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Innovation for development of sustainable integrated plantation polyculture on dry land: Using Structural Equation Modelling

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Abstract: The land in the South Tasikmalaya Regency is dominated by dry land with a steep and hilly land contour. In addition, the area has a shallow soil solum, so it has a high potential for erosion and landslides. Therefore, it is necessary to innovate an integrated cultivation system that is economically feasible, but still maintains environmental sustainability. In this research, the aim is to formulate a model for the development of integrated plantation polyculture farming (IPPF) for the welfare of farmers. The method in this study uses a mixed method design. The location of the research carried out is in the Tasikmalaya Regency. The data used are the results of interviews and questionnaires to 250 IPPF farmers. The data used were obtained by multistage cluster random sampling. The sustainable IPPF development model was analysed using Structural Equation Modelling (SEM). This analysis is used to determine the various potential capital factors for agricultural development on the sustainable development of the IPPF and farmers' welfare. The results of the study show that the potential development capital [natural resources (SDA) capital, economic capital, socio-cultural capital, physical capital, and multifunctional IPPF], jointly or partially affect the IPPF sustainability. Human resource capital has no effect on the sustainable IPPF development, while the sustainable IPPF development affects the farmers' welfare levels, and the potential agricultural development capital and its multifunctionality affect the sustainable IPPF development and farmers' welfare. The IPPF development model that improves the welfare of farmers is carried out through the development of specific local superior commodities, increasing the added value and cooperation, developing access to credit, regenerating farmers, sustainable assistance and infrastructure improvements. The results of this study are expected to be a reference for the government in improving IPPF sustainability to achieve the welfare of its farmers. Apart from that, the model that has been developed can make a contribution to science in the form of a comprehensive analysis of the factors that influence the sustainability of IPPF.

Keywords: development potential capital; farmers; integrated polyculture; multifunctionality

An important issue for agricultural development in Indonesia, especially on dry land, is maintaining its sustainability. Sustainable agricultural development aims to increase the income and welfare of the farming community at large (Adenle et al. 2018; Rela et al. 2021;). Activities can be carried out by increasing the agricultural production in a balanced manner by taking into account the ecosystem's carrying capacity. Thus, the sustainability of the production can be maintained in the long term, by minimising the occurrence of en-

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vironmental damage (Fischer et al. 2009; Ahamed et al. 2021). Dry-land in Indonesia encompasses 147.8 million ha, not all of which are suitable for agricultural land. This is due to soil limiting factors, such as very steep slopes, shallow and rocky soils, and also includes forest areas. Apart from that, for the West Java Province, the dry land area encompasses 1.54 million ha with 61.97% used as agricultural area. Based on the location, the majority, namely 55.98% of the dry land is in the southern and central areas of the West Java Province (34.50%), and only about 9.52% is contained in the northern region. Tasikmalaya Regency is one of the areas with the largest dry land areas in West Java, reaching 11.10% after Sukabumi Regency (15.11%) and Cianjur Regency (11.28%).

Tasikmalaya Regency is one of the disaster-prone areas in the West Java region, especially with landslides (Winarti 2018). The Regional Disaster Management Agency for West Java Province stated that Tasikmalaya Regency is the second district in West Java that often experiences landslides (Marlyono and Nandi 2018). Throughout 2016 (January–November 2016), there were 1 074 natural disasters consisting of 227 fires, 206 floods, 439 landslides, 164 tornadoes, and 38 earthquakes. The dry-land conditions are generally characterised by a low physical and social infrastructure and other access limitations. The isolation of the population from information sources causes them, in general, to be less able to develop their territory independently (McLeod et al. 2020; Riptanti et al. 2020;). This situation is exacerbated by the limited ability of government officials to reach people in the dry land, most of whom are relatively poor. This is due to its unfavourable geographical location, where the dry land in Tasikmalaya Regency is often located in areas far from natural and artificial water sources, such as rivers, lakes or irrigation canals. So the dry land that is difficult to reach receives less support in terms of counselling, assistance and facilities from government officials. In these conditions, a special design of dry land conservation farming systems is needed to create sustainable and environmentally friendly agricultural production (Enfors et al. 2011; Barokah et al. 2020).

In particular, currently in Tasikmalaya Regency, there are various forms of polyculture farming, smallholder plantations and ruminant farming businesses. For example, polyculture livestock businesses include Sheep–Cocoa–Coffee–Coconut–Banana; Goat–Coconut–Banana; Cow–Coconut; Cow–Coconut–Banana, etc. The southern part of Tasikmalaya Regency is one of the regions in West Java which has a natural resource potential in its local area, including the development of plantation farming.

The plantation business in Tasikmalaya Regency is mostly consists of plantations owned by a community or farmers with various limitations that exist in themselves, generally having a low level of productivity. This can be seen, among others, from the average productivity of cocoa and coffee which only reached 0.50 tonnes/ha for cocoa and 0.49 tonnes/ha for coffee, whereas the cocoa production potential can reach 2.16–3.20 tonnes/ha and, for coffee plants, it can reach 0.5–1.2 tonnes/ha (Djaenudin et al. 2003).

The existing cropping pattern is a form of local wisdom regarding farming systems that was developed based on the resources owned by the farmers, the technology, culture, and local economy. The cropping pattern carried out by these farmers is the result of a long journey of adapting their farming to various factors including the climate, soil, economy, and culture (Mertz et al. 2009; Akinnagbe and Irohibe 2014). The synergy between crops and livestock requires technological innovation to be able to lead to high productivity increases, production security, and the conservation of site-specific resources (Lemaire et al. 2014). Dryland management should not only be oriented towards commodity-based land-use arrangements, but commodity-based land management should be placed as an integral part of ecosystem management by paying attention to the balance and harmony of ecosystem services (Gebremedhin 2010; Kalfin et al. 2021).

