

Sustaining productivity and livelihood of livestock farmers of the Bundelkhand region through integrated farming system

GAURENDRA GUPTA¹, D.R. PALSANIYA², MANJANAGOUDA S.S.³, B.B. CHOUDHARY¹, DEEPAK UPADHYAY⁴, R.K. PATEL⁵, S.K. SINGH², KHEM CHAND⁶, SADHANA PANDEY² AND MANJU SUMAN²

ICAR-Indian Grassland and Fodder Research Institute, Jhansi 284 003, Uttar Pradesh

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ABSTRACT

The upsurge in high input-led mono-cropping or specialized production systems post-green revolution phase has evolved Indian agriculture significantly by uplifting production remarkably. However, this evolution also generated offshoot repercussions including degradation of natural resources, agro-waste management issues, fragile agro-ecosystem health, and unstable livelihood. Hence, a livestock-based integrated farming system (LIFS) model having food + vegetables + fruits + fodder + livestock + allied components was developed and assessed for its productivity, profitability, employment generation, and energy dynamics in farmers' participatory fashion in the Jhansi region of Uttar Pradesh, India. Results showed that the LIFS produced 35.91 t/ha/yr of wheat equivalent yield, net returns of ₹352.4×10³/ha with a B: C of 1.84, and generated 633 man-days/ha/yr employment. LIFS was assessed as 278.0% more productive, 226.6% more profitable, and 336.6% more employment generative than the region's traditional groundnut-wheat cropping system (GWCS). Furthermore, LIFS was 12.9% more energy productive than the traditional cropping system of GWCS. Overall results inferred that the LIFS could be recommended for improved production sustainability and livelihood stability of the marginal farmers in the Bundelkhand region of India.

Key words: Employment, Energy, Integrated farming system, Livestock, Livelihood, Resources

Indian farmers face a multitude of agro-ecological challenges, including erratic monsoons, degrading natural resources, emerging pests and weeds, excessive reliance on external inputs, low input efficiency, stagnating yields, and inefficient agro-residue management. (Babu *et al.*, 2023). Addressing these challenges demands sustainable, climate-resilient practices to enhance agricultural productivity and environmental health. Meanwhile, the livestock sector faces constraints such as low-yielding non-descript animals, fertility issues, inadequate feeding, neglect of fodder cultivation, unmanaged grazing, and limited veterinary services (Sharma *et al.*, 2021). A holistic approach integrating crop and livestock management is crucial for sustainable agro-ecosystems. Moreover, feeding the burgeoning population of humans and livestock under the

current set of limited production factors has been regarded as a challenge for researchers and policymakers (Palsaniya *et al.*, 2022). India holds 536.76 million livestock as per the recent 20th livestock census; however, despite this enormous livestock resource, the productivity of Indian livestock is 20-60% below the global average which is primarily believed as a result of inappropriate feeding which contributes 60-75% of the total cost of production (Roy *et al.*, 2019). The insufficient fodder supply is believed a major factor responsible for the underperformance of livestock; and this scarcity of fodder is driven by factors including ineffective synergy between livestock and crops, poor and marginalized fodder cultivation practices, unavailability of quality seed and critical inputs, insufficient irrigation, and improper plant protection (Sharma *et al.*, 2021).

The post-green revolution era after the 1960s, besides ensuring food security, gave birth to second-generation problems including fragile agro-ecosystem, loss of traditional knowledge, soil quality and environmental degradation, loss of soil biodiversity, depleting water resources and elevated energy-carbon input which compelling the farmers for practicing climate vulnerable farming at present (Gupta *et al.*, 2022; Kaur *et al.*, 2023). The major

