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# Economic analysis of an integrated pig farming system under coastal agro-ecosystem of Goa

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**Abstract**
Integrated farming system (IFS) enhances profitability and sustainability through enterprise diversification and resource recycling. This study evaluated the economics of an operational integrated pig farming system (IPFS) in Goa comprising piggery, poultry, aquaculture and horticulture. Enterprise-wise costs and returns were computed at prevailing farm-gate prices, while outputs were standardised using pig equivalent yield (PEY). The system achieved total gross returns of ₹71.18 lakh against costs of ₹28.89 lakh, yielding net returns of ₹42.28 lakh and an overall B:C ratio of 2.46. Piggery contributed the largest share of PEY (27,500 kg; 58%) and net returns (₹26.11 lakh), followed by aquaculture (16,253 kg PEY; net returns ₹13.96 lakh). Horticulture and poultry, though modest in scale, improved recycling efficiency and cash flow. The system generated 720 man-days of employment, underscoring its livelihood potential. Results confirm the economic viability of livestock-anchored IPFS as a replicable model for coastal farming communities.

**Keywords:** Integrated pig farming system, economic analysis, benefit-cost ratio, pig equivalent yield, employment generation

## 1. Introduction

Livestock farming plays a crucial role in ensuring nutritional security, rural livelihoods, and economic stability in India. Among livestock enterprises, pig farming offers notable advantages due to its high fecundity, efficient feed conversion, early maturity, and short generation interval, providing rapid economic returns for farmers (Thomas *et al.,* 2021) [15]. According to the 20th Livestock Census, India's pig population stands at 9.06 million, with crossbred and exotic pigs contributing significantly to commercial production. In Goa, where the demand for fresh pork exceeds local supply, pig farming presents a viable opportunity for livelihood enhancement and sustainable food production. Rising input costs, shrinking landholdings, and reduced resource-use efficiency have made conventional single-enterprise systems less profitable. To overcome these constraints, farmers are increasingly adopting integrated farming systems (IFS) that combine livestock, aquaculture, horticulture and crop components under one management unit. The interdependent and interlocking nature of IFS enables nutrient recycling, reduces external input dependency, enhances system resilience and provides multiple income sources year-round (Paramesh *et al.,* 2022a) [11].

Piggery units often encounter challenges such as high feed costs, waste disposal issues, and market fluctuations. The integrated pig farming system (IPFS) offers a sustainable alternative by linking piggery with aquaculture, horticulture and poultry components within a closed-loop framework. Pigs efficiently convert farm residues and kitchen waste into quality meat, while their manure serves as an organic fertilizer for fish ponds and horticultural crops. The nutrient-rich pond water, in turn, is reused for crop irrigation, thereby enhancing soil fertility and productivity. Such circular linkages improve economic efficiency, reduce environmental pollution, and promote resource-use sustainability. Previous studies have also reported that integrated pig-fish-crop models enhance overall productivity, profitability, and livelihood security (Das *et al.,* 2013; Paulpandi *et al.,* 2024) [3, 13].

Moreover, integration generates greater on-farm employment, as different components require continuous or sequential management, contributing to rural employment generation and household income stability (Barekar *et al.,* 2024) [1]. In this context, the present study was undertaken to assess the economic performance and employment generation potential of a pig-based integrated farming system (IPFS) under the coastal agro-ecosystem of Goa.

## 2. Materials and Methods

### 2.1 Study location

The field study was carried out during December 2024 to May 2025 to evaluate the economic performance of a pig-based integrated farming system (IPFS) established in Bicholim Taluka, North Goa, India (15°40′59.14″ N, 73°56′20.92″ E; altitude 45 m above mean sea level). The region experiences a humid tropical monsoon climate with an annual rainfall of about 3000 mm, average temperature of 17-35°C, and relative humidity above 75 percent (Paramesh *et al.,* 2022b) [10]. The model farm covered 1.875 ha and was developed under the technical guidance of the ICAR-Central Coastal Agricultural Research Institute (CCARI), Goa.

### 2.2 System components

The IPFS comprised four interlinked components designed for resource recycling and continuous income generation:

#### 2.2.1 Piggery

A total of 255 Large White Yorkshire crossbred pigs of different age groups were reared under stall-fed conditions on swill feed. The pig unit occupied an area of 400 $m^2$ and included composting facilities for pig manure and farm waste. Pig manure was used as organic input for horticultural crops and aquaculture ponds. Weaned piglets of three months of age were included in the system and sold after fattening period of six months.

