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Design Integrated Crop-Livestock and Fish Farming Model with LEISA System in North Minahasa Regency

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ABSTRACT

Agricultural land in North Minahasa district has been shrinking. The number of farming families with land ownership of less than 0.5 ha is increasing due to land fragmentation. Designing an Integrated Farming System (IAS) model is a solution to the land problem, so that intensive farming can be carried out. The purpose of the study is to analyze the integrated farming with various integrated farming patterns based on land area feasibility, economic feasibility, ecological feasibility, social feasibility for farming development in North Minahasa district. The results of the analysis was obtained that the land area for crops and livestock/fish is between 0.2 ha to 0.4 ha including 0.1 ha for housing and other household businesses. Economically, the net income from crops and livestock/fish is at least an average of Rp 175,000 per day IDR 3,485,000/month), with a ratio of net income to RTP needs ≥ 1.0. Ecologically, the production of organic matter from livestock/fish is sufficient/exceeds theneeds of crops (≥ 1.0) The strategic model for SPT development in North Minahasa district is to increase the variety of farmer income sources, increase the use of organic matter from livestock and agricultural residues, optimize land and soil utilization.

Keywords: Agriculture; Demand; Fish Crop Livestock Integration; Income; LEISA

INTRODUCTION

Beef demand in North Sulawesi averages 3.38% annually, while local cattle production growth is very low, averaging -13.33% per year. This causes beef prices to be high and compete with imported beef (Endoh et al., 2021). This condition, according to Kalangi et al. (2022), is the cause of competition between local and imported beef sold in the North Sulawesi market. According to him, limited land accompanied by limited knowledge of proper cattle rearing is the source of the problem why the cattle populationin North Sulawesi is unable to meet production needs. Therefore, a strategy is needed to increase local cattle production in North Sulawesi with an integrated farming system model. North Minahasa Regency is one of the regions in North Sulawesi province.

In general, each farming household in North Minahasa Regency owns less than 0.5 ha of cultivated land. This condition is caused by various things, among which the most prominent is the fragmentation of land. The results of the 2013 agricultural census, nationally the average land ownership per household is between 0.3-0.4 ha. Whereas according to Nazam et al. (2011) in Suwarto et al. (2015), the minimum land area for a decent living is 0.78 ha per farmer household. Data from BPS North Sulawesi2022 explains that on average there is a decrease in agricultural land area every year.

Table 1. Agricultural Land Area in North Minahasa district in 2019-2020

No	Land	Year 2019 (hectares)	Year 2020 (hectares)	Fracmentation (hectares)
1	Tegal / Plantation	31.177,0	13.934,9	17.242,1
2	Field/Huma	6 915,0	4 642,0	2.273,0
3	Temporary not Cultivated	11 460,0	12 638,0	-

Source. BPS North Sulawesi 2022.

The design of an integrated farming system (IAS) model is a solution to the problem of increasingly narrow land availability, so that intensive agriculture can be carried out. Thissystem can also be a solution to food self-sufficiency in agricultural products in a sustainable manner that is economically and ecologically feasible. In theconcept of an integrated agricultural system, the term 4F is known, which is the main result that will be obtained from integrated agricultural system activities. The 4Fs are firstly, food can produce more diverse food, such as rice, vegetables, meat, and fish. Secondly, feed, waste from processing agricultural products such as bran and corn mealcan be reprocessed into concentrates for livestock and fishery feeds. Third, fuel is a biogas fuel can be obtained from processing livestock manure, so that it can meet household energy needs, such as cooking. Fourth, fertilizer is a waste from animal manure as well as the decay of other organic mattercan be used for liquid and solid fertilizer.

Integrated farming needs to be done with considerations/reasons as follows. Harvesting is not every day, so farmers have alternative income to fulfil their daily needs. Then, reducing the cost of production, integrated farming is a combination of agriculture, livestock, fisheries and other sectors in one farming area and the existence of this system will reduce the cost of production by implementing a zero-waste system. Increasing selling prices with continuous coaching, crops have an advantage over conventional agriculture, thereby increasing farmers' income.