¹Corresponding author's Email: guptagaurendra@gmail.com

¹Scientist, ²Principal Scientist, ICAR-Indian Grassland and Fodder Research Institute, Jhansi, Uttar Pradesh 284003; ³Scientist, ICAR-Indian Institute of Seed Science, Regional Station, Bangalore, Karnataka 560065; ⁴Associate Professor, Rani Laxmi Bai Central Agricultural University, Jhansi, Uttar Pradesh 284003; ⁵Principal Scientist, ICAR-Indian Institute of Soil and Water Conservation, Regional Centre, Datia, Madhya Pradesh 475661; ⁶Principal Scientist, ICAR-National Institute of Agricultural Economics and Policy Research, New Delhi 110012

theme of the green revolution i.e. high input led monoculture or specialized farming based on component approach has been blamed as a cause to distort the balance of agro-ecosystem which not only affected farm's provisioning ecosystem services but also influenced the supporting and regulatory ecosystem services (Palsaniya *et al.*, 2022; Meena *et al.*, 2024). This scenario regards it most pertinent to diversify the monoculture production system through livestock-based integrated farming systems (LIFS) with the inclusion of diverse crops and cropping systems and also a proper integration of livestock with crops for climate resilient production, sustained employment, efficient resources recycling for improved livelihood and ecosystem services (Singh *et al.* 2020; Paramesh *et al.*, 2019; Palsaniya *et al.*, 2021).

New emerging challenges in intensive livestock production are making the production process energy sustainable which could be possible by optimizing the energy use under feeding management (Palsaniya *et al.*, 2022; Garg *et al.*, 2016). The prevailing mono-cropping systems require more energy-intensive inputs (diesel, electricity, fertilizers, pesticides, concentrate feeds) which negatively affects environmental sustainability by altering energy use irrationally thus, makes the production process economically, environmentally, and socially unsustainable. In this regard also, LIFS has been referred to as a potential technology to outcome cleaner and environmentally friendly production systems since LIFS helps in balancing energy use by reducing the dependence on external inputs and utilizing indigenous resources efficiently (Babu *et al.*, 2023; Paramesh *et al.*, 2019; Palsaniya *et al.*, 2022). Further, the need to assess the on-station IFS models at farmer's field under participatory on-farm trial (OFT)

mode has been found prospective from the study of Patel *et al.* (2020); Palsaniya *et al.* (2022) and Babu *et al.* (2023) for improved LIFS adoption and its popularization among the stakeholders. Hence, the present study was executed to assess the economic and environmental robustness of LIFS concerning the traditional practice of the region. The objectives of the study were to explore the merit of LIFS adoption concerning improvement in production, profitability, and employment of the farm as well as its impact on ecological indicators including energy indices.

MATERIALS AND METHODS

The assessment study on LIFS was carried out in the village Padri, Jhansi, Uttar Pradesh during 2019–2024. The site is located at 25°51' N latitude, 78°60' E longitude, and 193 m altitude in the Bundelkhand region of central India. The experimental region falls under a semi-arid climate which receives 825±150 mm average annual precipitation, of which, more than 90% was received during the monsoon period (June to September). The mean annual temperature of the region is 25°C which rises as high as 47°C during summers and falls up to 2°C during winters (Kumar *et al.*, 2021). The initial soil physico-chemical parameters included pH (7.9), EC-electrical conductivity (0.30 dS/m), OC-organic carbon (0.65%), N-nitrogen (188.2 kg/ha), P-phosphorus (16.5 kg/ha), K-potassium (268.5 kg/ha).

The selected farmer's field was located in a peri-urban area and had a net acreage of 0.9 ha, a year irrigation facility, all the necessary machinery and an organized animal shed having animals equal to three adult cattle units (ACUs). This farm was reorganized following the inte-

Table 1. Components of livestock based integrated farming system and traditional system

