung cake is obtained freely by producers and is used at household level for cooking, which is often not calculated in the economic value (see Table 7).

Table 7. Dairy activities and attached value (November 2011)

Economic dairy activity (simplified) in Jabalpur cluster (40 000 buffalos)	Total milk production (Litres)	Economic value by sales price INR36-38/litre milk with content of 7.5% fat
210 farms	185 000	6 845 000
1 processing plant	10 000-20 000	555 000
Total economic value per day	**200 000**	**7.4 million**
Total economic value per month	**6 million**	**222 million**
Total economic value per year	**72 million**	**2 664 million**

Furthermore, prices for fresh cow dung increased by more than 300 per cent over the last 20 years. It is predicted that the value of the industry will further increase in line with overall rising energy prices, especially because of the high potential of its increasing formalization and the possible 'new discovery' of dung as a source of energy and fertilizer (see Figure 8).

Figure 8. Dung cake and oil price trend from 1990 to 2011 in INR

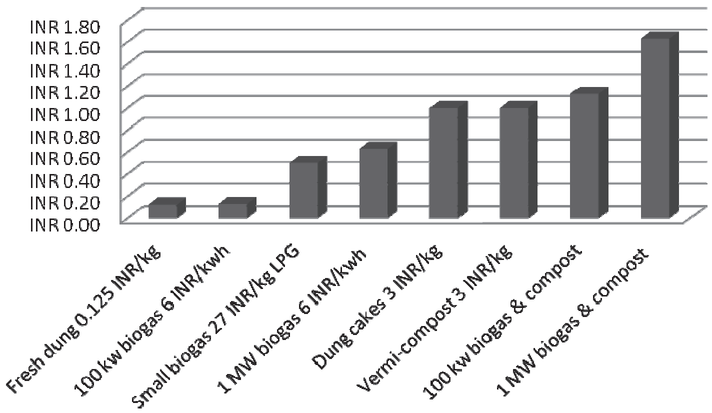


According to the level of processing, dung has various applications with different economic values. The farm gate price of fresh unprocessed dung is INR100-150 per tonne. The most common productive use of fresh dung is for dried cakes which are used as an energy source for cooking or burning of bricks and cement. To produce dung cakes the fresh dung is formed into cakes manually in open fields, and is subsequently dried in the sun. It is then either used by the women making dung cakes directly or sold to kilns or on the market to other women as cooking fuel. Three tonnes of fresh dung make approximately 1 tonne of dry dung cakes. The economic value of dry cakes is INR2,000-2,500 per tonne when sold in bulk to cement factories and INR3,000 when retailed on markets as cooking energy cakes. Using fresh dung for processing vermicomposting requires similar quantities to yield between INR2,000 and 4,000 per tonne for 1 tonne of output.

In addition, through anaerobic digestion, biogas can be extracted from dung for energy purposes including lighting, cooking or electricity generation. Typically, small-scale plants of 2 to 6 cubic metres produce biogas for cooking and lighting, whereas bigger plants are mainly used for electricity generation. The smallest sized plant (2 cubic metres) can produce up to 30 kilogramme of gas per month with a value of INR25.5 per kilogramme. A medium-sized plant with an attached generator of 100 kW can generate 10,000 kWh per month with an economic value of INR75,000, assuming a commercial price of electricity in India of INR7.5 cents per kWh. As in the case of Jabalpur, large plants of up to 1.2 MW produce an estimated 630,000 kWh per month with economic viable generation costs of around 6 cents per kWh with a monthly value of INR378,000. The slurry that comes from the digester after the biogas process can be further processed into vermicomposting. A similar amount of up to INR3,000 per tonne of compost can be produced. Alternatively it can be sold directly as slurry at a price similar to that of fresh dung.

Calculating the value of 1 tonne or 1 kilogramme of fresh dung in the different end-products, such as dung cakes, biogas, electricity and compost, it is interesting to find that dry dung cakes yield the highest single value (INR1 per kilogramme), even higher than in electricity generation (INR0.6). Only when electricity generation is combined with compost making, the economic value of 1 kilogramme of fresh dung is higher (up to INR1.8 per kilogramme). Vermicomposting reaches values of up to INR1 per kilogramme of fresh dung whereas small-scale biogas production for cooking yields INR0.5 per kilogramme. Accordingly, the lowest value of dung is obtained when sold only as fresh dung, whereas the highest value can be reached by large biogas plants, producing and commercially selling electricity at the same time as compost (see Figure 9).

Figure 9. Value of 1 kilogramme of fresh dung in final products (cake, biogas, electricity and compost)



It is expected that the value of manually forming and sun drying dung cakes is much lower than when processing dung into electricity. Notably, this is because technology and investment are not necessary in dung cake making which does not require a very highly skilled labour force. Conversely, biogas plants of 1 MW involve large capital investments and high computerized technology which is expected to yield higher economic value. However, this assumption is proven wrong because of the undervalued price of cooking energy. Cooking energy is a basic need, which in wood constrained regions is essential to cook food.

Table 8. The economics of dung

Type of dung product	Sales price	Seller	Buyer	Value added out of 1 kg of primary raw cow dung
Fresh cow dung (sold in tractor trolleys of approx.1.25 tonnes)	INR0.125/kg	Dairy farm	Contractors, biogas plants, vermicomposting producers	INR0.125 /kg
Dried cow dung cakes in bulk (sold as trolley in pieces of approx. 300g cakes)	INR2.5/kg	Contractor	Brick kilns and cement factories	INR0.8/kg
Dried cow dung cakes on local markets (sold in pieces of approx. 300g cakes)	INR3/kg	Women dung cake maker	Housewives	INR1/kg
Vermicomposting	INR3/kg	Compost producer	Farmers	INR1/kg
Biogas for very small (family-size) cooking from 2m3 plant	Not sold but shadow price of INR27.5/kg	Farmers	Own consumption	INR0.5/kg 1.5 when slurry is used for compost
Biogas for small (100 kW) power generation (10 000 - 20 000 kWh/month)	INR3-7.5/kWh	Farmers	Own consumption	INR0.01-0.2/kg INR1.01-1.2/kg when slurry is used for compost
Biogas for large (1MW power (630 583 kWh/month)	INR3-7.5/kWh	Power generation company	Sold to national grid	INR0.315-0.788/kg INR1.3-1.8/kg when slurry is used for compost

2.3 Dung: A source of cooking energy

Seventy-two per cent of the Indian population rely on traditional biomass for cooking (IEA, 2011b). Firewood, crop residues and dung cakes are the primary sources of cooking energy for 78 per cent of rural households. While 1-2 per cent of rural households and 7-10 per cent of urban ones reported dung cake as the first cooking energy source, the figures mask the fact that most households use dung cake as a secondary or tertiary energy source and rely primarily on firewood. In the states of Bihar, Haryana, and Punjab, the percentage distribution of rural households using dung cakes as the primary cooking fuel is reaching 22–33 per cent (TERI, 2010). In terms of monthly average spending, rural households spend approximately INR35 on firewood and INR7.5 on dung cakes but only INR5.5 on kerosene, as well as INR5.5 on liquefied petroleum gas (LPG) (TERI 2010). In clusters such as Jabalpur, nearly 100 per cent of rural households cook primarily with dung cakes (see Box 7).