Molden (2013), explains that ecosystem services reflect the usable functions of an ecosystem. The Millennium Ecosystem Assessment (MEA) also classifies ecosystem services into four categories: provisioning, regulatory, cultural, and supporting services. The four ecosystem services are interrelated with each other and can function fully through balance and harmony in land and water management. Poorly designed land conversion, including forest and agricultural land, can distort the ecosystem services that exist in agriculture (Swinton et al. 2006). In the face of environmental changes that have occurred, strategic agricultural development, today and in the future, is very much needed. The integrated plantation polyculture farming model requires the synergy of several factors, namely natural resource capital (SDA), technology capital, human capital (HR) with social capital and financial capital as well as physical capital.

Based on previous research, the research that was conducted has not analysed the factors that have a comprehensive influence on the development of inte-

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grated polyculture plantation farming. Where, in general, analysing several factors that influence the development of the IPPF the most, the carried out research is not yet at the comprehensive analysis stage in the development of the IPPF. Regarding this gap, a model is needed to analyse the factors that influence the development of sustainable and adaptive IPPF as a strategy for developing dryland agriculture to support the success of efforts to improve the farmers' welfare. The research was carried out with the aim of formulating an IPPF development model in Tasikmalaya Regency. The novelty of the carried out research was the development of an IPPF development model in Tasikmalaya Regency by carrying out a comprehensive analysis. The research hypothesis states that the sustainable IPPF is directly or indirectly influenced by the potential capital for agricultural development [natural resources (SDA), economic capital, socio-cultural capital, human resources (HR), physical capital, and their multifunctionality]. The development of a sustainable IPPF is jointly or partially influenced by the potential capital of the agricultural development and its multi-functionality and the sustainable IPPF has a significant effect on the welfare of IPPF farmers. From the results of the obtained research, it is hoped that it can be a reference for the government in developing IPPF in a sustainable manner and can increase the development in the agricultural sector more effectively.

MATERIALS AND METHODS

The research was designed using a mixed method, which is a combination of qualitative and quantitative methods, with a dominant quantitative design. The types of data collected are primary data and secondary data. The primary data were obtained from the results of field surveys and structured interviews with the respondents (farmers) guided by a questionnaire. The primary data were also collected qualitatively using in-depth interviews and Participatory rural appraisal (PRA) techniques (including Focus Group Discussions FGDs) with community leaders, village officials, farmer group leaders and other related parties. The secondary data are obtained from searching various research results, literature studies, reports and documents from various agencies related to research.

The variables that are operationalised relate to efforts to describe the diversity of IPPF in the form of natural resources capital (X1), economic capital (X2), socio-cultural capital (X3), HR capital (X4), physical/infrastructure capital (X5), multifunctionality of IPPF (X6), IPPF sustainability (Y1), and welfare (Y2) (Nuryati et al. 2022). Natural resource capital (SDA) is all-natural potential that can be used or exploited to support the sustainability of IPPF in the form of land, water, vegetation, animals / livestock / forages, and soil fertility. Economic capital is capital that already exists in the society which has the potential or can be utilised to support the sustainability of IPPF in the form of cash, credit and savings. Socio-cultural capital is capital that arises from the results of interactions between individuals and institutions that give rise to emotional bonds in the form of mutual trust, reciprocal relationships, and social networks, as well as values and norms that form the structure of society and become the glue between members. Sociocultural capital can be in the form of institutions, mutual trust, cooperation, and norms, forming a useful group for coordinating and collaborating in supporting the sustainability of IPPF. HR capital is the potential possessed by farmers as capital that can be developed in the production process so as to support the sustainability of IPPF in the form of health, education, experience and labour. Physical capital / infrastructure are the facilities and infrastructure or a physical building (structure) that supports the sustainable development of IPPF in the form of transportation, communication, information and technology. The multi-functionality of IPPF includes the various positive services or functions contributed by IPPF in the form of economic functions, environmental functions and socio-cultural functions.

The integrated crop-livestock farming system has four main functions, namely improving welfare, encouraging economic growth, ensuring food security, and maintaining environmental sustainability (Ngxetwane 2011). The welfare of farming families is the output of the process of managing family resources and overcoming problems faced by farming families (Birner et al. 2009). Farmers who carry out crop and livestock integration activities have a better household economic performance compared to farmers who do not follow this pattern (Mujeyi et al. 2021). The current and future agricultural development in the region that is facing strategic environmental changes requires new breakthroughs focused on the synergistic integration between human resources (HR capital) together with institutions (social capital), natural resources (natural capital), with the support of advanced environmentally friendly technology based on agro-ecology (technological capital) and financial and financing institutions (financial capital) as well as an agricultural and rural

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irrigation infrastructure (Nuryati et al. 2022). Farmers have a strong need to adhere to local culture. Changes that are not in harmony with their social, cultural and spiritual values can cause stress and create opposing forces (Xu et al. 2006). Social capital is capital that can be applied as an important step in achieving the successful development in the economic sector (Dika and Singh 2002). The theoretical research model path diagram is given in Figure 1.