Systems	Components	Gross area (ha)	<i>Kharif</i>	<i>Rabi</i>	<i>Zaid</i>
Livestock based integrated farming system (LIFS)- Net Area: 0.9 ha	Food	0.60	Mungbean, urdbean, groundnut	Wheat	Mungbean
	Vegetables	1.35	Bitter gourd, brinjal, cowpea, tomato, chilli, okra	Tomato, brinjal, radish, cabbage, onion, leafy vegetables	Bitter gourd, brinjal, bottle gourd, cucumber, okra
	Fodder	0.35	Sorghum, cowpea, guar	Berseem, oat	Sorghum, cowpea, guar
	Fruits	0.15	Bajra Napier Hybrid, cactus, Subabul, moringa, azolla, leaves from fruit trees		
	Livestock	-	Citrus, papaya, karonda, guava, moringa, Ber, jackfruit, mango		
Traditional cropping System	Allied activities	-	Buffalo-1, cattle- 1, goat-3, sheep-2 (Total 3 ACUs)	Mushroom, vermicompost, silage, azolla	
				Groundnut-wheat (GWCS)	

grated farming system principles where 20.0% area was allocated to food crops, 45.0% to vegetables, 5.0% to fruits, and 19.0% to fodder crops. Besides, the animal herd of one *Murrah* buffalo, one *Sahiwal* cow, three *Bundelkhandi* goats, and two *Jalauni* sheep was integrated with the crop components (Table 1). For efficient utilization of farm waste and generation of additional income, a few allied activities including mushroom, Azolla, vermicompost, and silage production were added to the LIFS model. To compare the performance of LIFS with the traditional double crop-based system of the region, observations from a cluster of farmers practicing groundnut-wheat cropping system (GWCS) of the same village were recorded. The LIFS assessment study was based on a life cycle assessment and process analysis approach as described and adopted in various IFS studies and referred to as an effective method for the assessment of farming systems (Paramesh *et al.*, 2019; Garg *et al.*, 2016). To compare various enterprises of the LIFS, wheat equivalent

yield (WEY) was calculated by converting the output from different components based on their marketable value prevailing during the period, and expressed in t/ha. The following equation has been adopted for the computation of WEY.

$$\text{Wheat equivalent yield (WEY)} = Y_w + Y_1 \times \frac{P_1}{PP} + Y_2 \times \frac{P_2}{PP} + \dots$$

Where Y_w is the yield of wheat; Y_1, Y_2, \dots are the yields of other crops or output from other enterprises; P_1, P_2, \dots are the prices of non-wheat crop/enterprise and PP is the price of wheat.

Similarly, the man-days of labor engaged under production systems were recorded on a daily basis around the year and then summed up to find out the monthly as well as annual employment generated.

The energy budgeting of the present study was performed by estimating the energy input-output using specific input-output energy equivalents given in Table 2. After estimating the component-wise energy input and

Table 2. Energy equivalent of inputs and outputs adopted for energy calculation

Particulars	Unit	Energy Equivalent (MJ/unit)	Reference
<i>Input</i>			
Human power	Man-days	1.96	Devasenapathy <i>et al.</i> (2009)
Farm machinery	kg	62.7	Pathak <i>et al.</i> (2022)
Tractor	kg	68.4	Pathak <i>et al.</i> (2022)
Diesel	l	56.31	Devasenapathy <i>et al.</i> (2009)
Electricity	kWh	11.93	Devasenapathy <i>et al.</i> (2009)
Manure/FYM	kg	0.3	Devasenapathy <i>et al.</i> (2009)
Fertilizer Nitrogen	kg	60.6	Devasenapathy <i>et al.</i> (2009)
Fertilizer Phosphorus	kg	11.1	Devasenapathy <i>et al.</i> (2009)
Fertilizer Phosphorus	kg	6.7	Devasenapathy <i>et al.</i> (2009)
Micronutrient fertilizers	kg	8.40	Strapatsa <i>et al.</i> (2006)
Water	m ³	1.02	Devasenapathy <i>et al.</i> (2009)
Herbicides	kg/l	288	Chaudhary <i>et al.</i> (2006)
Insecticides	kg/l	237	Khosruzzaman <i>et al.</i> (2010)
Fungicides	kg/l	196	Khosruzzaman <i>et al.</i> (2010)
Feed concentrates	kg	6.3	Komleh <i>et al.</i> (2011)
Oilcakes	kg	5.61	Singh and Mittal (1992)
Crop seeds	kg	14.7	Singh and Mittal (1992)
<i>Output</i>			
Food grains	kg	(As input)	Mittal and Dhawan (1988)
Vegetables	kg	1.0	Ozkan <i>et al.</i> (2004)
Fruits	kg	1.9	Singh and Mittal (1992)
Dry fodder	kg	18	Devasenapathy <i>et al.</i> (2009)
Milk	l	7.14	Coley <i>et al.</i> (1998)
Meat (goat, sheep)	kg	9.22	Frorip <i>et al.</i> (2012)
Mushroom	kg	1.62	Salehi <i>et al.</i> (2014)
Silage	kg	8.0	Komleh <i>et al.</i> (2011)
Straw (rice and wheat)	kg	12.5	Singh and Mittal (1992)
Stover (moong)	kg	11.25	Soni <i>et al.</i> (2013)
Fuel wood	kg	18.0	Singh and Mittal (1992)
Vegetables	kg	10.0	Singh and Mittal (1992)
Manure	kg	0.3	Taki <i>et al.</i> (2012)
Urine	l	0.64	Paramesh <i>et al.</i> (2019)