Box 7

Dung cake, a basic fuel for cooking

Almost every woman in the dairy cluster in Jabalpur uses dung cake as a fuel for cooking, which is much cheaper than wood fuel except during the rainy season when dung cakes are not available. Women working in the dung cake fields can usually get broken dung cakes for free. In the market, 1 kilogramme of wood costs INR5, while 1 kilogramme of dung cake costs INR3 in the summer time (100 dung cakes of around 500 grams cost approximately INR150). Using locally fabricated mud cook stoves, 20 cakes are needed to cook a meal for 4-6 persons. The weekly expenditure for fuel is therefore nearly INR400 which is equal to a labourer's salary (an unskilled labourer could earn up to INR3,000 per month). Moreover, dung cake is the primary fuel source not only because of its cheap price, but also due to its easy and quick functionality for burning. In terms of health, it is reported that the indoor smoke emanating from dung cakes, although only happening at lighting, still has negative effects on health, causing for example eyes irritation.

The potential number of household-level biogas plants is estimated at around 12 million with a production of approximately 17 million m^3 cooking gas per day. According to official data from the National Project on Biogas Development (NPBD), 4.19 million biogas plants have been installed. However, considering official evaluations, only 55 per cent of the plants installed are actually functioning and a relatively small 15-17 per cent of total small-scale biogas potential is being exploited (see Box 8) (GoI, 2002).

As of 2006, the total number of community-level biogas plants stood at 3,902 which is a relatively small number considering India's 600,000 villages (approximately 154 villages share one plant) (Ravindranath and Balachandra, 2009; Arora et al., 2010).

The primary reasons for the low performance productivity of the Biogas Programme and the low take-up rate of biogas plants are (i) the ineffectively implemented policy at state and local level which are not aligned to the milk industry policies; (ii) poor selection criteria to identify potential households in need, not taking enough consideration of dung and water availability, solar radiation, need for biogas and other available cooking sources; (iii) lack of skills training for masons and engineers; (iv) lack of monitoring and maintenance of biogas plants due to little incentives for the installing masons; (v) low quality building material; (vi) farmers operating the plants without sufficient training; and (vii) lack of awareness, motivation and cultural acknowledgement of biogas as an energy source. The bottling of biogas, which is not yet developed, would open further investment and growth opportunities, probably incentivizing the take-up and increase attention on the value of biogas (see Box 8).

These barriers could be easily overcome by giving biogas energy the same importance as milk and aligning the Biogas Programme to the milk development plans, including education and awareness, skills training and small enterprise development. As a first step, the coherence and alignment of the National Biogas and Manure Management Programme (NBMMP) (see Box 8) and animal husbandry policies would support the achievement of the Government's 11th five year goal to meet 'lifeline energy' needs for cooking, as envisaged in the Integrated Energy Policy (MNRE, 2009a).

Box 8
National Biogas and Manure Management Programme (NBMMP)

The National Project on Biogas Development programme (NPBD) started in 1981-82 to promote household biogas plants, which could provide clean alternative fuel to the rural masses and enriched organic manure for agricultural plants. It also provides a package of subsidies for the adopters, implementing agencies and the turnkey workers. It was renamed the National Biogas and Manure Management Programme (NBMMP) in 2003. The implicit objective of the programme is to reduce the use of nonrenewable fuels and fuel wood. The Programme promotes indigenously developed simple-to-construct and easy-to-operate household biogas plants (i) to provide fuel for cooking and organic manure; (ii) to mitigate drudgery for rural women, reduce pressure on forests and accentuate social benefits; and (iii) to improve sanitation in villages by linking sanitary toilets with biogas plants.

The Programme is implemented by local government departments which are implementing the policy of the Ministry of New and Renewable Energy (MNRE). The local government provide the following services for NBMMP:

- Sending a mason to build biogas plant. The mason is selected from a pool of masons who have received a ten days training in biogas installations provided by the government,
- Providing loan for the farmer who needs to pay a mason (around INR15,000 per person) and build the biogas plant.
- Providing a subsidy of approximately 50 per cent of total costs (around INR10,000) once the biogas plant has been installed.

The number of small biogas plants has the potential to increase to 12 million. However in 2009, at household level, the functionality rate of a total of 4,185,442 installed biogas plants (typically 2 cubic metres) was approximately 55 per cent (GoI, 2002) due to a lack of cow dung from households to feed the plants. For a typical 2 cubic metres biogas plant, 50-60 kilogramme of dung is required per day with an additional 2,000 kilogramme in the first 25 days to start the digestion. This requirement is difficult to meet at household level. Consequently certain farms have never managed to start operating the biogas plants. The underperformance of masons and the lack of good building material for the plant also represent a challenge for the functionality of biogas plants. The location of the plant and its maintenance determine the functionality, however, the masons often lack the skills to identify a good location and farmers are not experienced in maintaining the plant.

Possible solutions to increase the usage rate and functionality of small biogas plants include:

- Clustering of plants to facilitate maintenance and operation as well as dung collection;
- Examining the quality of the building materials before installation;
- Strict controlling of the distribution of subsidy and only distribute payment after being ensured that the plant is functional;
- Basing the selection criteria of the NBMMP participants on the water and cow dung availability in the farm, the needs of biogas (lack of other fuel for cooking such as wood), the availability of a feasible location for the installation, and the ability of maintenance for the plants;
- Pre-installing training (including on-the-job training) for farmers on technical skills, the understanding of the advantage of using biogas plants, and the function of the plants;
- Enhancing the trainings for masons for more detailed and practical knowledge;
- Improving incentive scheme to ensure regular maintenance of the plant (while masons are unemployed in the winter time, they can be recruited for maintenance)
- Developing a holistic and full-time employment concept for masons. This includes developing further income

opportunities such as improved stove building and dissemination of compact fluorescent lamp (CFL) bulbs, solar lanterns or other energy product. These activities could be linked to the local governmental Renewable Energy Shops which exist in all districts.