Based on what has been explained above, the strategic model for the development of SPT in North Minahasa district emphasizes solving the problem as follows. First, how to increase the variety of income sources and farmers' welfare. Second, how to reduce production costs by using organic materials from livestock and agricultural waste to fertilize the land. And the third, how to optimize land utilization with consideration of land and soil conservation aspects.

The approach taken for this is to use technology with the LEISA (low-external input andsustainable agriculture) system model, which is able to combine the components of plants, livestock, fish, soil, water, climate, and humans in a comprehensive production system and synergize in one area. LEISA is a system that optimizes the use of natural resources and reduces external inputs, with the aim of production cost efficiency, increasing productivity and income, product competitiveness by considering the balance of the ecosystem.

Research by Djuwendah et al. (2018), by building the LEISA model, agribusiness can optimize the use of locally-based productive resources, reduce dependence on externalresources, and support sustainable food security. Research by Nuraini et al. (2015) with the aim of increasing farmers' knowledge and skills in developing agriculture on dry landwith the LEISA system, showed that in general, the extension program had succeeded in increasing farmers' understanding from not knowing to knowing and skilledand expressed interest in using the LEISA system by utilizing local potential for agricultural production on dry land, and transmitting their knowledge to other farmers. The application of LEISA to produce healthy food and sustainability of agricultural land productivity in Sigi Regency - Central Sulawesi, conducted by Tangkesalu et al. (2021),succeeded in having a significant positive effect on farmers, namely reducing the use ofinorganic fertilizers and chemical pesticides by using organic fertilizers (compost) and biorational pesticides (bio-fungicides) developed by farmers themselves. The training on LEISA rice cultivation showed that the communities involved in this activity could adopt and apply the technology in their farms. The sustainability of the training program onLEISA farming can support public health, through the provision of healthy food. Researchby Elly et al. (2019), shows the potential of integrated farming between maize crops andcattle that can be done because it is economically beneficial and minimizes environmental pollution due to the application of the LEISA concept.

In general, this research aims to conduct an analytical study of the development of an integrated agricultural system in Minahasa district with the concept of the LEISA (low-external input and sustainable agriculture) system model, while specifically conducting a study of the feasibility analysis of land use, economic feasibility, ecological feasibility andsocial feasibility. This research is considered very urgent because nationally faced with food sovereignty and independence program. Furthermore, the whole world is faced with the impact of climate change due to global warming which affects the environment, especially the agricultural sector. The phenomenon of farmers with limited land ownership status threatens to reduce food production, which in turn affects national foodavailability as well as the income and welfare of farmers themselves. On the other hand,the demand for agricultural, livestock and fishery products in North Minahasa Regency continues to increase. Moreover, in terms of market, this area is in a strategic position, which is close to the city of Manado and the city of Bitung. Therefore, the design of the model carried out in this study is expected to maximise production which in turn is able to contribute; not only to the ecological condition and welfare offarmers, but also to the fulfilment of food, nutrition as well as the role of stunting prevention.

LITERATURE REVIEW

The crop-livestock integration program is a government program that is to develop an integrated agricultural system with the aim of maintaining national food security (Ministryof Agriculture Strategic Plan 2020 – 2024). The crop-livestock integration system can become a productive and sustainable agricultural system (Sekaran et al., 2021), and has the opportunity to continue to be developed both in areas with large land areas limited agricultural areas or in areas with large potential agricultural land, with the hope that it will be able to increase production, population and productivity (Utami & Rangkuti, 2021).In addition, integrated farming systems can be a source of fertilizer (Hawerroth et al., 2015) and provide higher profits compared to monoculture farming (Bahasoan & Buamona, 2023; Fyka et al., 2019; Kadir, 2020; Tulele et al., 2023).