The research was conducted in the southern part of Tasikmalaya Regency, specifically in Cibalong and Karangnunggal sub-districts, from February to November 2018 on 250 sample farmers using the Multistage Cluster Random Sampling method. Meanwhile, the total number of IPPF farmers in these two sub-districts is 8 981 people. This research uses the multistage cluster random sampling method, because probability sampling divides the farmer population in the southern Tasikmalaya area into small groups called clusters, then randomly selects several clusters to be sampled. So, the sample data used in this research is representative of the farmer population in the southern Tasikmalaya area. The location was chosen in the southern part of Tasikmalaya because the land is dry with a steep and hilly contour. Apart from that, this area has a shallow soil solum, so it has a high potential for erosion and landslides when compared with other areas in the Tasikmalaya Regency. The sustainable IPPF development model was analysed using Structural Equation Modelling (SEM) analysis with Amos analysis. This analysis is used to determine various potential capital factors for agricultural development (SDA capital, economy, social culture, human resources, and physical capital) and the multi-functionality of IPPF that affects the sustainability of the IPPF development and farmers' welfare. The path diagram of the research model using SEM is given in Figure 2.

In the Structural Equation Modelling (SEM) analysis, the estimation of the population is carried out with the aim of knowing the extent to which the independent variable affects the dependent variable (Ahmad et al. 2016; Elastika et al. 2021). In addition, the estimation of the population to see the suitability of the research model designed with the real model using the SEM analysis that was computed using SPSS 16 software and Amos analysis. In general, SEM is used to analyse the structural influence between the variables, either directly or indirectly (Musil et al. 1998; Grapentine 2000; Sarstedt et al. 2017). SEM is an integrated approach between data analysis and concept construction. In this study, SEM is used to test the model of the relationship between the latent variables (exogenous variables and endogenous variables) and obtain a useful model for estimation. Therefore, SEM is not used to generate a model, but to confirm a hypothetical model through empirical data.