- Implementing awareness building and education campaigns on the benefits and parity of biogas. Most of the functional plants are owned by affluent farmers who use biogas only as a supplementary source of energy, whereas the potential for the poor to reduce energy expenditures is huge. However, biogas is often not seen as a dependable source of energy and therefore not valued.

2.4 Dung: A source of electricity for rural areas

In addition to cooking, biogas can also be effectively used for the generation of power. Through a biogas-based power-generation system, the high calorific value of biogas (approximately 4,700 kcla or 20 MJ) could be turned into electricity after dewatering and cleaning of the gas.

Although the number of small and medium biogas power units of 3-250 kW is limited, they are commonly used in India along large-scale plants with production in the range of megawatts. Nevertheless, while the emergence of the commercial dairy sector is quite a recent phenomenon and the sector is still dominated by smallholder cattle farmers, there has been an increased focus on small-scale gas plants for cooking purposes. Little attention has, however, been given to larger-scale power generation from biogas. Consequently, and in relation to the growing size of commercial dairy, biogas capacity is not well developed. Estimates on the overall potential of commercial power generation are scarce and figures remain vague. It would appear that only a fraction of the potential for power generation has been realized (MNRE, 2010b).[4] Under the Biogas based Power Generation Programme (BPGP) – the main policy in India to promote biogas power – as of 2011, 73 projects were installed with a total capacity of 461 kW (MNRE, 2010b). A number of investments into megawatt plants have been recorded recently, including in Jabalpur. The low level of investment into biogas power generation plants could be explained by the lack of an integrated policy on animal husbandry and energy. There is no harmonized planning which combines livestock development and rural electrification.

Simplified calculations based on the findings from this study indicate that the power generation potential from commercial dairy lies in the range of 4,800 and 5,200 MW.[5] Assuming that this potential could be tapped into by 1 MW plants which support around 70 jobs in operation, 330,000 to 360,000 jobs could be created. Additional jobs would also be needed to turn the slurry into compost, bringing the total job creation potential estimation in the range of 910,000 to 990,000.

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[4] The Ministry of New and Renewable Energy (MNRE) estimates the power potential from dairy liquid waste at only at 77 MW. While figures on the potential of biogas are limited, the International Energy Agency (IEA, 2011a) estimated the potential of biopower from agro-residues at approximately 40,000 MW. However only 866 MW has been realized by 2010 which represents 2 per cent of the estimation.

[5] The calculations are based on the assumption that 880,000 tonnes of dung are available per day from commercial dairy (see next section) and that a 1-1.2 MW plant such as the one in Jabalpur consumes approximately 200 tonnes of dung per day. Other calculations which lead to much higher figures can be derived from basic assumptions from the MNRE that 0.75 m3 biogas is needed per kWh for a 100 per cent biogas engine and that biogas production is approximately 0.04 m3 per day per kilogramme of wet dung. The potential for commercial biogas derived from this calculation is in the range of 35 million m3 per day and the electricity generation potential at approximately 26,400 MWh.

In addition to the job creation potential, 25 per cent of the total population does not have access to electricity. In rural and peri-urban India where most of the livestock is reared, the figure reaches 50 per cent (IEA, 2011b). The potential for social progress and economic growth through energy access is vast and would result in further downstream job creation.

Challenges for small-scale biogas power in urban areas are linked to technical constraints. Feeding into the grid is not a feasible option because of technical constraints. The electricity consumption of the farm is lower than the full amount of electricity generated. Consequently, electricity generation is not a core business for the farms and investment into small-scale power generating plants is practically inexistent with the exception of a few project-driven examples. Lack of government support adds to the underutilization of dung at farm level. As commercial and confined animal feeding systems in urban and peri-urban centres, such as Jabalpur, Delhi and Mumbai, are experiencing rapid growth, the potential to systematically develop biogas power generation is enormous. However, as long as dung remains unutilized and mostly dumped into the surrounding areas, the environmental challenge will grow.

Incentivizing private-private or public-private partnerships between a utility and a farm would overcome such hindrances and could lead to investments by private companies into biopower plants at farm level. To enable such activities, a policy framework which allows feed-in tariffs for small capacity plants, or rewards electricity generation for small clusters and mini grids is needed.

In rural areas, the lack of (mini) grids hinders the generation and distribution of biogas electricity to households which are without power. Conversely, self-generation and consumption is not economical, as the energy needs of a medium farm are too low to make an investment profitable. Integrated planning of rural electrification, specifically the full integration of the Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) and Biogas based Power Generation Programme (BPGP), into the livestock development policy would overcome these impediments (MNRE, 2009a).[6] Importantly the clustering, organization and collection of dung need to be planned jointly along with livestock development and rural electrification.

Box 9
Biogas based Power Generation Programme (BPGP)

The Biogas based Power Generation Programme (BPGP) is led by the Ministry of New and Renewable Energy (MNRE), which oversees the subsidy pattern for Biogas Based Power Generation Systems (BPGS). Different subsidy schemes apply depending on the power generating capacity:

3-20kW: INR40,000 per kW
>20kW to 100kW: INR35,000 per kW
>100kW to 250 kW: INR30,000 per kW

For investors to benefit from these subsidies, an energy purchase agreement with the state electricity board has to be signed.[1] The initial objective of the programme was to use power for water pumping for irrigation. It was later developed to cover the use of combination of firing (20 per cent) and diesel engines (80 per cent).

[6] The objective of the Programme launched in 2004 is to electrify over 100,000 un-electrified villages and to provide free electricity connections to 23.4 million rural households.

However, the uptake of these biogas power plants is still low, primarily because of the non-permanent settlement of farmers. In rural areas, farmers usually do not have a permanent farming location which makes a long term investment into biopower plants unprofitable.

[1] Biogas technology provides an alternative source of energy mainly from organic wastes. It is produced when bacteria degrade organic matter in the absence of air. Biogas contains around 55-65 per cent of methane, 30-40 per cent of carbon dioxide and small quantities of hydrogen, nitrogen, carbon monoxide, oxygen and hydrogen sulfide. The calorific value of biogas is high (approximately 4,700 kcla or 20 MJ, at around 55 per cent methane content). The gas can be effectively used for the generation of power through a biogas based power-generation system after dewatering and cleaning of the gas. In addition, the slurry produced in the process provides valuable organic manure for farming.

