CHAPTER 7

SYNTHESIS OF SUSTAINABILITY INDICATORS

In this chapter, based on the values of sustainability indicators of crop production systems in Chapter 6, the synthesis assessment was employed to find out the best crop production systems. The methods used in this analysis were AMOEBA approach, analytic hierarchy process (AHP), and sustainability indicator analysis (SIA). The assessments were carried out in both household and commune level corresponding with each micro-zone.

7.1 AMOEBA diagram

As mentioned before, sustainable development as a whole as well as sustainable agriculture in particular has become a leading target of scientific research and policy agenda. In the context of agricultural production, understanding and evaluating the performance of complex socio-environmental systems has become a challenge, and the design of more sustainable alternatives is a driving need.

The crop production systems (CPSs) in Nam Dong district are complex systems made of many different components that operate in parallel on different space-time scales. Hence, to understand the structure of CPSs is a fundamental prerequisite for this analysis. In this analysis, the results obtained by monitoring the indicators are summarized and integrated. In order to achieve an adequate integration and synthesis of the results, five stages carried out, those are: (1) placing the results by indicator and by system into a single table, using both in original units and as percentages relative the optimum corresponded with each indicator; (2) determining thresholds or baseline values for each indicator; (3) building indices for each indicator, according to baseline values or thresholds. These indices were built on quantitative data; (4) putting all indicators together, using graphs and tables; (5) examining the connections between indicators. These results of assessment of sustainability of CPS in three study communes are presented as Table 7.1-7.3 and Figure 7.1-7.3.

From Table 7.1 to Table 7.3, soil fertility management, pest-disease management, and input self-sufficiency are converted from original units into percentage. Both the soil fertilizer and pest-disease management, the rate of use of chemical fertilizer or chemical pesticide corresponded with each CPS in total chemical fertilizer or total chemical pesticide that are used for the whole farm is taken into this comparison. It noted that due to consider on sustainable side, the value of soil fertilizer management and pest-disease management in AMOEBA diagram were calculated from the formula as follows:

- Fertilizer management value (%) = 100 - existing percentage of chemical fertilizer used for each CPS in total chemical fertilizers used for the whole farm

- Pest-disease management value (%) = 100 - existing percentage of chemical pesticide used for each CPS in total chemical pesticides used for the whole farm

Similarly, in input self-sufficiency, the proportion of local input cost in total cost was considered. For land use, crop diversification, yield stability, profitability, and labor use are used under the original units. Land use was calculated from proportion of land under each crop production system (CPS) in total of cultivation land area (Note: The value of land use in AMOEBA diagram = 1 – existing proportion of land under each CPS in total of cultivation land area). The index of crop diversification (ICD), and index of trend of yield (ITY) is used for crop diversification and yield stability, respectively. Gross margin (GM) is considered as profitability indicator, and labor requirement is taken into comparison in labor use indicator. For optimum indices in this analysis was not referring any standards of local or any other nation levels. This optimum is indicated under the values that derived survey and monitoring corresponded with the indicator in each CPS.

7.1.1 Huong Loc commune

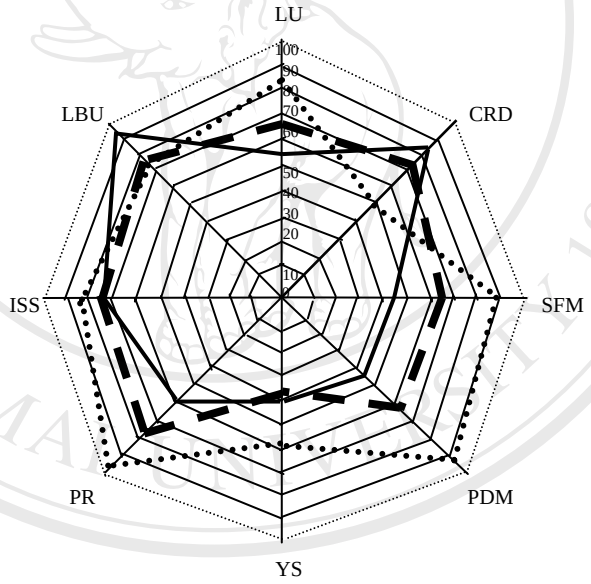
The aspect of CPSs is shown in Table 7.1 and Figure 7.1. This is commune located in valley zone where three CPSs such Rice-A.Crop, I.A.Crop, and Fruit-I.P.Crop occurred popularly.

Table 7.1 Indicators used in the AMOEBA diagram for three CPSs in Huong Loc

Indicators	Symbol	Unit	Rice-A.Crop	I.A.Crop	Fruit-I.P.Crop	Optimum
Land use	LU	decimal	0.534 (53*)	0.848 (85*)	0.672 (67*)	1 (100*)
Crop diversification	CRD	decimal	0.857 (86*)	0.500 (50*)	0.750 (75*)	1 (100*)
Soil fertility management	SFM	%	45	90	65	100
Pest-disease management	PDM	%	45	92	63	100
Yield stability	YS	decimal	0.40 (40*)	0.59 (59*)	0.38 (38*)	1 (100*)
Profitability	PR	mil. VND	3.346 (61*)	5.383 (98*)	4.360 (79*)	5.5 (100*)
Input self-sufficiency	ISS	%	74.5	81.9	75.2	100
Labor use	LBU	workday	81.8 (96*)	65.9 (78*)	66.7 (79*)	85 (100*)

Source: Survey, 2004

Note: * indicated value under percentage



Note: ——— *Rice-A.Crop;* ····· *I.A.Crop;* ▬ ▬ *Fruit-I.P.Crop;* ····· *Optimum*

Figure 7.1 Integration of sustainable indicators for three CPSs in Huong Loc

Based on the AMOEBA diagram in Figure 7.1 that shows graphically integration the different indicators of CPSs in Huong Loc commune. Comparison on advantages and limitations of the CPSs being evaluated can be seen clearly here.