#### 2.2.2 Poultry

The backyard poultry unit comprised of 58 Vanaraja birds housed in a shed constructed with locally available materials. The birds were maintained primarily on swill feed, supplemented with a small quantity of concentrate and allowed to scavenge on the farm area.

#### 2.2.3 Aquaculture

Five tarpaulin-lined ponds with an average depth of 2 m and a total area of 6520 $m^2$ were used for fish culture. The first three ponds were stocked following a predatory fish polyculture system with Asian seabass (*Lates calcarifer*; 2000 fingerlings pond$^{-1}$), tilapia (*Oreochromis mossambicus*; 2000 adults pond$^{-1}$) and weed fish (*Rasbora dandia*; 20,000 numbers pond$^{-1}$). The remaining two ponds were stocked intensively with striped catfish or Basa (*Pangasianodon hypophthalmus*; 5000 fingerlings) under continuous aeration and partial water exchange. Tilapia and weed fish were maintained on natural pond diet consisting of phytoplankton and supplemented with wheat bran, while seabass predated on live fish within the system. Basa were fed minced chicken by-products obtained from slaughterhouse waste. Piggery and poultry litter were periodically added as organic inputs to enhance pond fertility. Pond water was later utilised for irrigating horticultural crops, and pond silt was applied as a fertiliser source in the horticulture unit.

**2.2.4 Horticulture:** The horticulture component covered 0.4 ha and included fruit crops such as pineapple, banana, papaya and passion fruit, cultivated following the standard package of practices without the use of chemical fertilisers. In addition, seasonal vegetables were grown over 480 $m^2$, including amaranthus, ivy gourd, brinjal, cluster bean, okra and tapioca, arranged in rotational and intercropping patterns. All crops were organically managed using farmyard manure, compost, and pond water irrigation.

### 2.3 Data collection and analysis

Enterprise-wise input and output data were compiled from farm records and direct observations. The cost of production and gross returns for each component of the IPFS were estimated based on the prevailing market prices of inputs and outputs during the study period. The total cost comprised variable and fixed costs. The variable cost included expenditure on feed, micronutrients, farmyard manure (FYM), seeds, labour and machinery, while the fixed cost accounted for annual depreciation and interest on initial investment. Gross returns were calculated by multiplying the quantity of produce with the respective farm-gate prices and net return was obtained by deducting total cost from gross return. The benefit-cost (B:C) ratio was also computed. The economic performance of IPFS was done as per the methodology used by Palsaniya *et al.* (2024) [9] and Paramesh *et al.* (2019) [12].

To compare the piggery component with other enterprises under the integrated farming system, component-wise production data were used to derive the pig equivalent yield (PEY). It was calculated by converting the value of outputs from piggery, poultry, aquaculture and horticulture into the equivalent yield of pig live weight using the following formula:

$$\text{PEY (kg)} = \frac{\text{Yield of Y (kg)} \times \text{Price of Y (₹ kg}^{-1}\text{)}}{\text{Price of pig live weight (₹ kg}^{-1}\text{)}}$$

Where Y refers to the output of different integrates of IPFS; and Price of pig live weight refers to the farm gate price of live pig (₹ kg$^{-1}$) prevailing during the study period (Sammuria *et al.,* 2025) [14].

Labour utilisation was recorded for each enterprise. One man-day was defined as eight working hours. The total employment generation was estimated using the actual man-days employed in farms (Sammuria *et al.,* 2025) [14].

## 3. Results and Discussion

### 3.1 Pig equivalent yield

The component-wise pig equivalent yield (PEY) of the integrated pig farming system (IPFS) showed considerable variation among enterprises (Table 1). The piggery unit contributed the highest PEY (27500 kg), accounting for nearly 58% of system output, followed by aquaculture (16253 kg; 34%) and horticulture (3045 kg PEY; 6%) in the form of fruits and vegetables, while poultry contributed only 2% (652 kg). These results highlight the improved productivity obtained through the integration of multiple components and the efficient recycling of resources within the farming systems. The high share from piggery is consistent with the intensive biomass turnover and higher market value of live pigs. Aquaculture also showed strong performance due to nutrient recycling from pig and poultry manure, which improved pond productivity. The relatively modest contributions from horticulture and poultry reflect the short evaluation period, which limited perennial crop yields and the low scale of backyard poultry rearing. The cumulative PEY of 47450 kg highlights that integrating multiple components significantly improved overall system productivity compared to the conventional monoculture system. A similar trend was reported by Kumar *et al.* (2025) [5], where the field crops + fish + horticulture + cattle model achieved the highest productivity (Rice equivalent yield: 28.30 t $ha^{-1}$), highlighting the synergistic benefits of integrating diverse farm components compared to field crop monoculture (REY: 7.9 t $ha^{-1}$).