Large-scale biogas power generating plants of 0.8-1.2 MW are only viable in clusters producing at least 150-200 tonnes of dung per day. They are, therefore, likely to be found in urban and peri-urban milk producing areas. In addition, power grids and feed-in laws are needed to attract private or public investors allowing for generation and distribution. India's Central Electricity Regulatory Commission (CERC) introduced feed-in tariffs for the first time in 2009. With the CERC providing the national framework, including for biogas, different feed-in tariffs apply in different states. The Jabalpur biogas plant, for example, needs to sell electricity at INR6 per kWh to make its operation viable. Due to a lack of policy regulation it only receives INR3.36 based on biomass tariffs, which puts at risk the survival of the plant and hinders investment into biogas plants.

In case of future up-scaling of investments into biogas, the transitory effects on the labour force need to be considered from the onset. As aforementioned, the transition from traditional dung cake making toward economic activities in higher valued segments, such as electricity generation, influences the structure of labour markets. The transition of the labour force is of paramount importance, as the working poor and women particularly are most affected. However, if a transition is well managed, women, for example, who currently work in the fields and make dung cakes could be trained and transferred to compost making in biogas plants (see Box 10).

Box 10

Just transition from dung cake making to building biogas plants

A 1.2 megawatt biogas plant in Jabalpur which operated in 2011 was able to absorb approximately 200 tonnes of cow dung per day. The operation of such a biogas plant may have an impact on the dung cake labour market, as some of the current dung cake workers may lose their jobs in the future if more investments are made into biogas plants.

Considering the transitioning effect on dung cake makers, especially women workers, as a consequence of large biogas investments, the International Labour Organization (ILO) rolled out a business training programme to empower and accommodate women to start up and run their own businesses. However, in light of strong competition, starting up a new business appears to be more difficult than making dung cakes. Profits are also lower at the onset of the business. Consequently there is little incentive for dung cake makers to transfer to other businesses. Comparing the INR100 per day that can be earned for making dung cakes working 10 hours per day, women could for example only earn INR75 to make incense sticks.[1]

However, an ILO project has found that a just transition could be facilitated by training women dung cake makers to make compost from slurry out of biogas digesters, especially considering the similarity of the industry and the similar techniques and skills required for both jobs.

[1] INR15 per 1,000 sticks, which takes approximately two hours to make.

2.5 Dung: A source of fertilizer

The potential number of small-scale biogas digesters in India which could be constructed is estimated at around 12 million units, and could produce 17,340 million m^3 of biogas. In addition, these plants provide high quality organic manure that make nutrients available and improve the quality of soil for sustainable productivity. As part of the 11^{th} Five Year Plan, it is envisaged that 1.4 million m^3 of biogas generation capacity plants may be installed in the country. Use of these biogas plants would result in an annual savings of approximately 0.24 million tonnes of liquefied petroleum gas (LPG) equivalent, while also producing biofertilizer of 62.8 million kilogramme of urea equivalent, or 11.6 million tonnes of organic manure per year. One thousand kilogrammes (1 tonne) of manure from the biogas plant is, therefore, equal to 5.4 kilogramme of urea (MNRE, 2010a). Although the pure nutritional value of manure seems to be a low organic fertilizer to improve soil quality and water retention capacity, it has no negative impact on ground water and a positive impact on resilience against climate change (UNCTAD/UNEP, 2008).

While urea fertilizer is highly subsidized, organic fertilizer is not. Urea is estimated to be subsidized at INR17.23 per kilogramme out of total production with a cost of INR22.06. If the government continues to subsidize fertilizer based on food-security parameters, fertilizers which have the same nutritional value should be equally subsidized. Accordingly, the production of organic fertilizer should also be subsidized. This would result in a subsidy of nearly INR100 per tonne of organic fertilizer from biogas plants (see Table 9).

Table 9. Urea pricing calculations

Subsidy calculations	
Total subsidy (in INR) per year	274 980 million
Total production (in tonnes) per year	15 960 million
Subsidy/kg (total subsidy/total production)	**INR17.23/kg**
Sales price of urea (per kg)	INR4.83
Total cost of urea = subsidy + MRP (per kg)	INR22.06

Source: Sharma and Thaker, 2009

2.6 Dung: A threat for the environment and climate change

Dung that is not processed or dumped into open fields is considered to be a source of methane emissions. During the monsoon seasons in particular, when dung is not dried in the sun but washed into rivers, it pollutes the environment and aquifers up to river levels, making soil and water unusable. In clusters such as Jabalpur, the dung pollution of the Paryat River exacerbates the increasing scarcity of drinking water and has led to a lawsuit against dung polluters (India Environment Portal, 2011). According to the US Environmental Protection Agency, improperly managed manure has caused chronic water quality problems and is a significant component of water body impairments. Manure and wastewater from CAFOs can contribute pollutants such as excessive amounts of nitrogen and phosphorus, (...), heavy metals, hormones and antibiotics to the environment (US EPA, 2007).

According to the United Nations Framework Convention on Climate Change (UNFCCC), methane emissions from 1,000 stall-fed animals' manure results in annual emissions of approximately 1,600 tonnes of CO_2 equivalent (tCO_2e).[7] In the case of the 1.2 MW electricity plant in Jabalpur, the baseline emissions, which can potentially be eliminated from the transformation of dung into biogas, is estimated to be 23,500 tCO_2e per year, thus removing emissions from approximately 14,600 animals (UNFCCC, 2010). From this analysis it is possible to assume that dung which is wasted causes methane emissions through anaerobic digestion. This is not the case for 40-60 per cent of the dung which is mainly used for dung cake making, as there are no methane emissions from dung cake drying (REEP, 2010; HWWA, 2004; MEF, 2007).

Nevertheless, although the actual quantity of emission reductions of biogas plants is unclear and subject to much debate, UNFCCC guidelines provide an internationally agreed framework upon which emissions, and subsequently subsidies are calculated and Clean Development Projects financed. This is also the case for the 1.2 MW investment in Jabalpur that was accepted by the Clean Development Board of the UNFCCC, and which credits the aforementioned emission reductions.

Taking into account the 176 million stall-fed animals in India (see Section), the total emission reduction potential from the livestock sector is estimated at approximately 4.3 million tCO2e per year (see Table 10).