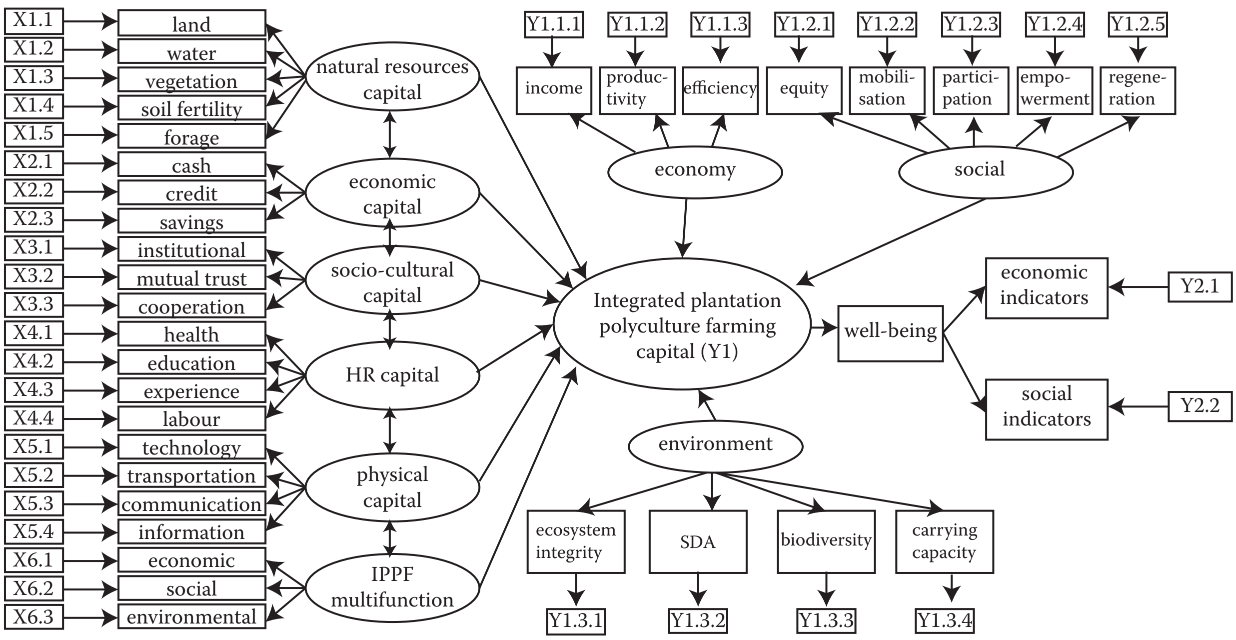

Figure 1. Path diagram of the theoretical research model

Source: Authors' own processing

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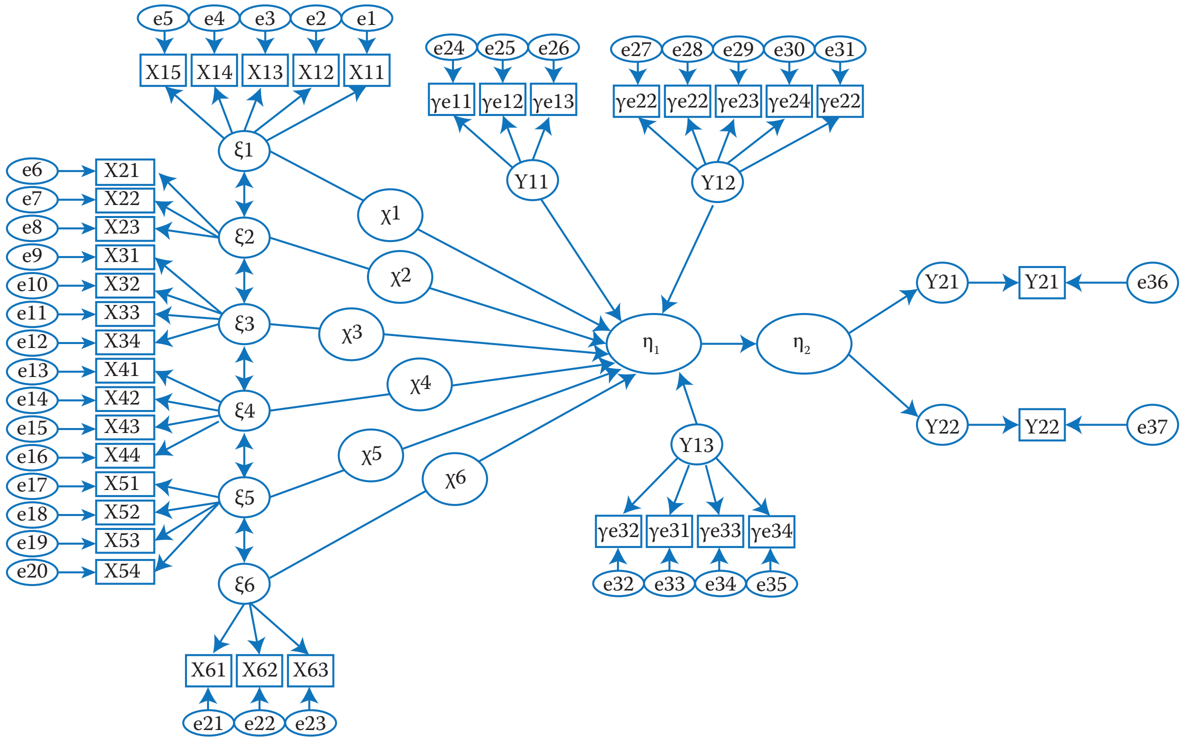

Figure 2. Research model path diagram

ξ1–5 – potential capital factors for agricultural development, these include various forms of capital such as natural resources, economic, socio-cultural, human, and physical capital; ξ6 – integrated plantation polyculture farming (IPPF) multifunctionality, which represents the multiple functions and benefits provided by theIPPF system; η1 – IPPF capital, encompassing the resources and assets specific to the IPPF system η2 – well-being, referring to the overall welfare and quality of life of the farmers involved in the IPPF system.

Source: Authors' own processing

RESULTS

Synthesis of the potential capital performance for agricultural development. Based on the survey results, a synthesis of achieving the potential capital performance for the agricultural development in the sustainability of IPPF in the Southern part of the Tasikmalaya Regency using the complete average score can be seen in Table 1.

In Table 1, this was undertaken to see the achievement of the agricultural development capital performance in the IPPF sustainability in the Tasikmalaya Regency. The level of measurement is carried out by categorising the performance measures in the form of good (< 81) and very good (≥ 81). The performance measure of each of these variables is seen from the Average Index. Based on Table 1, the total average score of the natural resource capital performance shows a very good level of performance. This is related to the contribution of the performance of nutrient variables to natural resource capital which also shows a very good level of performance. The good performance of the nutrient variable is because IPPF is an integrated farming business that cultivates various types of agricultural crop commodities and livestock businesses, thus ensuring the availability of organic fertiliser material originating from livestock waste and inedible feed residue to meet the nutrient and mineral needs for polyculture plants.

Likewise, the performance of the land variable has a very good level of performance because IPPF is suitable for the development in areas that have valleys and a hilly topography with steep slopes. The South Tasikmalaya Regency, as a research location, generally has hilly conditions with steep slopes. The annual plants cultivated at IPPF have deep roots to improve the function of the terraces in an effort to reduce erosion and provide depth to the cultivated layer through the resulting litter into the soil. The good performance of the natural resource capital is also supported by the good performance of the IPPF forage, vegetation and

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Table 1. Synthesis of potential capital performance achievement for agricultural development in IPPF sustainability in Tasikmalaya Regency

Dimensions	Variable	Average index	Performance
Natural resources capital	nutrient	84.10	very good
	land	82.85	very good
	IPPF Forage	80.80	good
	vegetation	79.60	good
	water	79.50	good
	total average score	81.37	very good
Sociocultural capital	cooperation	79.40	good
	mutual trust	79.20	good
	norm	77.67	good
	institutional	75.55	good
	total average score	77.95	good
Economic capital	credit	79.20	good
	cash	78.90	good
	savings	71.80	good
	total average score	76.63	good
Physical capital	communication	76.80	good
	information	73.13	good
	technology	72.60	good
	transportation	72.27	good
	total average score	73.70	good
HR capital	education	78.93	good
	health	76.90	good
	experience	74.60	good
	labour	62.90	good
	total average score	73.33	good

IPPF – integrated plantation polyculture farming
Source: Authors' own processing

water variables. IPPF provides feed for livestock that comes from grass that grows around the planting area and from forage produced by polyculture plants so that livestock feed needs are met. Likewise with vegetation conditions, IPPF is a multi-commodity farming business that provides good vegetation cover so that it can protect the soil from erosion and increase the availability of organic material. In the water variable, IPPF can help reduce the potential for floods and landslides because the farming pattern applied to IPPF can increase the process of absorbing water into the soil in the rainy season and can release it slowly through the spring in the dry season.