### 3.2 Cost-return analysis of different components

The economic analysis for each component in the study period revealed that the profitability of the system was largely driven by piggery and aquaculture, which together accounted for more than 90% of total net returns. Piggery generated the maximum gross returns (₹41.25 lakh) and net returns (₹26.11 lakh) with a B:C ratio of 2.73, reflecting high productivity and steady demand for pork in the local market (Table 1). Aquaculture recorded net returns of ₹ 13.95 lakhs due to the higher market price of species such as seabass and tilapia, while the recycling of organic manure into ponds reduced feed inputs and enhanced productivity. Comparable profitability has been reported by Kumar *et al.* (2023) [6] and Paulpandi *et al.* (2024) [13] in pig-fish integrated systems.

The crop and poultry components, while contributing less in absolute terms, enhanced the sustainability of the system through input substitution and early cash flow. Horticulture benefitted from the application of FYM and compost together with the use of pond water for irrigation, thereby reducing dependence on externally purchased fertilisers and water resources and reinforcing the ecological benefits of integration (Ibrahim *et al.,* 2023) [4]. Poultry, on the other hand, was maintained at low cost through simple sheds and reduced external feed inputs, while improved backyard varieties provided steady returns. The cost of production from different components of IPFS had a wide range, from the piggery unit (₹ 1513638) to the poultry unit (₹ 51976). The variation in costs can be attributed to the higher input requirements of certain integrates, particularly piggery and aquaculture.

At the system level, the IPFS recorded net returns of ₹42.28 lakh and an overall B:C ratio of 2.46. The increased profitability observed under the IPFS could be due to higher overall production from its multiple components and lower cultivation costs, resulting from improved input use efficiency and reduced reliance on external resources (Paramesh *et al.,* 2019) [12]. Similar findings were reported by Birbal *et al.* (2025) [2] and Mitra *et al.* (2018) [8].

### 3.3 Employment generation

The IPFS model generated a total of 720 man-days of employment during the study period, reflecting the labour-intensive nature of a diversified system (Table 1). The piggery component contributed 360 man-days (50%), followed by horticulture (180), aquaculture (108) and poultry (72). The labour pattern highlighted the key role of piggery in ensuring steady on-farm employment, with crop and fish units supplementing labour needs during different phases of the cycle. Such diversification maintained year-round engagement and improved livelihood security, in line with the observations of Meena *et al.* (2022) [7], Kumar *et al.* (2025) [5] and Sammauria *et al.* (2025) [14], who reported higher employment opportunities in integrated systems than in monoculture farming.

**Table 1:** Economics of integrated pig farming system

| Components | PEY (kg) | Cost of production (₹) | Gross returns (₹) | Net returns (₹) | B:C ratio | Employment generation (Man-days) |
|---|---|---|---|---|---|---|
| Piggery | 27500 | 1513638 | 4125000 | 2611362 | 2.73 | 360 |
| Poultry | 652 | 51976 | 97750 | 45774 | 1.88 | 72 |
| Aquaculture | 16253 | 1042412 | 2438000 | 1395588 | 2.34 | 108 |
| Horticulture | 3045 | 281333 | 456770 | 175437 | 1.62 | 180 |
| Total IPFS | 47450 | 2889359 | 7117520 | 4228161 | 2.46 | 720 |

## 4. Conclusion

The pig-based Integrated Farming System (IPFS) demonstrated high economic efficiency and sustainability under coastal conditions. Integration of piggery with complementary farm components enhanced overall productivity, profitability and employment generation through effective recycling of nutrients and resources. The model provided steady income and reduced external input dependence, indicating its potential as a viable livelihood option for smallholders. Wider adoption of such integrated systems can strengthen rural resilience and promote sustainable livestock-based farming.

## 5. Conflict of Interest

Not available.

## 6. Financial Support

Not available.

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