Table 10. Methane emission reduction potential in the livestock sector in India

Sector	Methane emission reductions	Carbon emission reductions	Fuel replacement offsets	Total carbon emission reductions
	Metric tonnes CH4/year	*Metric tonnes CO2e/year*	*Metric tonnes CO2e/year*	*Metric tonnes CO2e/year*
Dairy farms (milk production)	173 455	3 642 560	686 054	**4 328 614**

Source: Global Methane Initiative, 2011

This emission reduction potential could be further aligned to support India's National Climate Change Action Plan as outlined in the biogas and manure management objectives. The Clean Development Mechanism for instance, can substantially leverage international climate funds for India to invest in its Climate Change Action Plan (GoI, 2008).

[7] These relatively complex compounds are broken down naturally by bacteria. In the presence of oxygen, the action of aerobic bacteria results in the carbon being converted to carbon dioxide. The emission of carbon dioxide is part of the natural cycling of carbon in the environment and results in no overall increase in atmospheric carbon dioxide. The carbon dioxide, originally absorbed from the atmosphere through photosynthesis by the plants which formed the livestock feed, is simply being released. However, in the absence of oxygen, anaerobic bacteria transform the carbon to methane and so the decomposition of livestock wastes under moist, oxygen free (anaerobic) environments results in an increase in the concentration of greenhouse through the production of methane.

3. Dairy industry in India – Key challenges and opportunities

3.1 Past and current milk and dung policies

The Operation Flood Programme (OFP) which was launched in 1970 successfully enabled smallholders to organize dairying in village, district and state cooperatives (the Anand Model). This was a commodity (milk) programme, using food aid as a tool for socio-economic development to increase food security and production.[8] Under the programme's processing and marketing, infrastructures were created and rural dairies and chilling centres were built. The programme supports smallholders for the upgrade of milk animals, veterinary and health care and provision of balanced nutritional feed to enhance production. The success of OFP has demonstrated how dairy farming can act as a catalyst to enhance domestic production. It thus ushered in the 'White Revolution'. The OFP made it possible for stakeholders who are primarily small, marginal and landless to become self-reliant (Banerjee, 2008).

In the Anand Model of cooperative institutions, while milk is used as a tool for socio-economic development, dung, despite of its cooking energy and fertilizer value, is not addressed and has not been integrated into the cooperatives' roles and services (see Box 11). This paper argues that higher gains for accelerated socio-economic development and employment creation could be achieved through systematically promoting the use of dung for energy and fertilizer production through the creation of biogas plants.

Until today, cooperative channels from rural farmers control more than half of the produced milk although growth is leveling off. At the same time, commercialized dairy is rapidly expanding with the number of large private milk producers growing in peri-urban centres (Delhi, Mumbai, Haridwar, Jabalpur). Although the dung business is becoming commercialized and employs an increasing number of middlemen, labourers and women making dung cakes, it is largely informal and unknown from the authorities.

Current policies addressing dung and manure are fragmented. Policies, such as the National Biogas and Manure Management Programme (NBMMP), the Biogas based Power Generation Programme (BPGP) and the Remote Village Electrification (RVE) Programme, are not able to fully integrate with the National Dairy Plan and policies from the Ministry of Animal Husbandry and Dairying. This leads to inefficiencies, such as the slow uptake of biogas power generation and high failure of small biogas plants. Due to the underlying lack of policy coherence, the economic and employment potential of dung has not been fully realized.

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[8] The National Dairy Development Board (NDDB) of India launched this programme in 1970. The OFP during its three phases of implementation between 1970 and 1992 established cooperative institution based on the Anand Model in 183 milk sheds spread over the different states of India.

Box 11

Sanchi Cooperative in Jabalpur

The Sanchi Cooperative which covers 17 districts is a governmental support programme open for all farmers to join with a one-off contribution of INR100 and no annual membership charges. It provides training services for farmers for dairy making, animal keeping and nourishing, milking, farm keeping and other types of work. Guidance is also provided to help farmers to set up and operate a village dairy society, including farm management, testing techniques and budgeting guidelines. In addition, farmers' cows can receive artificial insemination for high quality breed. Fodder seeds, such as sorghum and oat, are also provided to farmers for free. Sudana (concentrated food) can be purchased in bulk for INR12 per kilogramme. Loan facilities are provided for farmers to purchase calves. Local breeds cost INR16,000 and Murrah buffaloes cost INR35,000. A farmer wishing to start dairy farming must purchase a minimum of two to a maximum of five calves. An interest rate of 10 per cent is guaranteed with local banks and the farmer is paid a subsidy of 33 per cent of total investment.

The main business activities of the cooperative include milk production and cow/buffalo keeping. It collects milk at village level from small farmers with two to five animals and transports the milk collected to one of the three cooperative-owned processing plants for further production. The processing plants can process 15,000-100,000 litres of milk per day. In 2011, the average production was approximately 55,000 litres per day.

Nevertheless, the cooperative is facing strong competition (to purchase milk) from the private sector which is paying higher milk prices to the farmers (INR10 per kilogramme of fat content in milk or higher). Still, in 2011 milk production grew by 25,000 litres. The objective for next year is 10,000 more cattle with 5 litres of additional milk per day per animal. The strategy is to set up new dairy village societies and to assist existing farmers to purchase more calves. With a turnover of INR400 million per year, the operating profit added up to INR15,000 per month in 2011, covering losses from the previous year. Net profits are distributed to farmers.

3.2 Opportunities from an integrated Dairy-Energy Policy

Dairy farming in India is one of the largest contributors to Indian GDP and employment. It constitutes 5 per cent of GDP and involves 70 million farming households providing employment to around 75 million women and 15 million men.[9] Though mostly carried out as a part-time activity in the rural areas, dairy farming is an essential source of nutrition and income for the poor.

It is estimated that rural farmers own 75 per cent of the country's livestock resources from which almost half of their income derives. In terms of trade, the value of output from livestock is higher than paddy and wheat. Thus, in terms of value of output, milk is the single largest agricultural commodity in India.

The livestock industry is, therefore, an essential source of livelihood for rural households and regarded by many as one of the most pro-poor industries, contributing to increased income and employment opportunities for millions across the country. Interventions to systemically tap into the energetic and nutritional value of dung could therefore be expected to translate into pro-poor growth. Strengthening farmers' skills in using both dung and milk productively would further increase their competitive advantage by enabling them to produce these goods at a very low cost. This would also contribute to sustaining and likely improving the competiveness of India in the international dairy market.