The total average score of the social and cultural capital performance shows a good level of performance. The good performance of the socio-cultural capital is related to the good performance of the variables of the cooperation, mutual trust, norms and institutions. The collaboration variable has good performance because the farmers at the research location always try to convey the information they receive to fellow farmers and generally have a spirit of helping and respecting each other. This awareness is very important in establishing cooperation to support the sustainability of IPPF. The good contribution to the performance of social and cultural capital is also provided by the mutual trust variable regarding IPPF, which is a farming business that is strongly supported by the willingness of farmers to always try to fulfil all their obligations and farmers who always try to comply with the agreed agreements and always convey information according to reality and every farmer has equal opportunity to express opinions so as to support the sustainability of IPPF. The performance of the norm variable in socio-cultural capital also has good performance. This is related to the farmers' attitudes and obedience to religion, mutual assistance with other farmers who experience problems and the farmers' attitudes and obedience to the mutually agreed rules, which simultaneously supports the sustainability of IPPF. The institutional variable in socio-cultural capital also has a good level of performance related to the institutions that are always actively seeking information for farmers and conveying this information to farmers and always providing marketing facilities and collaborating with other parties to facilitate the capacity and abilities of farmers who also have a good level of performance so as to support the sustainability of IPPF.

The economic capital from the analysed capital factors obtained a good level of performance. This good performance relates to the IPPF, which is a business that provides opportunities to earn cash and increase the ability to pay credit as well as increases the opportunity to have savings because IPPF is a farming business that cultivates various agricultural crop commodities and livestock businesses, thus opening up opportunities for farmers to obtain various sources of income. The credit variable obtained a good level of performance because credit facilities were available around the farmers which were in accordance with the farm-

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ers' needs. Apart from that, the credit facilities around farmers are adequate for the farmers and the farmers have access to credit facilities and the farmers are able to optimise the available credit facilities. Likewise, the cash variable has a good level of performance, because adequate cash is needed to meet IPPF's cost requirements for sustainability. Therefore, the sustainability of IPPF can be guaranteed because the farmers generally have cash to meet the cost needs. The final variable of economic capital that contributes to the good performance of economic capital is the savings because the savings variable also has a good level of performance. The good performance of the savings variable is because IPPF provides opportunities for farmers to be able to save and increase the ability to save for farmers through various commodity businesses including livestock businesses.

The physical capital / infrastructure has a good level of performance. This applies to all the physical capital / infrastructure variables, namely communication, information, technology and transportation, which also have good performance levels. Communication achieves a good level of performance related to the ease of communicating with information sources and the ease of communicating with fellow farmers. The information variable has good performance in relation to the information that farmers need is always available, information sources are affordable and the information available is in accordance with the needs. IPPF farmers get the information they need from agricultural extension officers, farmer group administrators, fellow farmers and assistants from universities. The farmer groups at the research location have succeeded in becoming a source of information and technology for their members. The technological variable in the physical capital/ infrastructure has performed well because the farmers have been able to utilise forage from the IPPF for animal feed and have applied fertilisers in a balanced manner. However, farmers still need to improve their mastery of the technology for processing livestock waste into organic fertilisers. The transportation variable, as the fourth variable of physical capital/infrastructure, also has good performance. This good performance is related to the adequate road conditions, transportation facilities that are always available to transport inputs and outputs and affordable transportation costs so as to support the sustainability of IPPF.

The HR capital obtained a good performance level because all the HR capital variables, namely education, health, experience and workforce, also obtained a good performance level. The education variable obtains a good level of performance because various non-formal education is available around the farmers and this non-formal education can be easily accessed by farmers and non-formal education is available according to the farmers' needs. The health variable also contributes to the good performance of the HR capital because the health variable has good performance. The good performance of the health variable is due to the behaviour of the farmers who have cultivated a healthy lifestyle and from the farmers that have produced and marketed food/ drinks that are healthy and highly nutritious through the use of IPPF products. The experience variable has good performance because the farmers generally have a great deal of experience in farming and in IPPF, thus supporting its sustainability. The labour variable has good performance due to the availability of a sufficient amount labour to support the sustainability of IPPF.

Measurement model validity analysis. The validity test with the confirmatory factor analysis (CFA) test or construct validity test (indicator) measures whether the construct is able or not to reflect the latent variable. The results meet the criteria, namely the value of the critical ratio (CR) > 1.96 with a probability (P) < 0.05. The validity test with the convergent validity test, namely testing the construct (indicator) whether it has a high proportion of variance or not, and whether it meets the criteria if the standardised loading factors (SLFs) > 0.5.

At this stage, the validation test process of the SEM model that has been compiled is carried out using AMOS ver.18 software. Based on the results of the analysis using the AMOS ver.18 software, the results of the *SLF* values obtained for each exogenous and endogenous indicator/variable are presented in Table 2.

Based on the results of the validation test from the SEM model given in Table 2, it shows that all the manifest variables have an *SLF* value > 0.50. This shows that the indicators used from the SEM model reflect the studied variables.