- *Rice-A.Crop pattern*: Land use and crop diversification in ecological side in this CPS, as well as labor use in social side were positive dominant compared with remains CPSs. However, this pattern also used more chemical in fertilizer and

pest-disease management. So this needs to be improved because those issues indicated negative effects when considering in sustainability. In addition, other indicators such as yield stability, profitability, etc. also need be improved.

- *I.A.Crop pattern*: Although this CPS consumed the least area as well as was not diversified in crop diversification and required less labor use but this pattern should be continued. Because it got the highest profit and local input cost, and yield was the most stable compared with Rice-A.Crop and Fruit-I.P.Crop. In addition, it used the least chemical fertilizer and pesticide. The least cultivation area, this pattern was high sustainable in land use compared to other two patterns.

- *Fruit-I.P.Crop pattern*: This pattern may be is popular in local area such as in Nam Dong district. However, in Huong Loc commune, it had separate features that are presented through crop diversification. Particularly, areca was more dominant in this pattern. In general, all of indicators did indicate typically that they almost were in the medium level.

7.1.2 Huong Phu commune

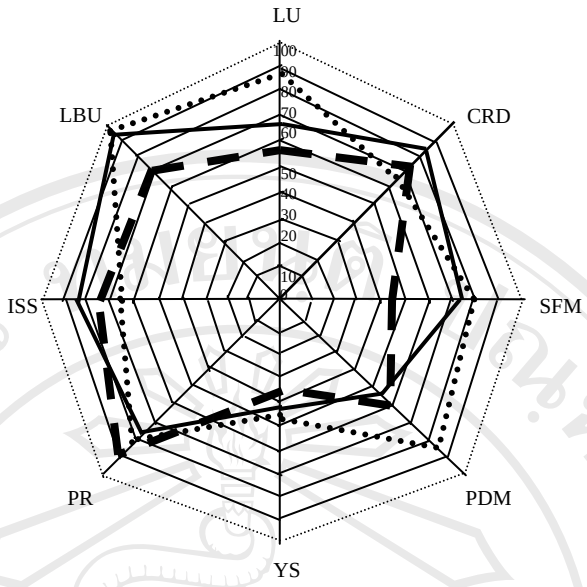
This commune located in medium high hill zone. It also had three CPSs that seem similar with Huong Loc commune such Rice-Fish-A.Crop, I.A.Crop, and Fruit-I.P.Crop pattern. The aspect of CPSs is shown as Table 7.2 and Figure 7.2.

Table 7.2 Indicators used in the AMOEBA diagram for three CPSs in Huong Phu

Indicators	Symbol	Unit	Rice-Fish-A.Crop	I.A.Crop	Fruit-I.P.Crop	Optimum
Land use	LU	decimal	0.67 (67*)	0.885 (89*)	0.566 (57*)	1 (100*)
Crop diversification	CRD	decimal	0.833 (83*)	0.666 (67*)	0.750 (75*)	1 (100*)
Soil fertility management	SFM	%	75	80	45	100
Pest-disease management	PDM	%	55	85	60	100
Yield stability	YS	decimal	0.42 (42*)	0.47 (47*)	0.35 (35*)	1 (100*)
Profitability	PR	mil. VND	4.655 (78*)	4.831 (81*)	5.507 (92*)	6 (100*)
Input self-sufficiency	ISS	%	85.5	67.3	75.5	100
Labor use	LBU	workday	133.4 (95*)	136.6 (98*)	100(71*)	140 (100*)

Source: Survey, 2004

*Note: * indicated value under percentage*



Notes: ——— *Rice-Fish-A.Crop;* ..... *I.A.Crop;* — — *Fruit-I.P.Crop;* ..... *Optimum*

Figure 7.2 Integration of sustainable indicators for three CPSs in Huong Phu

Similarly, to see entirely management of CPSs of farmers, the AMOEBA approach also carried out. Through Table 7.2 and Figure 7.2, we can recognize evidently the features of production process that are expressed as follows:

- *Rice-Fish-A.Crop pattern:* In Huong Phu commune, this pattern did not make up high proportion in land use compared with Fruit-I.P.Crop pattern. However, it also concentrated on local input cost and slightly need high labor use. Although this pattern was not getting high profitability but can supply food for households consumption. Therefore, it still existed in Huong Phu commune.

- *I.A.Crop pattern:* The biggest advantage of this pattern was using the least chemical fertilizer and chemical pesticide than Rice-Fish-A.Crop and Fruit-I.P.Crop pattern. In addition, yield was stable and need more labor. Therefore, this pattern was preferred by farmers in this commune.

- *Fruit-I.P.Crop pattern*: This pattern was typical pattern in medium high hill zone in Nam Dong district as well as in Huong Phu commune. So that is why it made up the highest area in cultivation land of households. Orange and citrus was high dominant as compared with other crop types in this pattern. Although it gave high

profitability but this pattern still used more chemical fertilizer than the other two patterns above. In terms of labor requirement, it needed the least workdays. In general, this pattern existed for stable source of household's income, so how to restrain shortcomings are also issue is setting up for stakeholders.

7.1.3 Thuong Quang commune

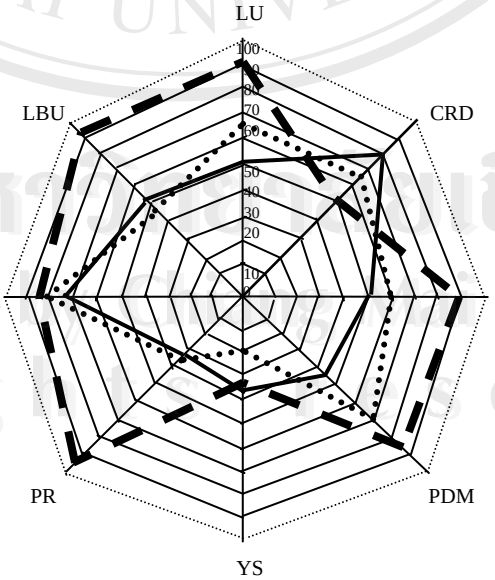
This is commune located in high hill with densely river and streams network, therefore the CPSs were presented typical characteristics. Three CPSs occurred popularly were Rice-Fish-A.Crop, Fruit, and Veg.Str. pattern (Table 7.3; Figure 7.3).