[9] Based on income parameters, the dairy sector provides the largest employment opportunity to women in India.

India might even face supply shortages of milk in the future as the growth of production is estimated at only 3 per cent, while demand for milk and milk products is forecast to increase by more than 4 per cent, driven by an increasingly protein-based but vegetarian urban diet.

Indeed, with the liberalization of the dairy sector, which begun in the 1990s, two trends will challenge future growth in supply of dairy farms in India. On the one hand, 52 million smallholder farmers hold 75 per cent of total cattle in herds of one to eight animals. With low productivity levels, they may not be able to meet the soaring demand, particularly in urban areas. On the other hand, international competition and the concurrence of international milk prices require the indigenous industry to improve its competitiveness in terms of both quality and quantity.

A comprehensive policy is required to address these challenges. One way to increase the quality and quantity of milk is to support smallholders in growing into commercial farms and incentivize commercial farms to increase productivity, for example, through an integrated dairy-energy farm management. The trend toward an increasing number of larger farms in urban and peri-urban areas has already been observed, whereas integrated dairy energy farming hardly exists. Accompanying the transition from smaller to larger farms with a comprehensive support in integrated dairy-energy farm management offers huge opportunities, especially considering the ever-increasing amount of commercially available dung.

While the low quantity and quality of milk is mainly due to rural poverty, and a lack of entrepreneurial capacity and investment capital, it would be possible to bolster incomes by making more productive use of dung. Additional income would allow for the necessary investments that could in turn make the industry more productive, while increasing quantity and quality.

In order to survive in the globalized market and meet future demand, dairy farms need to become dairy enterprises which produce milk. They also need to further integrate value chains such as dung in their business. Such integrated farm management is probably the most promising way to develop dairy farms into commercial dairy enterprises. Integrated farm management ranges from fodder cultivation and storage to milk processing, biogas production and compost making. Notably, the full integration of the productive use of the currently undervalued dung opens substantial opportunities. For example, the use of biogas for sterilization is a tested practice to increase the quality of milk, which in turn results in increased income and productivity.

Dung is not only a means to income generation and livelihoods, but also creates environmental problems. Under a business as usual scenario the livestock population is estimated to increase to 625 million by 2020, resulting in the highest density of cattle in the world (Global Methane Initiative, 2011). While the primary sources of agricultural GHG emissions in India already comes from livestock, the estimated growth will put additional pressure on the industry to act on climate change. Nevertheless, the situation could be improved if dung is used for commercial biogas and electricity production, instead of investments into conventional fossil-fuel based plants. Compost making out of the slurry of biogas plants could in turn reduce the use of chemical fertilizer, further benefiting the environment and reducing emissions from fossil-fuel based chemical fertilizers.

4. Recommendations

To enhance and facilitate the economic and job creation potential of the dung industry, the following recommendations are made for rural and peri-urban areas:

General strategy

- An integrated Dairy-Energy Policy is the key to success. It requires policy coordination and coherence between energy, dairy and agricultural policies.
- An integrated Dairy-Energy Policy needs to address both channels of the two-tier dairy industry namely (i) the rural smallholders and (ii) the peri-urban commercial farms.
- Incentives for rural smallholders and cooperatives to simultaneously invest into the dairy AND the dung industry are needed. Investments into animals, equipment and processing plants should be made simultaneously to investments into family-size biogas plants for cooking and lighting and village based biogas units for rural electrification and powering of milk plants.
- Sufficient incentives should be provided for peri-urban commercial farms and/or private or public investors to build commercial-scale biogas power plants at the same time as milk processing plants. An example is the Combined Heat and Power (CHP) plants in the energy sector.

Peri-urban Dairy-Energy Policy

- In peri-urban areas, an integrated Dairy-Energy Policy should also cover the private sector, power utilities and cooperatives. Feed-in tariffs, incentives for capital investment into biogas plants, tax rebates, accelerated depreciation and facilitated regulation and improvement of the electricity generation, transmission and distribution networks are all adequate policy tools to stimulate public and private investment.
- Particular focus should be placed on ensuring a just transition of the workforce, including from hazardous work in dung cake making to employment in higher value sectors such as electricity generation and compost making. Based on the assessment of the informal dung economy, training and reskilling programmes should be designed and adapted to different social economic contexts.
- Social dialogue should be facilitated between workers, especially for women working in dung cake making, and biogas investors. Good practices could be established through reskilling and employing women in compost making on biogas plants.

Directing public and private investment in peri-urban areas

- Designing an improved incentive scheme for investments into medium and large biogas plants and compost facilities. Feed-in tariffs which are based on scientific and economic expertise (covering at a minimum operation cost i.e. INR6-9 cents) are a power full tool to attract investment. When incentive schemes are not well designed, it is not possible to cover the investment and operation costs of commercial biogas plants.
- Supporting peri-urban dairy cooperatives and commercial private farms in financial literacy and business training, and supporting their investment in medium and large size biogas plants and compost facilities, as is currently being done in processing and chilling plants.
- Providing incentives for the formation of public-private or private-private partnerships for investments into biogas power plants. Especially when farmers are not willing, lack the capacity or do not have the incentives to develop new biogas businesses beyond their core milk business.
- Promoting synergies between electricity generation plants and milk processing plants by regulating the set-up of both plants adjacent to one another, as done by CHP plants. Providing support for an integrated management of both plants.

Rural Dairy-Energy Policy

- In rural areas, the productive use of dung should be promoted through established milk policies. Accordingly, the successful Anand Model for cooperatives which promotes small-scale and cooperative dairy farming could be upgraded to an Anand/Shakti Model (Anand Energy Model). In such a model, dung could be used as a tool for socio-economic development in addition to milk. Integrated farm management is necessary to ensure the success of such a model. Smallholders would thus be supported to transition into small and medium green enterprises, to invest into, and to productively produce and use biogas and fertilizer.
- Specifically, key components of such an integrated rural Dairy-Energy Policy would include:
  - Capacity building of rural cooperatives and smallholders on the value and productive use of dung in order to improve farmers' awareness of the value of biogas and compost facilities.
  - The full integration of skills training on biogas and compost production into dairy extension services and training for farmers.
  - The promotion of green enterprise and entrepreneurship development to stimulate the transition of subsistence smallholders to dairy enterprises in order to increase productivity and create additional green jobs.
  - The provision of incentives for public and private investment in rural areas:
    - Supporting rural dairy cooperatives in financial literacy and business training to invest into medium and large size biogas plants and compost facilities in the same way that they are investing into processing and chilling plants.
    - Designing an integrated and improved incentive scheme for investments into medium biogas plants, compost facilities and mini grids as part of the Rural Electrification Policy.
    - Promoting synergies of electricity generation and milk processing by regulating the set-up of plants adjacent to one another and building subsidized demonstration plants to power health centres, schools and public administration.
    - Extending the current cooperative loan programme for dairy smallholders to automatically include a loan for biogas plants (INR10,000) while purchasing calves (two buffalos for INR60,000 at a rate of 10 per cent).