Measurement model reliability analysis. At the stage of the reliability analysis process, the measurement model is carried out by calculating the construct reliability (CRe) and average variance extracted (AVE) values from the SLFs or the λ_i values and measurement error (e_i) through the following formulas:

$$CRe = \frac{\left(\sum \lambda_i\right)^2}{\left(\sum \lambda_i\right)^2 + \sum e_i}$$

$$AVE = \frac{\sum \left(\lambda_i\right)^2}{\sum \left(\lambda_i\right)^2 + \sum e_i} \tag{1}$$

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Table 2. Results of measurement model validity analysis

Variable	Value of standardized loading factors (SLF)											*CRe*	*P*
	X1	X2	X3	X4	X5	X6	Y1.1	Y1.2	Y1.3	Y2.1	Y2.2		
X1.1	0.94	–	–	–	–	–	–	–	–	–	–	28.06	***
X1.2	0.92	–	–	–	–	–	–	–	–	–	–	26.32	***
X1.3	0.93	–	–	–	–	–	–	–	–	–	–	27.59	***
X1.4	0.93	–	–	–	–	–	–	–	–	–	–	26.75	***
X1.5	0.93	–	–	–	–	–	–	–	–	–	–	–	–
X2.1	–	0.94	–	–	–	–	–	–	–	–	–	33.01	***
X2.2	–	0.93	–	–	–	–	–	–	–	–	–	31.24	***
X2.3	–	0.97	–	–	–	–	–	–	–	–	–	–	–
X3.1	–	–	0.96	–	–	–	–	–	–	–	–	33.11	***
X3.2	–	–	0.95	–	–	–	–	–	–	–	–	32.34	***
X3.3	–	–	0.95	–	–	–	–	–	–	–	–	32.26	***
X3.4	–	–	0.95	–	–	–	–	–	–	–	–	–	–
X4.1	–	–	–	0.93	–	–	–	–	–	–	–	27.82	***
X4.2	–	–	–	0.93	–	–	–	–	–	–	–	27.54	***
X4.3	–	–	–	0.94	–	–	–	–	–	–	–	28.07	***
X4.4	–	–	–	0.93	–	–	–	–	–	–	–	–	–
X5.1	–	–	–	–	0.92	–	–	–	–	–	–	25.95	***
X5.2	–	–	–	–	0.93	–	–	–	–	–	–	27.17	***
X5.3	–	–	–	–	0.93	–	–	–	–	–	–	26.64	***
X5.4	–	–	–	–	0.93	–	–	–	–	–	–	–	–
X6.1	–	–	–	–	–	0.92	–	–	–	–	–	28.41	***
X6.2	–	–	–	–	–	0.94	–	–	–	–	–	30.15	***
X6.3	–	–	–	–	–	0.96	–	–	–	–	–	–	–
Y1.1.1	–	–	–	–	–	–	0.95	–	–	–	–	–	–
Y1.1.2	–	–	–	–	–	–	0.97	–	–	–	–	35.94	***
Y1.1.3	–	–	–	–	–	–	0.92	–	–	–	–	28.78	***
Y1.2.1	–	–	–	–	–	–	–	0.99	–	–	–	–	–
Y1.2.2	–	–	–	–	–	–	–	0.97	–	–	–	59.24	***
Y1.2.3	–	–	–	–	–	–	–	0.98	–	–	–	68.81	***
Y1.2.4	–	–	–	–	–	–	–	0.98	–	–	–	61.78	***
Y1.2.5	–	–	–	–	–	–	–	0.97	–	–	–	53.72	***
Y1.3.1	–	–	–	–	–	–	–	–	0.97	–	–	–	–
Y1.3.2	–	–	–	–	–	–	–	–	0.97	–	–	46.63	***
Y1.3.3	–	–	–	–	–	–	–	–	0.99	–	–	52.27	***
Y1.3.4	–	–	–	–	–	–	–	–	0.99	–	–	54.06	***
Y2.1.1	–	–	–	–	–	–	–	–	–	0.93	–	–	–
Y2.1.2	–	–	–	–	–	–	–	–	–	0.94	–	29.06	***
Y2.1.3	–	–	–	–	–	–	–	–	–	0.94	–	28.44	***
Y2.1.4	–	–	–	–	–	–	–	–	–	0.94	–	28.40	***
Y2.2.1	–	–	–	–	–	–	–	–	–	–	0.92	–	–
Y2.2.2	–	–	–	–	–	–	–	–	–	–	0.92	24.98	***
Y2.2.3	–	–	–	–	–	–	–	–	–	–	0.91	24.64	***
Y2.2.4	–	–	–	–	–	–	–	–	–	–	0.92	24.89	***
Y2.2.5	–	–	–	–	–	–	–	–	–	–	0.91	24.56	***

*** $P < 0.001$; *CRe* – construct reliability
Source: Authors' own processing

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Table 3. Results of measurement model reliability analysis

Indicator	*SLF* (λ_i)	Latent variable	*CRe*	*AVE*	SQRT *AVE*
X1.1	0.94	X1	0.97	0.87	0.93
X1.2	0.92				
X1.3	0.93				
X1.4	0.93				
X1.5	0.93				
X2.1	0.94	X2	0.96	0.90	0.95
X2.2	0.93				
X2.3	0.97				
X3.1	0.96	X3	0.97	0.91	0.95
X3.2	0.95				
X3.3	0.95				
X3.4	0.95				
X4.1	0.93	X4	0.96	0.88	0.94
X4.2	0.93				
X4.3	0.94				
X4.4	0.93				
X5.1	0.92	X5	0.96	0.87	0.93
X5.2	0.93				
X5.3	0.93				
X5.4	0.93				
X6.1	0.92	X6	0.96	0.89	0.94
X6.2	0.94				
X6.3	0.96				
Y1.1	0.73	Y1	0.85	0.70	0.84
Y1.2	0.84				
Y1.3	0.85				
Y1.1.1	0.95	Y1.1	0.96	0.90	0.95
Y1.1.2	0.97				
Y1.1.3	0.92				
Y1.2.1	0.99	Y1.2	0.99	0.96	0.98
Y1.2.2	0.97				
Y1.2.3	0.98				
Y1.2.4	0.98				
Y1.2.5	0.97				
Y1.3.1	0.97	Y1.3	0.99	0.96	0.98
Y1.3.2	0.97				
Y1.3.3	0.99				
Y1.3.4	0.99				
Y2.1	0.73	Y2	0.77	0.68	0.83
Y2.2	0.86				
Y2.1.1	0.93	Y2.1	0.97	0.89	0.94
Y2.1.2	0.94				
Y2.1.3	0.94				
Y2.1.4	0.94				
Y2.2.1	0.92	Y2.2	0.96	0.85	0.92
Y2.2.2	0.92				
Y2.2.3	0.91				
Y2.2.4	0.92				
Y2.2.5	0.91				