Table 7.3 Indicators used in the AMOEBA diagram for three CPSs in Thuong Quang

Indicators	Symbol	Unit	Rice-Fish-A.Crop	Fruit	Veg.Str.	Optimum
Land use	LU	decimal	0.509 (51*)	0.661 (66*)	0.905 (91*)	1 (100*)
Crop diversification	CRD	decimal	0.800 (80*)	0.666 (67*)	0.500 (50*)	1 (100*)
Soil fertility management	SFM	%	50	60	90	100
Pest-disease management	PDM	%	45	70	85	100
Yield stability	YS	decimal	0.385 (39*)	0.20 (20*)	0.375 (38*)	1 (100*)
Profitability	PR	mil. VND	2.468 (33*)	2.611 (35*)	7.282 (97*)	7.5 (100*)
Input self-sufficiency	ISS	%	75.3	80.2	85.5	100
Labor use	LBU	workday	104 (52)	94.1 (47)	184.7 (92)	200 (100*)

Source: Survey, 2004

*Note: * indicated value under percentage*



Notes: ——— *Rice-Fish-A.Crop;* ..... *Fruit;* — — *Veg.Str.;* ..... *Optimum*

Figure 7.3 Integration of sustainable indicators for three CPSs in Thuong Quang

- *Rice-Fish-A.Crop pattern*: This pattern had the highest cultivation area of households, it mean this pattern was less sustainable in land use. But it had more crop types. However, this pattern also presented more shortcomings such as used more chemical in fertilizer and pesticide compared with the two patterns. It had the lowest profitability as well as local input cost. However, this pattern still existed as though indispensable because of the food security issues. With farmers far from district center where foods and other things can be found, then the existing of this pattern was as though optimum solution. Here issue was how to improve those problems to salvage maximum of advantages of this pattern.

- *Fruit pattern:* Although soil type and terrain in Thuong Quang commune were somewhat suitable for more fruit tree types and other perennial crops. But this Fruit pattern is not concerned considerably in this commune. As compared with Veg.Str. pattern, this pattern occupied higher area and crop diversification was also more diversified. However, due to lack of intensive farming so leading to low profitability. If this pattern is considered reasonably maybe also is one of the optimum alternatives for this commune also.

- *Veg.Str. pattern:* Due to existing of geographical and topographical, this pattern was found only in this commune, and is located along streams where fresh water can be supplied for this pattern. This pattern just made up small area and lacked diversified in crop type compared with two patterns above in this commune. But with the advantages such as more labor used, high local input cost and profitability, lower chemical fertilizer and pest-disease use, and higher sustainable land use. This pattern got high priority in alternative of farmer households.

In fact, the CPSs corresponded with each commune implied different trade-offs in terms of performance of indicators reflected other perspectives, or in other words, these CPS type have different shapes when described with the AMOEBA approach. So when dealing with sustainability of CPS, the relations of preference and indifference are not enough, because when a CPS is better than another for some criteria, it is usually worse for others, so that many pairs of comparison remain

incompatible with respect to a dominant relation. Moreover it is impossible to assess with a single type of description/analysis the effect of a particular combination of techniques of farming on all the chosen dimensions.

7.2 Assessment of sustainable crop production systems at the household level

7.2.1 Assumed indicators are unequal importance

The method used for this assessment is AHP method. Based on this method, the priorities for sustainable indicators are synthesized from farmer group discussion. Thus, a workshop was organized with the 40 farmers for each commune. Initially, pairwise comparison of the seven criteria was done through open discussion. The exercise was repeated several times until the Consistency Ratio (CR) was in acceptance level (CR≤ 0.1 for 7x7 matrix). Hence, the first result in pairwise comparison of the seven criteria (Table 4.1) corresponded each commune is presented in the Figure 7.4 (Table 6A-8A in Appendices)

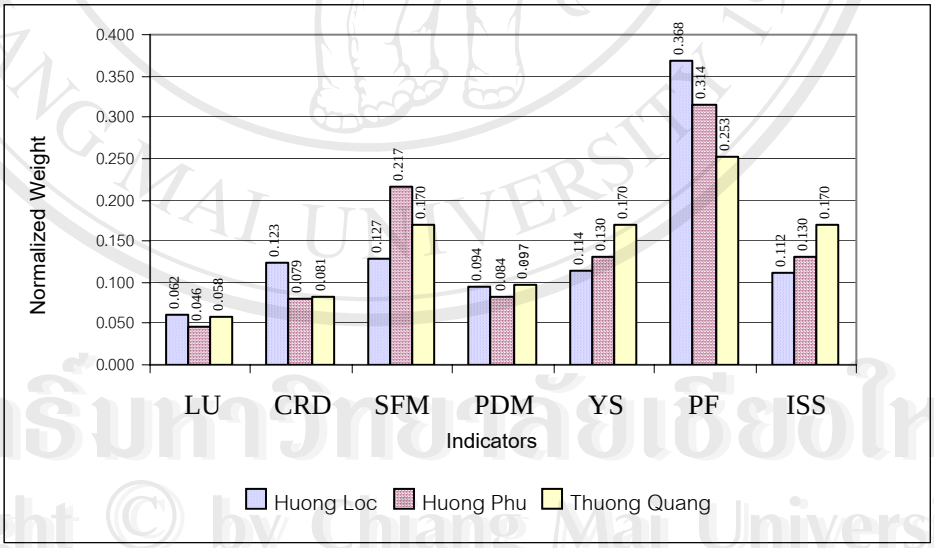


Figure 7.4 Weight of seven indicators of farmers in three communes
Source: Discussion of farmer group, 2004

From Figure 7.4, it can be seen that the farmers in three communes had the same priority for sustainable indicators. The profitability was indicator that farmer more preferred, it got the highest priority as compared with others. Followed that indicator, input self-sufficiency also got high alternative, especially in Thuong Quang

commune. Because the distance between Thuong Quang and district center is so long, therefore the farmers will take the time and capital to get the input of production. However, each commune, farmers had a little difference in alternative. It depended on natural and socio-economic characteristics. In general, soil fertility management, pest-disease management, and yield stability also got high priority, followed two indicators above in sequence compared with land use and crop diversification.