The crop-fish integrated farming system model has been very popularly applied in various countries with satisfactory results (Wiesner et al., 2020; Harahap, 2019; Carof and Godinot, 2018; Garret et al., 2017). The system optimizes crop waste into animal feed, and livestock manure as fertilizer to improve fertility, nutrient cycling and land productivity (Reddy, 2016). Wide-scale implementation of the system can even accelerate poverty and malnutrition reduction, strengthen environmental sustainability, and reduce global warming (Munandar et al., 2014; Reddy, 2016; Wiesner et al., 2020).The results of research by Sulistiyanto et al. (2016) two cows can produce enough biogasto fulfil household needs. According to Seseray and Santoso (2013) elephant grass can produce 5.2 tonnes of BK/ha per month, in addition to preventing soil erosion. In addition to obtaining plant waste, *gamal (gliricidia sepium), indigofera (indigofera zollingeriana), calliandra (calliandra callothyrsus meisen), lamtoro (leucaena leucocephala), flemingia (flemingia congesta),* and *turi (sesbania grandiflora)* and sprawling cactus *(opuntia ficus- indica)* can also be obtained (Herdiawan et al., 2013; Reis et al., 2018).

The concept of integrated agriculture, according to Haryanta et al. (2018), will produce 4F, namely food, feed, fuel, and fertilizer. Food is the main result of each farm run in theform of the main food ingredient. Feed is the result obtained from farming as feed for cattle, pigs, broiler chickens and native chickens as well as fish farming. Fuel is energy in the form of heat energy (biogas). While fertilizer is the result of the decomposer process of making biogas in the form of solid and liquid fertilizer. The results of researchby Ruhiyat, et al. (2020), on the carik land of Injeman village, Cibodas village, combine dairy farming and corn farming activities, producing four products (4F), namely fuel, fertilizer, feed and food. The four products are basic needs in farming and livestock raising, so as to create sustainable agricultural and livestock businesses and be able tominimise external inputs. Research results Mukhlis et al. (2019).

LEISA (Low External Input Sustainable Agriculture) means low use of inputs from outsidethe system which shows a concept of utilising residual substances or waste from a commodity to be used as input for other commodities (Franjaya et al., 2013). The LEISAconcept implemented according to Ramadhani et al (2019), will give birth to benefits andadvantages, namely optimising the use of local resources, maximising recycling (Zero Waste), minimising environmental damage (environmentally friendly), product diversification, sustainable business, and creating independence.

The results of LEISA research conducted by Kesseler and Moolhulizen (1994) in Firman*et al* (2019), in the Philippines and Ghana show that in areas that have high agriculturalproduction potential, LEISA simultaneously from the socio-economic side increases by reducing the use of inputs from outside the region and is able to improve the ecological environment in a sustainable manner. Conversely, in areas of low production, LEISA can stabilise and restore carrying capacity, but has limited potential to improve socio- economic conditions due to the use of many external inputs. In the research of Elly et al.(2019) showed the potential of integrated farming between corn crops and cattle that canbe done because it is economically beneficial and minimises environmental pollution dueto the application of the LEISA concept. Hapsoh et al. (2021), the application of the LEISAsystem through a demonstration plot system shows the use of inorganic fertilizers can be reduced by 25% to get better plant growth and yield.

RESEARCH METHOD

This research was conducted in North Minahasa Regency from March 2023 to October 2023. The type of data in this research uses primary and secondary data. Primary data was obtained through interviews with informants, while secondary data was obtained through books, journals, the internet and other related sources. The population in this study are farmers who own land under 0.4 ha.

Then a purposive sampling of 30 Farmer Households (RTP) spread across Dimembe sub-district, Kalawat sub-district and Talawaan sub-district, which have limited / narrow land 0.2 ha to 0.4 ha, but have agricultural, livestock and freshwater fishpond farming businesses. Sampling was done through the snowball sampling method, which is a rolling process from one informant to another to find informants who fit the target. The number of samples was 30 people, where the number of samples for the snowball sampling method of 30 people is included in the large sample size.

RESULTS

Characteristics of the Study Area

North Minahasa Regency is located in North Sulawesi Province with a population in 2020of 224,993 people, with a density of 212 people/km. Uniquely, there are three sub-districts that are partially separated from the island of Sulawesi, namely Wori sub-district (Mantehage and Nain), East Likupang sub-district (Bangka), and West Likupang sub-district (Gangga, Talise, Kinabuhutan).