Table 3. Energy indices used in assessing energy dynamics of livestock based integrated farming

Energy indices	Unit	Calculation equation
Net energy gain (NEG)	MJ	Total energy output (MJ)-Total energy input (MJ)
Energy use efficiency ratio (EUE)		Total energy output (MJ)/Total energy input (MJ)
Energy productivity (EProd)	kg/MJ	Economic yield (kg)/ Energy input (MJ)
Energy profitability (EProf)	MJ	Net energy gain (MJ)/ Total energy input (MJ)
Human energy profitability (HEP)	MJ	Total output energy (MJ)/ Labour energy input (MJ)
Energy intensiveness (EI)	MJ/₹	Total energy input (MJ)/ Cost of production (₹)
Energy intensity in physical term (EI _{et})	MJ/kg	Total energy input (MJ)/ Total output (kg)
Energy intensity in economic term (EI _{pt})	MJ/₹	Total energy output (MJ)/ Cost of production (₹)
Direct energy (DE)	MJ	Energy input (Labor + fuel + electricity)
Indirect energy (IE)	MJ	Energy input (Seed + feed + fertilizers + chemicals + machineries + water)
Renewable energy (RE)	MJ	Energy input (Labor + organic fertilizers + feed + water)
Non renewable energy (NRE)	MJ	Energy input (Fuel + electricity + seed + fertilizers + chemicals + machinery)

output, different energy indices were worked out by using equations (Table 3) as outlined by Devasenapathy *et al.* (2009) and Khosruzzaman *et al.* (2010).

The economic assessment of LIFS was done under the parameters of cost of production (CoP), gross returns (GR), net returns (NR), and benefit-to-cost ratio (B:C). The input cost for field preparation, sowing, manures and fertilizers, agrochemicals, water, wages, animal feed, etc., comprised variable costs. The initial one-time investment occurred during the first year in the establishment of perennial components (like fruit trees, and perennial grasses), construction of the animal shed, and animal cost was taken as fixed cost. The total annual cost was then estimated by summing the variable and fixed costs. The GR indicates the gross economic value of all the produce while NR indicates the net profit after deducting the CoP from GR. The B: C indicates the ratio of GR to CoP.

RESULTS AND DISCUSSION

Production performance

The LIFS model produced a total of 35.91 t/ha of wheat equivalent production annually which had the maximum share from livestock component (44.0%) followed by vegetables (38.4%), food (8.6%), fodder (8.0%), allied (2.1%) and fruits (1.1%) (Table 4). The relative comparison of production performance among production systems indicates 3.8 times increased production under LIFS over GWCS production. The increased production under LIFS might be a result of major factors including multi-enterprise nature, dominance of livestock, and most importantly synergistic relationship among components which ensured proper resource flow and utilization (Palsaniya *et al.*, 2022). Moreover, LIFS benefitted directly with higher cropping intensity (267%) which was 1.3 times more than the cropping intensity of 200% under GWCS. The increased cropping intensity was seen as a result of

the appropriate selection of crop rotations and efficient resource recycling and use. Further, the adoption of various best crop and animal management practices including improved crop varieties and animal breeds, precision sowing, contingent crop management, integrated nutrient-weed-pest management, water harvesting and irrigation scheduling, balanced livestock feeding, better post-harvest management and marketing of LIFS produce has resulted in optimum factor productivity and thus improved production, even under the prevailing farming constraints (Paramesh *et al.*, 2022).