Table 7.4 Final ranking of crop production systems in Huong Loc (household level)

Criteria	Alternative	Weights			Rank
		Criteria	Alternatives within a Criteria	Alternatives related to all Criteria	
Land use		0.062	CR: 0.004		7
	Rice-A.Crop		0.581	0.036	1
	I.A.Crop		0.110	0.007	3
	Fruit-I.P.Crop		0.309	0.019	2
Crop diversification		0.123	CR: 0.037		3
	Rice-A.Crop		0.633	0.078	1
	I.A.Crop		0.106	0.013	3
	Fruit-I.P.Crop		0.260	0.032	2
Soil fertility management		0.127	CR: 0.037		2
	Rice-A.Crop		0.106	0.014	3
	I.A.Crop		0.633	0.081	1
	Fruit-I.P.Crop		0.260	0.033	2
Pest-disease management		0.094	CR: 0.028		6
	Rice-A.Crop		0.103	0.010	3
	I.A.Crop		0.723	0.068	1
	Fruit-I.P.Crop		0.174	0.016	2
Yield stability		0.114	CR: 0.024		4
	Rice-A.Crop		0.201	0.023	2
	I.A.Crop		0.681	0.077	1
	Fruit-I.P.Crop		0.118	0.013	3
Profitability		0.279	CR: 0.009		1
	Rice-A.Crop		0.164	0.060	3
	I.A.Crop		0.539	0.198	1
	Fruit-I.P.Crop		0.297	0.109	2
Input self-sufficiency		0.112	CR: 0.018		5
	Rice-A.Crop		0.137	0.015	3
	I.A.Crop		0.623	0.070	1
	Fruit-I.P.Crop		0.239	0.027	2

Source: Analyzed by AHP method

Following the pairwise comparison step of the seven criteria, the value for each three alternatives of CPSs was assigned according to their relative importance and again the pairwise comparison was done. The exercise was carried out until the

CR value was within the acceptable level (CR≤ 0.05 for 3x3 matrix). The final analysis of prioritizing the CPSs was done individually using the first output (pairwise comparison of criteria) and second output (pairwise comparison of alternatives).

Within each criterion, alternatives were ranked. In Huong Loc commune, Rice-A.Crop pattern ranked first in the land use and crop diversification, while I.A.Crop pattern as best alternative for remainder criterion such as soil fertility management, pest-disease management, profitability, etc; conversely, the Fruit-I.P.Crop pattern is not found to dominate any particular criteria, it is considered as a second alternative for all criterion excepted yield stability (Table 7.4).

Table 7.5 Final ranking of crop production systems in Huong Phu (household level)

Criteria	Alternative	Weights			Rank
		Criteria	Alternatives within a Criteria	Alternatives related to all Criteria	
Land use		0.046	CR: 0.037		6
	Rice-Fish-A.Crop		0.265	0.012	2
	I.A.Crop		0.080	0.004	3
	Fruit-I.P.Crop		0.656	0.030	1
Crop diversification		0.079	CR: 0.004		5
	Rice-Fish-A.Crop		0.581	0.046	1
	I.A.Crop		0.110	0.009	3
	Fruit-I.P.Crop		0.309	0.024	2
Soil fertility management		0.217	CR: 0.037		2
	Rice-Fish-A.Crop		0.106	0.023	3
	I.A.Crop		0.633	0.137	1
	Fruit-I.P.Crop		0.260	0.057	2
Pest-disease management		0.084	CR: 0.009		4
	Rice-Fish-A.Crop		0.164	0.014	3
	I.A.Crop		0.539	0.045	1
	Fruit-I.P.Crop		0.297	0.025	2
Yield stability		0.130	CR: 0.018		3
	Rice-Fish-A.Crop		0.239	0.031	2
	I.A.Crop		0.623	0.081	1
	Fruit-I.P.Crop		0.137	0.018	3
Profitability		0.314	CR: 0.009		1
	Rice-Fish-A.Crop		0.107	0.033	3
	I.A.Crop		0.194	0.061	2
	Fruit-I.P.Crop		0.700	0.220	1
Input self-sufficiency		0.130	CR: 0.037		3
	Rice-Fish-A.Crop		0.633	0.082	1
	I.A.Crop		0.106	0.014	3
	Fruit-I.P.Crop		0.260	0.034	2

Source: Analyzed by AHP method

While in Huong Phu commune, Rice-Fish-A.Crop pattern ranked first in crop diversification and input self-sufficiency, I.A.Crop pattern ranked first in soil fertilizer management, pest and disease management, and yield stability. Land use and profitability was considered first in Fruit-I.P.Crop pattern (Table 7.5).

Similarly, in Thuong Quang commune, Rice-Fish-A.Crop pattern also got the highest priority in land use, crop diversification, and yield stability. The Veg.Str. pattern was a best alternative for all remainder criteria. While Fruit pattern was not found to dominate any particular criteria (Table 7.6).