North Minahasa Regency has 10 sub-districts, 6 urban villages and 125 villages. The topography of the area is mostly plains and hills at an altitude of around 0 - 650 meters above sea level, except for the area around the mountains, especially Mount Klabat which reaches around 1,995 meters above sea level. Most of the area is fertile land andhas the potential to be utilised for the development of food agriculture, plantations, livestock, forestry, and overall for the benefit of the community and development. Effective soil depth averages 0-3 m, average soil pH 6.0 to 8.0, with soil texture varying from clay (alluvial), sandy clay (latosol), clay loam (meditrean) and sandy loam (regosol).

Farming Business Potential

Horticultural agricultural areas, spread across all sub-district areas with an area of approximately 27,721.62 Ha, with mainstay commodities; pineapple, red damar mango, rambutan and papaya, while potential commodities are durian and mangosteen. While the livestock area is spread throughout the sub-district area with the same overall area as the dryland food crop agricultural area, approximately 27,721.62 Ha, with superior commodities of cows, pigs, chickens and ducks. For mainstay fruit production; durian, mango, papaya and rambutan. For seasonal vegetables, spinach, spring onions, shallots, red beans, water spinach, cucumber, eggplant. The development of cattle, pig and chicken and duck populations over the last few years has shown significantprogress. This condition is illustrated by North Sulawesi BPS data for 2022, which is explained in table 4. Where in North Minahasa Regency, each livestock business has shown significant development, so that it has the potential to develop an agricultural system that is integrated with agriculture. Livestock waste production is sufficient to contribute to meeting fertilizer needs and as a source of biogas energy.

Table 4. Development of Livestock Population in North Minahasa Regency

No	Livestock	2019	2020	2021
1	Cattle	18351	18627	19493
2	Pig	24381	32025	35796
3	Goat	3763	4264	4289
4	Horse	178	124	131
5	Layers	305000	315000	-
6	Broilers	4583936	5339516	-
6	Ducks	4747	3790	2998

One adult cow in North Minahasa district produces an average of 9-17 kg/day of solid manure and 3-4 litres/day of liquid manure. Fish farming in North Minahasa district is generally semi-intensive, where the pond is made of concrete walls and the bottom is made of soil. Some fish farmers are already doing their own hatcheries, and to get male tilapia, monosex treatment is carried out but it is still not said to be superior and some fish seeds are produced by BPBAT Tatelu. The types of fish kept are tilapia (Oreochromis niloticus), goldfish (Cyprinus carpio), tilapia and ornamental fish, but tilapia is the most common. The water temperature of theponds at the study site ranged from 25-33°C, with dissolved oxygen content in the pondsranging from 4.5 - 7.00 ppm and pH ranging from 6 - 7. Aquaculture Production in North Minahasa Regency explained in table 5, explained in table 5 which is the source of NorthSulawesi BPS data for 2022.

Table 5. Aquaculture Production in North Minahasa Regency (Tonnes)

Type of Cultivation	2018	2019	2020	2021
Pond	81.00	12.00	70.00	65.50
Pond	41.964,00	29.578,00	16.768,00	15.566,00
Floating Net	474.0.	384.00	506.00	453.00

Input-Output of Beef Cattle Farming Business in North Minahasa Regency

From the input-Output data collection, the net profit varies with different input and output characteristics for each livestock business in North Minahasa Regency, as explained in tables 7, 8 and 9 below.

Table 7. Input-Output Model of Beef Cattle Farming per Cow (180 days period)

No	Data	Quantity	Unit	Unit price (IDR)	Price (IDR)
1	Average seedling cow weight per head	250	kg	43,200	10,800,000
2	Cage	4	m2	187,500	750,000
3	Weight growth per day (ADG)	0.8	kg	39,000	31,200
4	Forage feed requirement/day	30	kg	470	14,100
5	Concentrate requirement	3	kg	4,000	12.000
6	Medicine needs	1	period	80,500	80,500
7	Maintenance labour/day	0.1	days	90,500	9,050
	Investment cost				11,696,850
	Daily investment cost				64,982
	Non-forage variable costs				30,000
	Daily cost				73,023
8	Final sales weight	388	kg	42,000	16,296,000
9	Faecal waste production/solid/day	31	kg	400	12,400
Daily net profit					24,380

The input output model for beef cattle includes costs for seedlings, cages, forage feed, concentrates, medicines and maintenance labour with a total investment value of Rp 11,696,850 or investment for each day of Rp 64,982. From this costing, the result of daily weight growth is 0.8 kg with a price value of IDR 31,200, where the unit price is IDR 39,000. After calculating the value of other benefits, the daily net profit is IDR 24,380. This condition illustrates that the daily utilization of cow manure waste has an economic value of Rp 12,400 (50.86%). This means that with zero waste, cattle rearing provides 50.86 per cent profit benefit.