- Harnessing synergies from milk and dung collection by establishing a system for the systematic collection of dung (similar to the collection of milk) organized by the cooperative as well as the private sector (e.g. as part of the National Rural Employment Guarantee Act (NREGA)).
- Organizing the systematic collection of dung as well as establishing the necessary rural infrastructure for water resources (e.g. as part of NREGA).
- Clustering small biogas plants based on thorough assessment and ex ante selection criteria in order to avoid plants to fail, particularly family size ones. A selection and assessment toolkit developed by the ILO and Development Alternative (DA) could serve as a basis.
- Including ex post training on operation and maintenance of small biogas plants. A careful selection and implementation scheme for the installation, maintenance and operation of biogas plants and the compost facilities is a precondition for the sustainability and long term success of using dung more productively.

Overall enabling Dairy-Energy Policies

- Integrated Dairy-Energy Studies should be institutionalized in technical and vocational skills training and education programmes (TVET).
- National curricula and diploma in Dairy-Energy should be established to ensure the quality of training. The existing ten Biogas Development and Training Centres (BDTCs) which have been established in various states should be further upgraded and their number increased. Specific curricula targeted at up-skilling masons in biogas technology following standard specifications are needed to improve the quality of construction of biogas plants. The training programme should be extended to include medium and large biogas plants and compost facilities. Electrical engineering should also be part of the programme.
- Policy coordination and coherence between the Energy, Dairy and Agriculture Policy are of paramount importance. The Biogas based Power Generation Programme (BPGP) and the National Biogas and Manure Management Programme (NBMMP) need to be fully integrated into the National Dairy Plan, the dairy development plans of the Department of Animal Husbandry and Dairying (DAHD), the National Dairy Development Board (NDDB) and the national and state Cooperative Dairy Federations of India. Such an integrated Dung-Energy-Dairy policy needs to be closely coordinated with the Ministry of Labour. A focus should be placed on skills training, reskilling and capacity building as well as green enterprise development for rural farmers. Targeted programmes should aim to promote decent work in order to support a just transition into higher value sectors while creating new green jobs.
- The Energy-Dairy Policy should be coordinated with the Ministry of Environment to align its programmes to the National and State Action Plans on Climate Change (GoI, 2007), notably on biogas development and manure management.
- In light of the importance of biomass – and in particular dung cake as a source of cooking energy for the poor – and the slow increase of households accessing liquefied petroleum gas (LPG)[10], the Dairy-Energy Policy should be further aligned to the LPG Policy (TERI, 2010).
- Funds for Research and Development (R&D) in biogas technology should be increased, building upon work which has been carried out by the MNRE at the Indian Institutes of Technology. It

[10] Currently only households with per capita spending of more than INR1,000 per month are able to afford LPG.

should include pilot projects on bottling and compressing biogas (CBG) from small and large biogas plants. Such technology has already been tested and could be piloted in established compressed natural gas (CNG) networks such as in Mumbai.

Elevating the importance of dung to the same level of milk could bring significant economic, social and environmental benefits. Most prominently, it would address the two key challenges which arise in milk production in India, namely the quality and quantity of the milk. It could foster income generation, reduce energy expenditures and create green jobs directly and indirectly. Together with its strong pro-poor developmental effects, the effective use of dung would contribute to increase energy security and reduce environmental degradation and greenhouse gases. It could further contribute to foster green growth and support the positioning of India and its labour force in biogas markets as part of a future global green economy.

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Appendix

Methodology

This paper is based on a case study of the dairy cluster in Jabalpur, Madhya Pradesh, India. Primary quantitative data was collected in November 2011. The range of data covers employment, wages, quality of work, and the prices of milk, dung, compost, biogas and electricity. The data was collected through a questionnaire designed specifically for dairy farmers and dung contractors of large, medium and small farms. Structured interviews were held with government officials, academics from university, dairy associations and cooperatives. Private sector companies engaged in activities including milk, compost and biogas, as well as other stakeholders such as brick kiln owners were also interviews with the support of a similar questionnaire. Meetings and discussions were held with women's associations and informal worker groups and dung cake makers.

The final estimated figures pertaining to employment, energy, value and size of the dung cake economy in Jabalpur were validated in interviews with the ILO, TERI and Development Alternative (DA), and subsequently cross-checked and completed with secondary data from national statistics and available international research.

Based on the consolidated figures for the Jabalpur cluster, extrapolations were made for the Indian dairy and dung economy as a whole. The basis for the extrapolation is the total population of cattle in India based on the latest national census 2011. The total available dung and the existing and potential employment at the national level is derived from estimations of the commercial size of the milk industry in India. These estimations were compared and aligned to academic literature, national censuses and official reports on the Indian dairy and biogas industry.

The data analysis in this paper is primarily based on the data collected and the interviews conducted in 2011, except for those with clear references indicating otherwise. However, due to the small sample size of the interviews and the weakness in rigorous data, the estimations on the Jabalpur dung economy and the national extrapolations should be treated with care.

In light of the aforementioned limitations on the robustness of the findings, the following assumptions were made which form the basis of the estimations and extrapolations.