Table 7.6 Final ranking of crop production systems in Thuong Quang (household level)

Criteria	Alternative	Weights			Rank
		Criteria	Alternatives within a Criteria	Alternatives related to all Criteria	
Land use		0.058	CR: 0.037		5
	Rice-Fish-A.Crop		0.656	0.038	1
	Fruit		0.265	0.015	2
	Veg.Str.		0.080	0.005	3
Crop diversification		0.081	CR: 0.018		4
	Rice-Fish-A.Crop		0.657	0.053	1
	Fruit		0.275	0.022	2
	Veg.Str.		0.068	0.006	3
Soil fertility management		0.170	CR: 0.009		2
	Rice-Fish-A.Crop		0.106	0.018	3
	Fruit		0.260	0.044	2
	Veg.Str.		0.633	0.108	1
Pest-disease management		0.097	CR: 0.018		3
	Rice-Fish-A.Crop		0.085	0.008	3
	Fruit		0.213	0.021	2
	Veg.Str.		0.701	0.068	1
Yield stability		0.170	CR: 0.018		2
	Rice-Fish-A.Crop		0.568	0.097	1
	Fruit		0.098	0.017	3
	Veg.Str.		0.334	0.057	2
Profitability		0.253	CR: 0.028		1
	Rice-Fish-A.Crop		0.103	0.026	3
	Fruit		0.174	0.044	2
	Veg.Str.		0.723	0.183	1
Input self-sufficiency		0.170	CR: 0.037		2
	Rice-Fish-A.Crop		0.106	0.018	3
	Fruit		0.260	0.044	2
	Veg.Str.		0.633	0.108	1

Source: Analyzed by AHP method

Among the seven criteria in relation to three CPSs in each commune we already found out the CPS was considered the best alternative. The final ranking of CPSs of three communes is shown in Table 7.7.

Table 7.7 Final ranking of crop production systems at household level (AHP method)

Category	Crop production systems					
	Rice-A.Crop	Rice-Fish-A.Crop	I.A.Crop	Fruit	Fruit-I.P.Crop	Veg.Str.
Huong Loc commune						
- Overall priorities	0.235		0.514		0.250	
- Rank	3		1		2	
Huong Phu commune						
- Overall priorities		0.242	0.350		0.408	
- Rank		3	2		1	
Thuong Quang commune						
- Overall priorities		0.259		0.208		0.533
- Rank		2		3		1

Source: Analyzed by AHP method

According to Table 7.7, in Huong Loc commune, the overall priority of I.A.Crop pattern was the highest, followed by Fruit-I.P.Crop. And Rice-A.Crop pattern was the lowest. Similarly, in Huong Phu commune, the order of ranking was Fruit-I.P.Crop, I.A.Crop, and Rice-Fish-A.Crop pattern. The Veg.Str., Rice-A.Crop, and Fruit pattern were priority order of Thuong Quang commune.

7.2.2 Assumed indicators are equal importance

Different from the AHP method, the sustainability indicator analysis (SIA) method assumed all sustainable indicators are equal importance. In assessing sustainability at the household level, also same with AHP method, 40 households corresponded with each commune were included in the analysis. According to this method the value of all sustainable indicators at the households in CPS are converted into scores. The sustainability at the household level is based on aggregation of all indicators. At the same time based on the classification of sustainability class, the number of household sample is determined. For comparison among CPSs, the

sustainability index, performance value as well as performance percentage are taken into calculation. The results for each CPS in each commune are shown in Figure 7.5-7.7 (Table 9A-11A in Appendices).

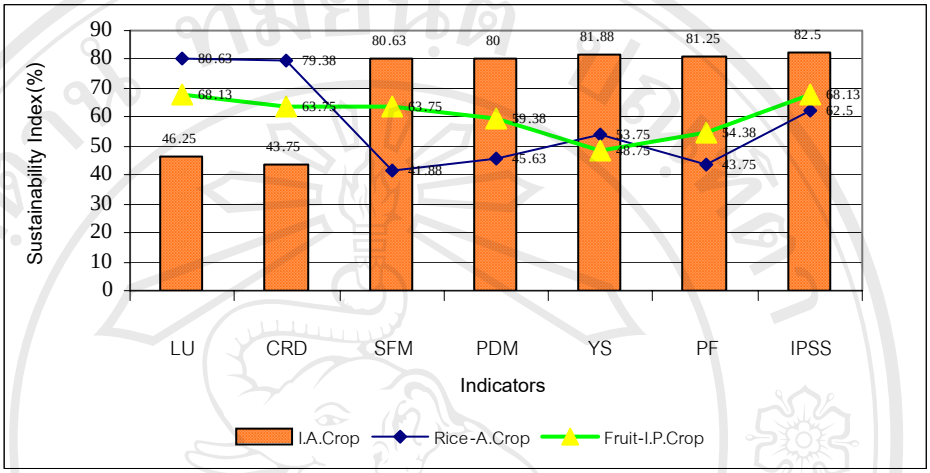


Figure 7.5 Sustainability of crop production systems in Huong Loc (SIA method)

Figure 7.5 showed that in Huong Loc commune, when the sustainability indices and performance values are ranked, crop diversification is considered the most critical issue, followed by land use in the I.A.Crop pattern. Input self-sufficiency is found to be sustainable in the I.A.Crop pattern. Conversely, in Rice-A.Crop pattern, soil fertility management was as a critical issue followed by pest-disease management. Land use and crop diversification for Rice-A.Crop pattern were more sustainable using this index. Meanwhile, land use and input self-sufficiency were considered as sustainability in Fruit-I.P.Crop pattern. The critical issue in this pattern was yield stability.

The sustainability index of CPSs in Huong Phu commune are presented as Figure 7.6. Huong Phu commune located in the medium high hill zone of Nam Dong district. The main problems associated with CPSs at Rice-Fish-A.Crop pattern were pest-disease management followed by land use and yield stability. While pest-disease management and soil fertility management in Rice-Fish-A.Crop pattern as well as land use and crop diversification in I.A.Crop pattern were least sustainable. The crop diversification, profitability, and soil fertility management were more sustainable criteria in Rice-Fish-A.Crop, Fruit-I.P.Crop, and I.A.Crop pattern, respectively.