For the input-output analysis of ducks, as explained in Table 8, the net profit/day is 346, of which the profit from feces production is 111. Based on the percentage calculation, the benefit of using feces is 32.08 per cent. This means that the zero waste system provides 32.08 per cent profit benefit.

Table 8. Input-output data of the laying duck business model/head

No	Data	Quantity	Unit	Unit price (IDR)	Price (IDR)
1	Average seedling weight	1	kg	35,000	35,000
2	Age of seedlings	140	day		
3	Cage	0.3	m2	45,000	15,000
4	Feedstuffs/day	0.16	kg	2,500	430
5	Labour/day	0.016	hour	2,400	40
	Investment cost				50,470
	Daily investment cost				53
	Variable costs				470
	Cost				523

6	Age at start of laying	140	day		-
7	Age at end of laying	1,080	day		-
8	Average egg production (75%)	0.75	grain	1,100	792
9	Feces waste (solid) production per day	0.3	kg	370	111
10	Weight of cull ducks per bird	3	kg	11,000	33,000
Net profit/day					346

For pigs (table 9), the net profit/day is 346, which includes the value of pig feces, 210. After percentaging, the contribution of feces use is 60.69 per cent. Of the three types of livestock business analysed, the largest contribution of feces use in the integrated crop, livestock and fish farming system in North Minahasa district, pigs provided the largest benefit, followed by cattle and ducks.

Table 9: Input-Output Model of Pig Business/ Tail

No	Data	Quantity	Unit	Unit price (IDR)	Price (IDR)
1	Average seedling weight	1	kg	35,000	35,000
2	Age of seedlings	140	day		
3	Cage	0.3	m2	45,000	15,000
4	Feed ingredients/ration/day	0.16	kg	2,500	430
5	Maintenance labour/day	0.016	hour	2,400	40
	Investment cost				50,470
	Daily investment cost				53
	Variable cost				470
	Cost				523
6	Age at start of laying	140	day		-
7	Age at end of laying	1,080	day		-
8	Average egg production (75%)	0.75	grain	1,100	792
9	Faces waste production (solid)/day	0.3	kg	370	210
10	Weight of cull ducks per bird	3	kg	11,000	33,000
Net profit/day					346

DISCUSSION

Development Concept of Integrated Farming System Livestock andAgriculture Integration

Integrated Farming System (IFS) is an agricultural system that effectively addresses changes in production methods at the farm level, by balancing production, profitability, sustainability, environmental safety, animal welfare and social responsibility. Integrated farming systems have been proven to be used for integrated resource management to deliver good production and productivity. The focus of integration is on crops, livestock and fish. IFS is a farming system that combines different crops, livestock, fish with the application of various techniques to create environmental protection, maintain land productivity, and increase farmers' income. This farming system occurs at the level of input-output linkages, linkages between production activities and pre-production as well as post-production and marketing activities. IFS is an important part of agroecological technology system which consists of various components related to non-farm business, natural biophysical, socio-economic, political, and cultural components, where it is explicitly stated that integrated farming system is a systematic approach to low external input use between crops, livestock, and fish.