Assumptions on the farm structure and size:

- The name 'Jabalpur cluster' refers to a geographical area of dairy farms in a radius of 7-10 km around Jabalpur city along the Paryat and the Gaur River.
- Approximately 40,000 buffalos are held in the Jabalpur cluster (31,000 at Paryat River, 6,700 at Gaur River and 2,000 by smallholders). The counting was done for the 1 MW Ayur biogas plant by the private Shreyans Ltd company in 2010.
- The cluster contains a total of 210 commercial farms (50-1,000 buffalos) and 90 small holder farms (2-50 buffalos or cows)
- Specifically there are:

- o 12 very large farms (800-1,000);
- o 8 large farms (500-800);
- o 75 medium farms (200-500);
- o 115 small farms (50-200);
- o 90 non-commercial farms (5-50);

Assumptions regarding employment on numbers and wages:

Type of employment in the dung industry	Assumption on number employed	Monthly income over the year in INR[1]
Women cleaning dung in the dairy farm	1 women cleans dung from 1 row of buffalos (40-50)	1 600
Contractors which are contracted by dairy farms to dispose of cow dung	60% of farms have contractors with on average 1 contractor working for 2 farms	50 000
Tractor drivers/owners transporting dung	1 male contractor employs/hires 1 driver	3 500
Women dung cake makers	1 women for 1 tonne of fresh dung/day	1 590[2]
Operator of small biogas generator (50 kW)	1 male electrician	4 500
Cleaner/feeder of small biogas digester	1 male labourer	3 500
Women employed in commercial vermicomposting business	2 women for 1,25 tonnes of cow dung/day	3 500
Permanent workers in big biogas plant 1.2 MW	70 skilled and unskilled workers	4 000
Permanent workers in compost making out of slurry of the big biogas plant of 1,2 MW	120 women	3 500

[1] The monthly salaries are averages which can differ quite significantly depending on the farm, the location, the years of experience and the exact nature of the job (notably for the contractors which income depends on the size of rented land).

[2] The calculation is as follows: INR85 per day x 7 = INR595 per week. 595 x 8 months = INR19,040. 19,040/12 month = INR1,590.

Assumption on the total production and use of fresh dung:

The total amount of fresh dung produced per day is based on the estimation of 30 kg per buffalo. Critics bring forward that this estimation is too high which is correct in the case of a national estimation (regarding the national extrapolation only 5 kg/animal was assumed). Nevertheless, for Jabalpur this estimation was upheld as the cluster is entirely made up of pure buffalo breeds with an intake of around 15-20 kg of dry and fresh fodder per day and approximately 70 litres of water.

- Total wet dung production = 1,200 tonnes per day.
- Dung used by 1,2 MW biogas plant = 200 tonnes
- Dung used by vermicomposting producer = 37 tonnes
- Dung used by large farms for own applications on fields and other = 324 tonnes
- Dung used by other farms is an estimated 10 per cent of the remaining dung = 88 tonnes

- Total remaining dung for dung cake making = 551 tonnes

Assumption on the value and economics of dung:

- Fresh dung is transported in standardized tractor trolleys with a capacity of 1-1.5 tonnes with a sales price of INR100-150 per trolley. Accordingly it is assumed that the value of fresh dung is INR0.1/kg.
- Concerning dry cake, one trolley fully loaded can transport approximately 7,000-8,000 dung cakes estimated to weight 1 tonne. Sold in trolleys through grocery stores, the trolley cost INR2,500 (INR2.5/kg). To fill one trolley with dry dung cakes the contractor calculates that he/she will need three trolleys of fresh dung. Accordingly, dividing this figure by three equals the value (added) of fresh dung in making dry cakes which is INR0.8/kg per fresh dung.
- The market sales price for 1 kg of dry dung cakes for cooking is INR3/kg. This is equal INR1/kg of fresh dung.
- The vermicomposting sales price for commercial use is INR3/kg which is equal to INR1/kg of fresh dung.
- Concerning biogas for cooking, from a small 2 cubic metres plant which needs a feeding of 60 kg fresh dung per day (1,800 kg per month), an equivalent of 30 kg of liquefied petroleum gas (LPG) can be produced. The value for 1 kg of LPG stands at approximately INR27.5/kg in bottles of 2 kg. Summing it up, a value of INR825 can be produced per month for 1,800 kg. Per kilogramme of fresh dung this is equal to INR0.5/kg. In addition the slurry out of the biogas digester can be further transformed into vermicomposting with a value of INR1/kg fresh dung making it a total value added of INR1.5/kg when fresh dung is used in small-scale biogas digesters.
- Concerning biogas for electricity generation for small-scale production of 10,000 kWh per month the total is calculated as follows. It is assumed that a digester with a capacity of 15,000 kg per day (500 buffalos x 30 kg making it 450,000 kg/month) is able to produce gas to run a generator generating 10,000 kWh a month. Applying a commercial electricity price of INR7.5 a total of 75,000 INR/month can be assumed. Per kilogramme of fresh dung, a value of INR0.01-0.2 can be achieved (only for electricity not using the slurry yet)
- The calculation for large-scale electricity generation from biogas (2 MW) is done as follows. A total of 200 metric tonnes of fresh dung is needed per day (6,000 tonnes per month or 72,000t/year). Assuming a production of 7,567 MWh/year (7,567,000 kWh/year or (630583 kWh/month) gives a value of INR22,701,000 to INR56,752,500 per year. The value added from 1 kg of fresh dung calculated on the basis of a price of INR3-7.5 for one kWh is INR0.315-0.788/kg fresh dung.
- These calculations are based on the assumption that for electricity generation 0.75 m3 gas is needed per kWh for a 100 per cent biogas engine. Accordingly the gas production per kilogramme of wet dung is 0.04 m3/day.

Assumptions on total milk production:

- It is assumed that 60 per cent of total animals are always producing milk concurrently. This is due to the lactating period of only 8-10 month and the pregnancy period. Accordingly, an overall total average of 5 litres of milk per animal per day is assumed (although a good breed buffalo might give 12-15 litres a day when lactating). The total cluster production is thus estimated at 200,000 litres per day.
- For the construction of a 2-3 cubic metres family-size biogas plant 30 man-days are required making it eight biogas plants for a full-time equivalent job per year (8 biogas plants = 1 full-time).
- The sales price in 2011 for one litre of buffalo milk with a fat content of 7.5 per cent is assumed INR36-38/litre. Accordingly the total production is INR7,400,000.
- Regarding the milk sales channels, 60 per cent is sold door to door and 40 per cent in outlets. A total of 20,000 litres in the Jabalpur cluster is directly absorbed by the local processing plants.
- It is assumed that dairy farms make a 10-15 per cent profit. A farm of 1,000 buffalos with 5l milk production per buffalo is able to produce 5,000 litres times INR37 per day. With a 15 per cent profit rate the income of the farmer could be estimated at INR27,750.
- A farm with 50 animals with 5l average makes 250 times INR37= 9,250 =INR1,388.

ISBN 978-92-2-127428-5

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