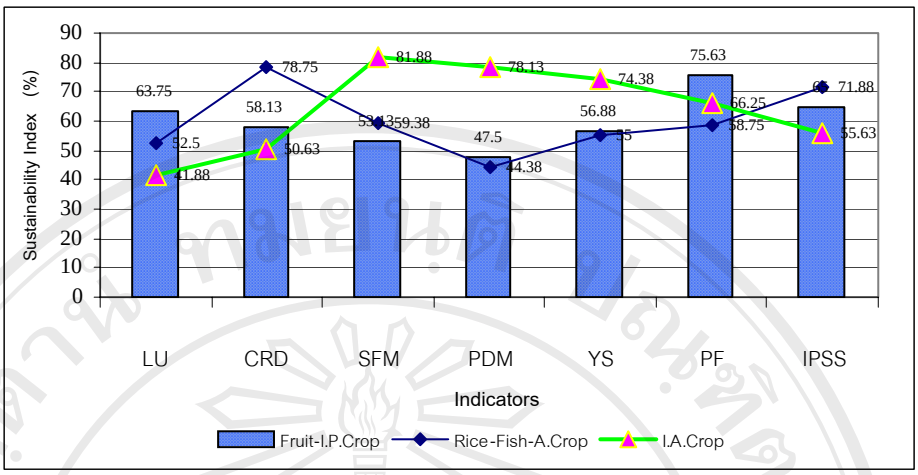


Figure 7.6 Sustainability of crop production systems in Huong Phu

For Thuong Quang commune, pest-disease management was the least sustainable component of Rice-Fish-A.Crop pattern, followed by soil fertility management and profitability. Similarly, land use and crop diversification in Veg.Str. pattern as well as soil fertility management and pest-disease management in Fruit pattern were critical issues. The land use is seemed to be the most sustainable component in Rice-Fish-A.Crop and Fruit pattern, while input self-sufficiency was the most priority in Veg.Str. pattern. (Figure 7.7)

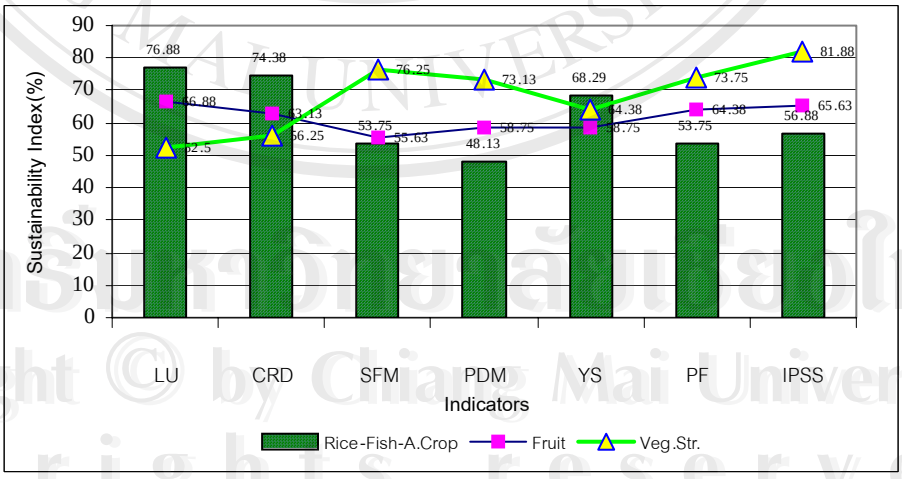


Figure 7.7 Sustainability of crop production systems in Thuong Quang

Through Figure 7.5 to Figure 7.7, it shown that in each commune, the sustainability of each indicator corresponded with each CPS was different. If considered on performance percentage then the alternative for the CPS in sustainable

side would be a little different with AHP method in all of three communes (Table 7.8).

Table 7.8 Performance percentages of crop production systems at household level

Category	Crop production systems					
	Rice-A.Crop	Rice-Fish-A.Crop	I.A.Crop	Fruit	Fruit-I.P.Crop	Veg.Str.
Huong Loc commune						
- Performance percentage (%)	58.2		70.9		60.9	
- Rank	3		1		2	
Huong Phu commune						
- Performance percentage (%)		60.1	64.1		60.0	
- Rank		2	1		2	
Thuong Quang commune						
- Performance percentage (%)		62.0		61.9		68.5
- Rank		2		2		1

Source: Analyzed by sustainability indicator analysis method

The Table 7.8 shown that the priority of the CPS in Huong Phu was I.A.Crop, Rice-A.Crop, and Fruit-I.P.Crop pattern in sequence. While in Thuong Quang commune, the Veg.Str. pattern was still high priority, followed by Fruit and Rice-Fish-A.Crop pattern. The order of priority of CPSs in Huong Loc was not changed and it was also the same with AHP method. The most sustainability of CPS was I.A.Crop pattern, followed by Fruit-I.P.Crop, and Rice-A.Crop pattern.

7.3 Assessment of sustainable crop production systems at commune level

7.3.1 Assumed indicators are unequal importance

Similarly, this analysis also followed the steps in AHP method as mentioned before. However, for commune level analysis, five indicators are considered into account. Among the five indicators, labor use and food security are considered as the most important criteria by the authorities (Figure 7.8; Table 12A in Appendices). Input self-sufficiency, crop diversification, and land use followed two indicators in sequence. Some of the explanation given for this ranking order was that labor and food security being the important aspect of all three communes in Nam Dong district.

Where limited agricultural land for cultivated food crops as well as transportation sometimes incurred obstructions. In addition, in situation of unemployed or underemployed at present then these labor and food security became more important issues that need attention.