The combination of crops, livestock and fish each has a balancing role, where waste from one component can be utilized for the other. The advantage is that there will bemore economic benefits than monoculture. IFS can provide a variety of benefits to smallholder systems with limited land, in the form of social, economic and environmentalbenefits. It can certainly provide opportunities for rural smallholders to increase theirproduction, which in turn can increase the welfare level of farmers. In addition to other benefits, it can maintain national food security, create jobs, increase biodiversity, increase carbon stocks and increase agricultural energy efficiency. Therefore, IFS mustbe well socialized through continuous and measurable agricultural extension activities. According to Munandar et al. (2015), IFS is one of the agricultural systems that can beused as a solution to climate change mitigation. Where, anagricultural system that regulates stable, unique and feasible agriculture is managedbased on practices that are in accordance with the physical, biological and socio-economic environment in accordance with the goals, preferences and resources ofhouseholds can make a productive and efficient farming system that has productivity. IFS is an agricultural commodity diversification strategy that can be implemented to meet the needs of the growing demand for food. This happens because there is a synergisticrelationship between commodities that are cultivated, without damaging theenvironment. This means that an integrated farming system is the right choice toincrease farmers' income while optimally utilizing agricultural resources.

Based on several descriptions that have been explained, the farming system should beused as an alternative policy and strategy to develop agriculture with limited land problems. Because the agricultural farming system combines more than one agricultural field, based on the concept of biological recycling, and input-output linkages between interrelated commodities with a low external input utilization approach carried out on the land, through the utilization of crop waste, livestock manure and fish waste for the purpose of increasing production and productivity so that there can be an increase in income and welfare of farmers in environmentally friendly agricultural system conditions. According to Thorat et al. (2015), The advantages of IFS are productivity, profitability, sustainability, balanced meals, environmental safety, waste recycling, energy savings, adoption of new technologies, year-round money, availability of fodder, fuel, and wood, year-round employment, agro-industry, improving input efficiency, living standards and avoiding forest degradation. Therefore, IFS is very important to develop because it can be solution to problems in rural development where the majority of the population works in the agricultural sector. It is also important as it relates to preventing damage tothe physical and biotic environment.

So far, sustainable agriculture policies in developing countries have emphasised food security, sustainability of smallholder livelihoods and food security for consumers as well as environmental protection. There are three multifunctional benefits of IFS, according to Dasgupta et al. (2015) in which economic benefits (related to income), social benefits (related to food security), environmental benefits (related to carbon storage, biodiversity, and energy efficiency).

This IFS model has received support from various studies. The results of research by Nguyen et al. (1996) in Mukhlis et al. (2018), in Vietnam, IFS development can increasecrop yields four times compared to non-integrated systems. In Japan, IFS can reduce the cost of purchasing animal feed and fertilizer costs so as to increase farmers' income. Then it is more intensive and profitable because it can increase yield and product quality in the highlands (Ukawa, 1999 in Mukhlis et al., 2018).

In northeastern Thailand, to stop land degradation and regain productivity, farmers organized themselves into groups to create IFS. This type of farming modifies the commercial farming system (CFS), which relies on rice-based monocultures, by adopting the production of vegetables, trees, livestock and fish. In Thailand, applied IFS can utilize livestock waste as a source of plant nutrients and organics to increase crop yields and reduce production costs (Kanto, 2011 in Mukhlis et al., 2018).

In North America, it can increase the diversification of agricultural production that is morecompetitive and more environmentally friendly. Where with IFS can improve soil quality and land use efficiency, reduce dependence on reduce dependence on external inputs, control pests and increase pollinating insect populations, promote conservation of rare biodiversity, increase yields, food diversification, food security benefits and strengthen the agricultural economy Kathleen, 2011 in Mukhlis et al., 2018).

Later, in India it showed an increase in farmers' income, reduced production costs. Thissystem can save resources and high production rates, sustainability and preserve the environment (Gupta, et al., 2012 in Mukhlis, et al., 2018). Likewise, in Ethiopia, Zimbabwe, Mali and Sub-Saharan Africa, IFS can reduce poverty, improve smallholder livelihoods and increase national economic growth. While in Nigeria, IFS as an integrated system of agriculture, livestock, fisheries, processing (Ugwumba et al., 2010, Sissay & Mekkonen, 2013 in Mukhlis et al., 2018).

In Africa, IFS development is capable of producing half of the world's cereals and one-third of beef and dairy, making it a livelihood for one billion people. Mutually reinforcing exploitation of crop farming systems and livestock systems can contribute to ecologically and economically sustainable growth. In mixed systems, livestock intensification is oftennot done for crops, but livestock can contribute positively to increasing productivity.