Table 3 to be continued

SLF – standardized loading factor; λ_i – lambda; C*Re* – construct reliability; *AVE* – average variance extracted; SQRT *AVE* – square root of average variance extracted
Source: Authors' own processing

A measurement model meets the reliability requirements well, if it has a construct reliability value ≥ 0.70 and average variance extracted value ≥ 0.50. Based on the results of the analysis that has been carried out for the reliability value of the measurement model on each latent variable, the variables are given in Table 3.

Based on the results of the analysis given in Table 3, it is known that the construct reliability value and the average variance extracted value of all the latent variables have met the specified requirements. Based on the results of the analysis that has been carried out, based on Table 3, it can be said that the reliability of this measurement model is good and all the latent variables in the SEM model that have been compiled are in accordance with the data in the field.

Analysis of the fit of the measurement model (goodness of fit). Based on the field data, an analysis of the fit of the measurement model (goodness of fit) was conducted. The process of testing the suitability of the measurement model was carried out using the help of AMOS ver.18 software. Based on the results of the analysis that has been carried out, the fit of the measurement model is given in Table 4.

Based on the results of the analysis given in Table 4, it shows that the absolute goodness of fit (GoF) measures, such as the χ^2 statistical values, *P*-value, *RMSEA* (root mean square error of approximation), *NCP* (noncentrality parameter), *ECVI* (expected cross-validation index), *NFI* (normed fit index), *NNFI* (non-normed fit index, also known as the Tucker-Lewis index), *CFI* (comparative fit index), and *IFI* (incremental fit index), have a satisfactory match value (good fit). This is also in line with other absolute GoF values such as the standardised *RMR* (root mean square residual) which also has a good fit. Although in other circumstances, *GFI* (goodness of fit index) and *AGFI* (adjusted goodness of git index) have quite good results (marginal fit),

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Table 4. Measurement model fit test results

Size of goodness of fit	Result match criteria	Estimate	Information
χ^2 statistic	Smaller value 942.85, where χ^2 for d*f* 873; level sig 5% = 942.85	908.985	good fit
P-value	$P > 0.05$	0.193	good fit
Non-centrality parameter (*NCP*)	small	35.985	good fit
Root mean square error of approximation (*RMSEA*)	*RMSEA* value 0.05 ≤ *RMSEA* ≤ 0.08 is good fit, while *RMSEA* < 0.05 is close fit and *RMSEA* > 0.08 is marginal fit.	0.013	good fit
Expected cross-validation index (*ECVI*)	The *ECVI* value which is closer to the *ECVI* value for the saturated model compared to the *ECVI* for independence model indicates a good fit.	4.590	good fit
ECVI for saturated model		7.952	
ECVI for independence model		71.092	
Independence *AIC*	The *AIC* value of the model that is close to the saturated *AIC* value compared to the *AIC* for independence indicates a good fit.	17 701.955	good fit
Model *AIC*		1 142.985	
Saturated *AIC*		1 980.000	
Independence *CAIC*	The *CAIC* value of the model that is close to the saturated *CAIC* value compared to *CAIC* for independence shows a good fit.	17 900.899	good fit
Model *CAIC*		1 671.996	
Saturated *CAIC*		6 456.246	
Normed fit index (*NFI*)	Values range from 0–1, with higher values being better. *NFI* ≥ 0.90 is good fit, while ≥ 0.80 ≤ 0.90 is marginal fit.	0.948	good fit
Comparative fit index (*CFI*)	Values range from 0–1, with higher values being better. *CFI* ≥ 0.90 is good fit, while ≥ 0.80 ≤ 0.90 is marginal fit.	0.998	good fit
Incremental fit index (*IFI*)	Values range from 0–1, with higher values being better. *IFI* ≥ 0.90 is good fit, while ≥ 0.80 ≤ 0.90 is marginal fit.	0.998	good fit
Relative fit index (*RFI*)	Values range from 0-1, with higher values being better. *RFI* ≥ 0.90 is good fit, while ≥ 0.80 ≤ 0.90 is marginal fit.	0.944	good fit
Standardized root mean square residual (*RMR*)	Values range from 0–1, with higher values being better. *RMR* ≥ 0.90 is good fit, while ≥ 0.80 ≤ 0.90 is marginal fit.	0.046	good fit
Goodness of fit index (*GFI*)	Values range from 0–1, with higher values being better. *GFI* ≥ 0.90 is good fit, while ≥ 0.80 ≤ 0.90 is marginal fit.	0.864	marginal fit
Adjusted goodness of fit index (*AGFI*)	Values range from 0–1, with higher values being better. *AGFI* ≥ 0.90 is good fit, while ≥ 0.80 ≤ 0.90 is marginal fit.	0.845	marginal fit

AIC – Akaike information criterion; *CAIC* – consistent Akaike information criterion
Source: Authors' own processing

but overall, it can be said that the value of the fit of the measurement model used in the conducted research is good (good fit).