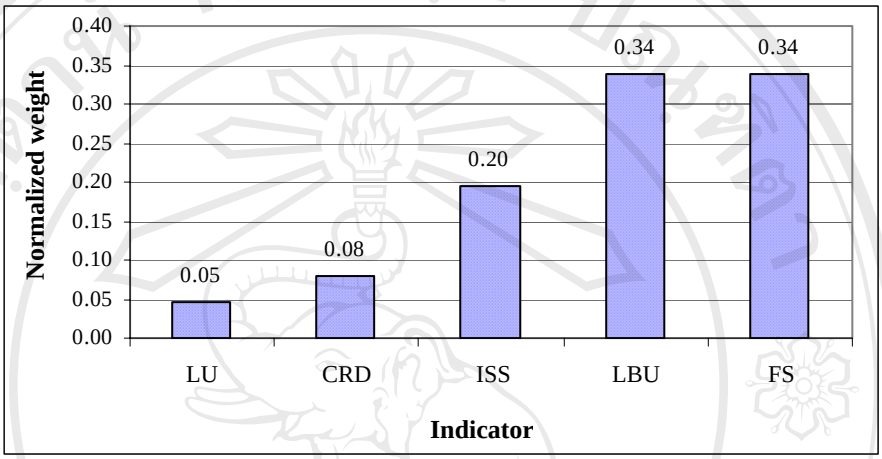


Figure 7.8 Weight of five indicators following authorities of three communes

Within each criterion, alternatives also are ranked. However, the order of alternatives of first three indicators such land use, crop diversification, and input self-sufficiency were the same with assessment at households level in all of three communes. But in terms of labor use and food security, alternatives had different order corresponded with different CPSs. In Huong Loc commune, Rice-A.Crop pattern ranked first both in the labor use and food security. Also in Huong Phu commune, using these two indicators Rice-Fish-A.Crop pattern got high ranking. While Rice-Fish-A.Crop pattern just got high ranking in food security in Thuong Quang commune. For labor use, Veg.Str. pattern got high ranking (Table 7.9-7.11).

Table 7.9 Final ranking of crop production systems in Huong Loc (commune level)

Criteria	Alternative	Weights			Rank
		Criteria	Alternatives within a Criteria	Alternatives related to all Criteria	
Land use		0.05	CR: 0.004		5
	Rice-A.Crop		0.581	0.026	1
	I.A.Crop		0.110	0.005	3
	Fruit-I.P.Crop		0.309	0.014	2
Crop diversification		0.08	CR: 0.037		4
	Rice-A.Crop		0.633	0.050	1
	I.A.Crop		0.106	0.008	3
	Fruit-I.P.Crop		0.260	0.021	2
Input self-sufficiency		0.20	CR: 0.018		3
	Rice-A.Crop		0.137	0.027	3
	I.A.Crop		0.623	0.122	1
	Fruit-I.P.Crop		0.239	0.047	2
Labor use		0.34	CR: 0.031		1
	Rice-A.Crop		0.755	0.256	1
	I.A.Crop		0.092	0.031	3
	Fruit-I.P.Crop		0.154	0.052	2
Food security		0.34	CR: 0.018		1
	Rice-A.Crop		0.623	0.212	1
	I.A.Crop		0.239	0.081	2
	Fruit-I.P.Crop		0.137	0.047	3

Source: Analyzed by AHP method

Table 7.10 Final ranking of crop production systems in Huong Phu (commune level)

Criteria	Alternative	Weights			Rank
		Criteria	Alternatives within a Criteria	Alternatives related to all Criteria	
Land use		0.05	CR: 0.037		5
	Rice-Fish-A.Crop		0.265	0.012	2
	I.A.Crop		0.080	0.004	3
	Fruit-I.P.Crop		0.656	0.030	1
Crop diversification		0.08	CR: 0.004		4
	Rice-Fish-A.Crop		0.581	0.046	1
	I.A.Crop		0.110	0.009	3
	Fruit-I.P.Crop		0.309	0.025	2
Input self-sufficiency		0.20	CR: 0.037		3
	Rice-Fish-A.Crop		0.633	0.124	1
	I.A.Crop		0.106	0.021	3
	Fruit-I.P.Crop		0.260	0.051	2
Labor use		0.34	CR: 0.024		1
	Rice-Fish-A.Crop		0.568	0.193	1
	I.A.Crop		0.334	0.113	2
	Fruit-I.P.Crop		0.098	0.033	3
Food security		0.34	CR: 0.037		1
	Rice-Fish-A.Crop		0.633	0.215	1
	I.A.Crop		0.260	0.088	2
	Fruit-I.P.Crop		0.106	0.036	3

Source: Analyzed by AHP method

Table 7.11 Final ranking of crop production systems in Thuong Quang (commune level)

Criteria	Alternative	Weights			Rank
		Criteria	Alternatives within a Criteria	Alternatives related to all Criteria	
Land use		0.05	CR: 0.037		5
	Rice-Fish-A.Crop		0.656	0.030	1
	Fruit		0.265	0.012	2
	Veg.Str.		0.080	0.004	3
Crop diversification		0.08	CR: 0.018		4
	Rice-Fish-A.Crop		0.657	0.052	1
	Fruit		0.275	0.022	2
	Veg.Str.		0.068	0.005	3
Input self-sufficiency		0.20	CR: 0.009		3
	Rice-Fish-A.Crop		0.106	0.021	3
	Fruit		0.260	0.051	2
	Veg.Str.		0.633	0.124	1
Labor use		0.34	CR: 0.034		1
	Rice-Fish-A.Crop		0.137	0.047	2
	Fruit		0.083	0.028	3
	Veg.Str.		0.780	0.265	1
Food security		0.34	CR: 0.024		1
	Rice-Fish-A.Crop		0.568	0.193	1
	Fruit		0.098	0.033	3
	Veg.Str.		0.334	0.113	2

Source: Analyzed by AHP method

The final ranking of CPSs dealing with five criteria in relation of three communes was employed. The results are shown in Table 7.12.

Table 7.12 Final ranking of crop production systems at commune level (AHP method)

Category	Crop production systems					
	Rice-A.Crop	Rice-Fish-A.Crop	I.A.Crop	Fruit	Fruit-I.P.Crop	Veg.Str.
Huong Loc commune						
- Overall priorities	0.571		0.248		0.180	
- Rank	1 (3*)		2 (1*)		3 (2*)	
Huong Phu commune						
- Overall priorities		0.590	0.235		0.175	
- Rank		1 (3*)	2 (2*)		3 (1*)	
Thuong Quang commune						
- Overall priorities		0.342		0.146		0.511
- Rank		2 (2*)		3 (3*)		1 (1*)

Source: Analyzed by AHP method

*Note: * indicated the overall ranking of sustainable CPS at household level*

From Table 7.12, the highest alternative in Huong Loc commune was Rice-A.Crop pattern, followed by I.A.Crop and Fruit-I.P.Crop pattern in sequence. While the Rice-Fish-A.Crop pattern was the highest priority in Huong Phu commune. Conversely, that pattern was just second alternative in Thuong Quang commune. The Veg.Str. was pattern got the highest priority.