Similarly, crop intensification can benefit livestock and improve natural resource management, particularly through increased biomass availability and improved livestockproduction efficiency (Duncan et al., 2013 in Mukhlis et al., 2018). These systems can improve soil fertility and productivity, reduce environmental hazards, food security potential, nutritional benefits, job creation and provide additional income, which is also profitable and productive. (Dashora & Singh, 2014, Manjunatha et al., 2014 in Mukhlis et al., 2018).

IFS can increase biomass production and enable higher levels of feedstock for livestockin grazing. Therefore, IFS implementation is seen as a strategy in sustainable agricultural intensification in Brazil (Gil & Berger 2015, in Mukhlis et al., 2018). Beef cattle integrated with agricultural crops can utilise crop yields and by-products (crop residues/waste) for animal feed as an added value to obtain greater profits. Likewise, livestock can provide raw materials for organic fertilizer (solid and liquid) as a sustainablesource of nutrients needed by plants.

The integration of beef cattle and agricultural crops applies the concept of zero waste farming because livestock waste is used as a source of organic fertilizer for agricultural businesses and energy sources (biogas) is an added value that opens up opportunitiesto increase farmers' income. Likewise, agricultural waste can be used as animal feed and as a source of organic fertilizer. This means that there is a strong correlation between the integrated farming system model and the increase in farmers' income and welfare.

The results of research by Lenzun et al., (2023), prove the strength of the relationship between the value-added variable and income, where based on the results of the analysis obtained the coefficient value of 0.577**, which is interpreted based on the provisions of de Vaus this means that the level of strength of the relationship between the value-added variable and the increase in beef cattle business is 0.577. While the significant correlation is at 0.001, and is positive, so the relationship between the two variables is unidirectional so that it can be interpreted that the more value-added engineering is improved, the income of beef cattle farming will increase. Furthermore, the Sig. (2-tailed) is 0.001, where this value is smaller than 0.05. So it can be stated thatthere is a significant relationship between the value-added engineering variable and thevariable of increasing beef cattle farming business income.

Research conducted by Syamsidar (2012) in Indrawanto and Atman, (2017), on the integration of beef cattle farming with annual crops in Sinjai district, South Sulawesi province, based on land area is; land area <0.5 ha, contribution to beef cattle as much as 58%; 0.5-1.0 ha, 51%; and >1.0 ha, 32%. As for annual crops, land area <0.5 ha contributed 42%; land area 0.5-1.0 ha, 49%; and land area >1.0 ha, 68%.

Livestock and Fish Integration

Fish farming using cattle, pig and poultry manure is a common integration model for the development of zero waste integrated farming systems. Livestock manure can be used as manure for fish rearing. Manure promotes the growth of plankton, which is used as food for fish. Livestock manure leads to increased biological productivity of the pond through various pathways, resulting in increased fish production. Technically, cattle pens can be built on the pond embankment or near the pond. The outlet of the pens is connected to the pond so that the effluent can be channeled into the pond. The most suitable fish species for integrated fish-livestock farming are those that can filter and feed on zooplankton phytoplankton and bacteria from the water. Since the goal of integrated fish-livestock farming is to produce maximum plankton in the water through the application of manure rich in protein and natural feed for the fish, the fish species are best suited for integrated fish-livestock farming. Based on the potential of North Minahasa district, the suitable fish species for cultivation in this integrated farming system are tilapia (Oreochromis niloticus) and goldfish (Cyprinus carpio), because in addition to economic value, these fish species are known as zooplankton and phytoplankton eaters. Pond aquaculture production (tilapia and carp) in North

Minahasa district, in 2018 (41 964.00 tons), in 2019 (29 578.00 tons) and in 2020(16 768.00 tons). Raising fish in combination with livestock can increase family income. Because animal manure can be a fertilizer as well as a provider of fish feed, where 65-75 per cent of the cost incurred for fish farming is feed, therefore the integration of livestock and fish farming is the best way for business sustainability. A 500 square meter fish pond requires about 0.5-0.7 tons of manure and urine per year to maintain its fertility. Integrated fish cultivation system in North Minahasa district based on ranking; (1) Duck- fish integration system. (2) Pig fish integration system. (3) Poultry-fish integration system. (4) Cattle-fish integration system. (5) Goat – fishintegration system.