Economics

The LIFS model incurred a CoP of ₹429.6×10³/ha and provided NR of ₹352.4×10³/ha in a B:C of 1.84. This profitability of LIFS includes the maximum share from vegetables (58.5%) followed by livestock (27.6%), food (11.4%), fodder (11.2%), allied (3.5%), and fruits (1.6%), (Table 4). The livestock component of LIFS was assessed as the costliest component which could be due to the limited land resources resulting in a 13.4% fodder deficit and dependence of farmers for market-purchased costly concentrated feed inputs of more than half of the required quantity. The net profitability of LIFS was assessed as 3.3 times higher than the net profit of GWCS. Although the LIFS translates with relatively lesser B:C than GWCS however, considering the overall provisioning, regulatory, and supporting ecosystem services being offered by the LIFS, it becomes more remunerative in a holistic sense (Palsaniya *et al.*, 2022). The advantage of increased returns from LIFS was seen as a function of various factors including improved production, reduced resource wastage and minimum post-harvest loss, and better marketing of the fresh produce of LIFS, as the farm was located in a peri-urban area. Further, the saving of inputs owing to the better synergy among enterprises and the adoption of best management practices has resulted in cost-cutting and thus

added to the net return (Paramesh *et al.*, 2019; Palsaniya *et al.*, 2022).

Employment generation

The estimated annual employment generation from LIFS was 633 man-days/ha which was 4.4 times higher than employment generation with GWCS (Table 4). Among the components of LIFS, the vegetables generated the most employment (41.5%) followed by livestock (31.6%), fodder (14.4%), food (9.0%), fruits (2.7%), and allied (0.9%). The advantage of increased employment opportunities under the LIFS was seen as a result of diversity among crops, livestock, and allied activities which required daily care and management thus offering regular employment throughout the year which not only checked labor migration but also curtailed the production cost by downsizing hired labor requirement (Patel *et al.*, 2019; Paramesh *et al.*, 2022; Palsaniya *et al.*, 2022).

Energy budgeting

The annual energy budget assessment of the LIFS model indicates a total energy input of 77187 MJ/ha, a total energy output of 299953 MJ/ha, and a net energy gain of 222766 MJ/ha annually (Table 5). Among the components of LIFS, livestock was seen as the most energy feeder (44.8%) followed by energy consumption by vegetables (29.9%), food (12.3%), fodder (10.5%), fruits (2.5%), and allied (0.1%). Relative to GWCS, the LIFS consumed 2.31 times higher total energy which might be due to the factors of increased cropping intensity under LIFS which increased the consumption of production inputs, thus elevated the total energy use. Moreover, the presence of livestock components as additional enterprises

has also added a significant amount of energy to total energy consumption. The highest energy consumption by livestock component was attributed to the feed input which alone shared 44.1% of the total energy input of LIFS. The higher energy consumption under LIFS vis-à-vis GWCS and the dominant role of livestock component in LIFS energy consumption was also studied by Palsaniya *et al.* (2022) in the same region of study and reported 1.9 times higher energy consumption under LIFS over the GWCS. Babu *et al.* (2023) reported the role of enterprise diversification by showing 1.8 times higher energy input under highly diversified LIFS over the less diversified LIFS. The fodder crops followed by vegetables, food, livestock, allied and fruits have been found as the topmost energy producers as well as net energy gainer components. Relative to GWCS, LIFS produced 1.3 times higher energy output and 1.13 times higher net energy gain (Table 5). The higher amount of energy output and net gain under LIFS over the GWCS was an outcome of the energy output from increased production from diverse products (food grains, vegetables, fruits as crop produce; milk, meat, manure, wool as livestock produce and Azolla, silage, vermicompost as allied activity produce). The topmost energy output share from crops, especially fodder, might be due to their energy equivalent values which are relatively higher than the energy equivalent values of animal products, mainly milk (Table 2). This pattern of energy output and net energy gain as a result of variable energy equivalent values can also be concluded from the studies of Palsaniya *et al.* (2022), Paramesh *et al.* (2019), and Babu *et al.* (2023).