Table 7.12 also showed that overall ranking of sustainable CPS was different from household and commune level. Particularly, in Huong Phu commune, the difference of rank was evident. Fruit-I.P.Crop pattern was first priority under household level but the last priority under commune level that weight of indicators was considered by authorities. In Huong Loc commune, the biggest change was Rice-A.Crop pattern. It was the last priority at household level but the highest priority at commune level. While in Thuong Quang commune, there were not changes of rank.

7.3.2 Assumed indicators are equal importance

Although food security and labor use are two issues very important according to authorities in these communes that are presented rather clearly in AHP method. But in such situation, when those two indicators also were taken into account following assumed all of them were equal importance. Then the critical issues as well as the most sustainable issues as though had particular features that are indicated in Table 7.13 to Table 7.15.

Table 7.13 Sustainability of crop production systems in Huong Loc (SIA method)

Indicators	Rice-A.Crop		I.A.Crop		Fruit-I.P.Crop	
	Sustainability index	Performance value	Sustainability index	Performance value	Sustainability index	Performance value
	-------%-------	-----Score-----	-------%-------	-----Score-----	-------%-------	------Score------
Land use	80.63	258	46.25	148	68.13	218
Crop diversification	79.38	254	43.75	140	63.75	204
Labor use	66.25	212	57.50	184	58.13	186
Food security	66.25	212	53.13	170	48.75	156
Input self-sufficiency	62.50	200	82.50	264	68.13	218
Performance percentage (%)		71.0		56.6		61.4

Source: Analyzed by sustainability indicator analysis method

Table 7.13 showed the sustainability index of each indicator as well as performance percentage of each CPS in Huong Loc commune. One can realize that the critical issue in Fruit-I.P.Crop pattern was food security with value of sustainability index was about 48%, followed by labor use issue (58%). While the crop diversification was critical issue in I.A.Crop pattern, it was only 43%. Input self-sufficiency was found to be sustainable in this pattern. But input self-sufficiency was critical issue in Rice-A.Crop pattern it just made up 62.5 % in sustainability index. Land use and crop diversification seem to be the most sustainable component. In general, if considered on performance percentage then Rice-A.Crop pattern was the highest alternative because their value reached at 71%, was higher than other CPSs.

Similarly, in Huong Phu commune, the results of this analysis are presented in Table 7.14. In both Rice-Fish-A.Crop and I.A.Crop pattern, the land use was most critical issue as compared with others. Especially, in I.A.Crop pattern, sustainability index of this indicator was under medium level, it was only about 42%. For the Fruit-I.P.Crop pattern, food security is considered the most critical issue, followed by labor use and crop diversification in sequence. The highest sustainable component of this pattern was input self-sufficiency. Meanwhile, the crop diversification in Rice-Fish-A.Crop pattern, and labor use in I.A.Crop pattern is considered as the most sustainable component. In fact, combining all indicators under performance percentage then order of priority was Rice-Fish-A.Crop, Fruit-I.P.Crop, and I.A.Crop pattern (Table 7.14).

Table 7.14 Sustainability of crop production systems in Huong Phu (SIA method)

Indicators	Rice-Fish-A.Crop		I.A.Crop		Fruit-I.P.Crop	
	Sustainability index	Performance value	Sustainability index	Performance value	Sustainability index	Performance value
	-------%-------	-----Score-----	-------%-------	-----Score-----	-------%-------	------Score------
Land use	52.50	168	41.88	134	63.75	204
Crop diversification	78.75	252	50.63	162	58.13	186
Labor use	67.50	216	70.00	224	55.00	176
Food security	64.38	206	55.00	176	48.75	156
Input self-sufficiency	71.88	230	55.63	178	66.03	206
Performance percentage (%)		67.0		54.6		58.0

Source: Analyzed by sustainability indicator analysis method

The most sustainable of CPS in Thuong Quang was also Rice-Fish-A.Crop pattern. Meanwhile, the Veg.Str. pattern although was highest in local input cost compared with two remains CPSs, but land use and crop diversification were not only were critical issues in this pattern but also the lowest value within three CPSs. So the Veg.Str. pattern was only second alternative in this commune. The lowest preferred alternative of CPS in this commune was Fruit pattern. Those are shown in Table 7.15.

Table 7.15 Sustainability of crop production systems in Thuong Quang (SIA method)

Indicators	Rice-Fish-A.Crop		Fruit		Veg.Str.	
	Sustainability index	Performance value	Sustainability index	Performance value	Sustainability index	Performance value
	-------%-------	-----Score-----	-------%-------	-----Score-----	-------%-------	------Score------
Land use	76.88	246	66.88	214	52.50	168
Crop diversification	74.38	238	63.13	202	56.25	180
Labor use	64.38	206	57.50	184	73.75	236
Food security	65.00	208	51.25	164	60.63	194
Input self-sufficiency	56.88	182	65.63	210	81.88	262
Performance percentage (%)		67.5		60.9		65.0

Source: Analyzed by sustainability indicator analysis method

In summary, the environmental-economic-social decision-making situation involves a complex decision-making process and usually requires a more comprehensive framework to arrive at the optimal solution. This chapter showed the synthesis assessment of sustainability of CPS. Quantitative, qualitative, and graphical or mixed procedures have been used to integrate results (AMOEBA, AHP, and SIA method). Each technique has its relative advantages and disadvantages. The results also varied in other cases. The AMOEBA approach implied different trade-offs in terms of performance of indicators reflecting other perspectives corresponding with CPSs. The results obtained using AHP and SIA method provided useful guidance for selecting optimum CPS taking into consideration the economic and environmental sustainability criteria and local people's perceptions (farmers and authorities). This shows that decision-making based on expert adjustment (SIA method) may provide a different out come compared to decision analysis with local farmers and authorities (AHP method). This further indicates that incorporation of local people's opinion is quite important in the environmental-economic-social decision-making process and should be considered at different levels of the decision hierarchy.