Crop-Livestock Integration

The concept of integrated farming involving fruit and vegetable crops with livestock (crop-livestock integration) has actually been applied by farmers in North Minahasa district. However, the application is still traditional, without calculating the profit and loss, both financially and in the context of environmental conservation. The added value (contribution) of crop-livestock integration farming activities to farmers' income varies between 10-80%. Land size <0.5 ha contributed 72%; 0.5-1.0 ha 66%; and >1.0 ha 44%. Crop-livestock integration technology applies the concept of cleaner production which aims to produce zero-waste farming, because livestock waste is used as a source of organic fertilizer for agricultural businesses and a source of energy (biogas). Meanwhile,agricultural waste is used for livestock feed and as a source of organic fertilizer. Livestock integrated with crops are able to utilize by-products and plant by-products (cropresidues/waste) for animal feed. Conversely, livestock can provide raw materials for organic fertilizer (solid and liquid) as a sustainable source of nutrients needed by plants.An integrated crop-livestock agricultural system, to help farmers overcome the problem of fertilizer input, as well as protecting the environment. The use of straw or agricultural residue is expected to be able to overcome the waste problem by not burning it but can be used as animal feed given directly or through a processing process, with the principles of 3R environmental management (reduce, reuse and recycle) and based on zero waste(Kallo et al., 2019; Rhofita, 2016). Likewise with livestock waste, where a lot of livestockwaste is simply left alone, causing losses, because it only pays attention to production aspects but does not pay attention to aspects of environmental conditions which is one of the causes of environmental pollution (De Vries & Melse, 2017; Ningrum et al., 2019).The integrated system of crop and livestock farming can also provide benefits accordingto the results of the study by Kallo et al. (2019) in Barru Regency, South Sulawesi, reported that the implementation of a Zero Waste-based rice and cattle integration system increased farmers' income by 20.25% with an R/C value of 1.8, which means thisbusiness is feasible to develop. The research results of Fyka et al. (2019) and Zailan (2022) stated that the integrated system of rice crops and cattle has a greater R/C Ratiovalue than a farming business with an integrated system that is feasible to implement.

CONCLUSION

This research aims to study the analysis of integrated agricultural systems of horticultural crops, livestock and fish on limited land with the LEISA (low-external input and sustainable agriculture) system. While specifically is to conduct a study of economic and ecological feasibility analysis and strategy formulation for its development strategy. Observations were made on 4 integration patterns: horticulture-livestock integration, integration of horticultural crops - fish ponds, integration of livestock and fishponds, and integration of horticultural crops-livestock-fish ponds. It is designed with a strategy formulation model. The results stated that the integrated farming system with the LEISA system fulfilled the feasibility of land area, between 0.2 ha to 0.4 ha, economic feasibility, where the net income from crops and livestock/fish had a ratio of net income to the needs of farmer households (RTP) ≥ 1.0. and ecological feasibility, where the production of organic matter from livestock/fish was sufficient or exceeded the need for plants ≥ 1.0. Crop-livestock and crop-fish integration in North Minahasa district can provide benefits (implicated) from various aspects as follows. First, the agronomic aspect, which is an increase in the capacity of the soil to produce. Secondly, the economic aspect, which is a diversification of products, yields and product quality with higher competitiveness. Third, there is efficiency in the use of production costs. Fourth, the ecological aspect, which is reduced pest attacks and the use of pesticides and erosion control. Fifth, the social aspect, which is a more equitable distribution of income. Sixth, the creation of new jobs for the younger generation of farmers in rural areas which results in a decrease in the level of urbanization. The development model of integrated farming system with LEISA system in North Minahasa district is directed to how to utilize the attractiveness of the industry by producing four products (4F), namely fuel, fertilizer, feed, and food, utilizing biogas and aquaponics in order to increase production, productivity and product competitiveness. The central strategy of developing integrated farming system with LEISA system in North Minahasa district is how to utilize biogas and aquaponic as intensive strategy, integrated strategy, and integrated strategy.

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