The energy assessment using various indices indicated

Table 4. Annual production, profitability and employment generation from livestock based integrated farming system

LIFS enterprises	Production (WEY, t/ha)	Cost of production ($\times 10^3$ ₹/ha)	Gross returns ($\times 10^3$ ₹/ha)	Net returns ($\times 10^3$ ₹/ha)	Benefit: cost ratio	Employment generation (Man-days/ha)
Food	3.08 (8.6)	31.1 (7.2)	67.7 (8.6)	36.6 (11.4)	2.18	57 (9.0)
Vegetables	13.78 (38.4)	108.9 (25.3)	303.1 (38.4)	186.8 (58.5)	2.78	263 (41.5)
Fruits	3.80 (1.1)	2.8 (0.6)	8.3 (1.1)	5.0 (1.6)	3.00	17 (2.7)
Fodder	2.86 (8.0)	27.1 (6.3)	63.0 (8.0)	35.9 (11.2)	2.32	91 (14.4)
Livestock	15.81 (44.0)	259.8 (60.5)	347.9 (44.0)	88.1 (27.6)	1.34	200 (31.6)
Allied	0.76 (2.1)	5.6 (1.3)	16.7 (2.1)	11.1 (3.5)	3.33	6 (0.9)
Overall LIFS	35.91	429.6	790.1	352.4	1.84	633
GWCS	9.5	83.0	190.9	107.9	2.30	145

Values in parenthesis indicate percentage of total value of the parameter.

Table 5. Components wise energy balance and indices of livestock based integrated farming system and groundnut-wheat cropping system

Energy indices	Unit	LIFS							GWCS
		Food	Vegetables	Fruits	Fodder	Livestock	Allied	Overall	
Total energy input	MJ	9471 (12.3)	23081 (29.9)	1915 (2.5)	8072 (10.5)	34554 (44.8)	94 (0.1)	77187	33375
Total energy output	MJ	56078 (18.7)	73920 (24.6)	2739 (0.9)	113400 (37.8)	44372 (14.8)	9444 (3.1)	299953	230770
Net energy gain	MJ	46607 (20.9)	50839 (22.8)	824 (0.4)	105328 (47.3)	9818 (4.4)	9350 (4.2)	222766	197395
Energy use efficiency	-	5.92	3.20	1.43	14.05	1.28	100.29	3.89	6.91
Energy productivity	kg/MJ	3.25	5.97	1.98	3.55	4.58	80.45	4.65	0.28
Energy profitability	MJ	4.92	2.20	0.43	13.05	0.28	99.29	2.89	5.91
Human energy profitability	MJ	558.8	159.6	93.2	704.9	125.8	963.7	268.7	1591.5
Energy intensiveness	MJ/₹	0.30	0.21	0.69	0.30	0.13	0.02	0.18	0.40
Energy intensity in physical term	MJ/kg	0.31	0.17	0.51	0.28	0.22	0.01	0.21	3.51
Energy intensity in economic term	MJ/₹	1.80	0.68	0.99	4.18	0.17	1.70	0.70	2.78
Direct energy	MJ	3143	7674	790	3051	840	69	15567	3143
Indirect energy	MJ	6328	15406	1125	5021	33714	25	61620	6328
Renewable energy	MJ	2224	5242	560	2179	30612	25	40842	2224
Non-renewable energy	MJ	7247	17838	1354	5894	3942	69	36344	7247

Values in parenthesis indicate the percentage of total energy.

that the LIFS provides relatively higher Eprod and lower EUE, Eprof, HEP, EI, EIp, and Eie than the GWCS (Table 5). Among the components of LIFS, allied activities showed the highest EUE, Eprod, Eprof, and HEP values while fruits computed with the highest EI and EIp values and fodder crops provided the highest Eie value. The higher Eprod of LIFS over the GWCS was seen as a result of a higher production level of physical output. The relatively lesser value of other energy indices under LIFS vis-à-vis GWCS could be attributed to the livestock-dominant nature of LIFS which demanded energy-expensive animal feed and thus consumed 44.1% of energy alone. Additionally, the increased annual demand for crop inputs under LIFS due to increased cropping intensity owing to favorable production factors can be seen as a factor for increased energy input thus, lowering the energy indices (Babu *et al.*, 2023 and Palsaniya *et al.*, 2022). The ratio among the different sources of energy used in studied systems was estimated and the direct-to-indirect energy source ratio as 20.2: 79.8 however; GWCS used this energy in 31.6: 68.4 ratios. Regarding the ratio of renewable to nonrenewable energy sources, LIFS used this energy in a ratio of 52.9: 47.1; however; GWCS used this energy in a 14.0: 86.0 ratio. The higher contribution from indirect energy sources was attributed mainly to the higher share of feed energy input (44.1%) required for sustaining the dominant livestock component. A similar reason could also be attributed to higher renewable energy use since feed has been regarded as a renewable energy input (Palsaniya *et al.*, 2022; Paramesh *et al.*, 2022).

Resources flow

The studied LIFS on actual acreage (0.9 ha) basis required annually 570.0 man-days of labor, 67.0 liters of diesel, 896.0 kWh electricity, 57.0 kg seeds, 275.0 kg fertilizers, 13.3-ton manure, 5388.0 m³ water, 9.0 liters agrochemicals, 152.0 hours of machinery and 18.0-ton animal feed (Fig. 1). All these inputs have incurred a cost of production of ₹429.6 × 10³ ha/yr and were equal to 77187 MJ/ha/yr of energy. These resources have provided a production equal to 35.9 t/ha/yr of wheat equivalent production. The 60% of food grains, and 90% of each of vegetables and fruits produce made up a food basket of 13.1 t/ha of WEY. Of this food basket, 42.0% was used for family consumption while 58.0% was marketed. Out of the total animal produce of 15.8 t/ha of WEY, a whole quantity of

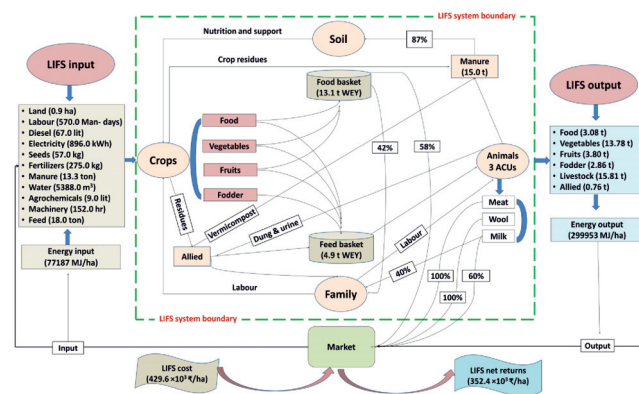


Fig. 1. Interrelationship and resources flow among components of livestock based integrated farming system

meat, wool and 60% of milk were sold in the market and the rest 40% of the milk was consumed by the family. Regarding the manure, 100% of vermicompost and 86.7% of farm yard manure (FYM) were recycled in farm soil, and the rest 13.3% of FYM was sold. The crop residue and animal byproducts recycling was to the level of >95% owing to the effective integration, and adoption of residue management practices including mulching, manuring, mushroom production, and accelerated decomposition *in-situ* using waste decomposer formulations.

Thus, the study inferred that the livestock-based IFS (livestock+ food+ fodder+ vegetables+ fruits+ allied) is an economically and environmentally robust production model over the traditional wheat-groundnut cropping systems of the region. Hence, the LIFS can be recommended for sustaining the productivity and livelihood of small and marginal farmers of the Bundelkhand region of India.

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