Interpretation of the SEM model analysis results for IPPF. Based on the results of the analysis in testing the assumptions given in Table 2, Table 3, and Table 4, a further analysis of the SEM model was carried out. Based on the results of the analysis, the AMOS output results of the SEM model of sustainable integrated plantation polyculture farming are given in Figure 3.

Furthermore, based on the path coefficient values of the structural equations in Figure 3 along with their significance levels, the results are presented in Table 5.

Factors influencing the IPPF sustainable development model. Based on the results in Table 5, the structural equations of the factors that influence the sustainable IPPF in the Tasikmalaya Regency can be formulated as follows:

$$Y_1 = 0.21X_1 + 0.21X_2 + 0.18X_3 + 0.07X_4 + \\ + 0.12X_5 + 0.23\,X_6;\ \text{for}\ R^2 = 0.51 \quad (2)$$

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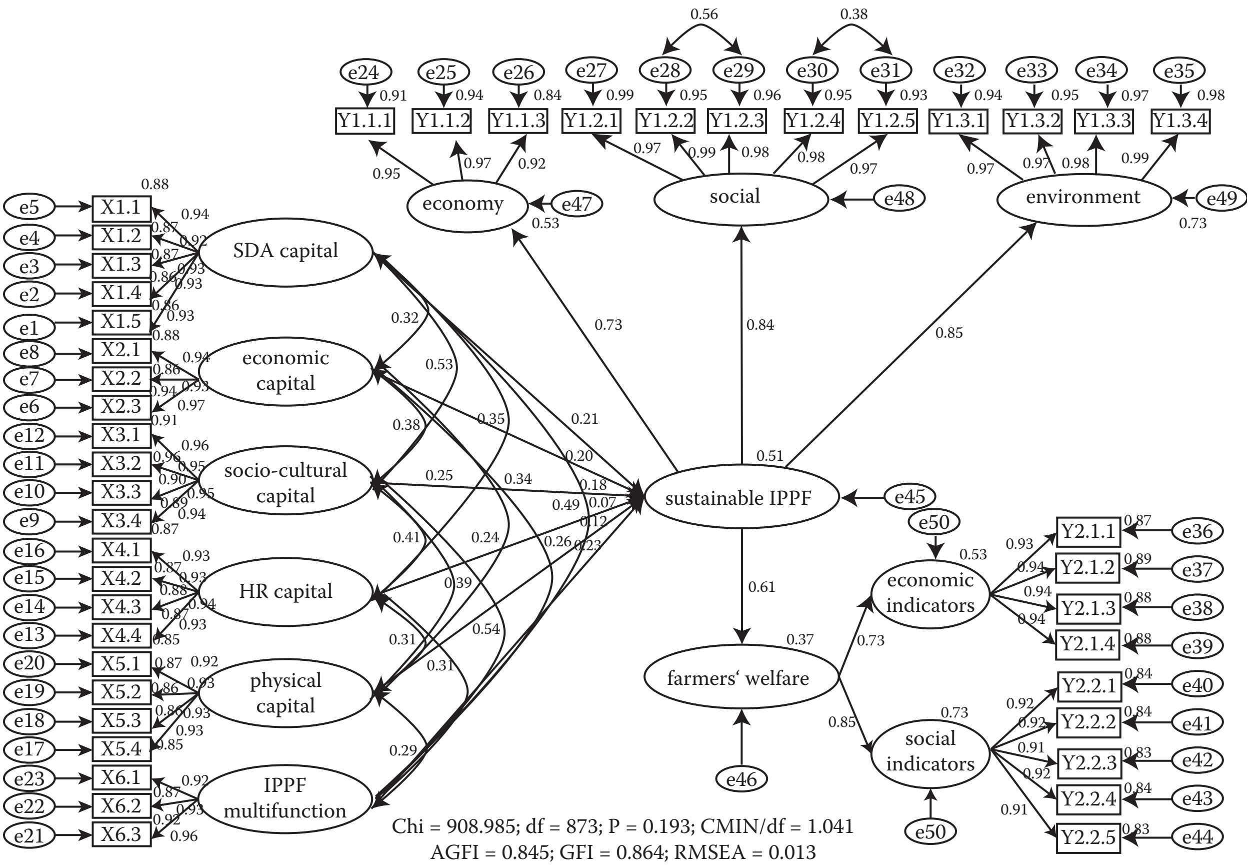

Figure 3. Results of SEM model analysis for sustainable development of IPPF

SEM – Structural Equation Modeling; IPPF – integrated plantation polyculture farming
Source: Authors' own processing

Based on the results in Figure 3 and Table 5, the equations that have been obtained have answered the first hypothesis. Where the first hypothesis states that the potential capital for the agricultural development, namely the natural resource capital (X1), economic capital (X2), socio-cultural capital (X3), physical capital (X5), and IPPF multi-functionality (X6), either jointly or individually have a partial effect on the sustainable IPPF (Y1). Simultaneously, the influence of these five variables on the sustainable IPPF in the Tasikmalaya Regency is 51%. This shows that the data performance that can be explained by the existing model is 51%, while the remaining 49% is explained by other variables not included in the model. The influence of the five variables is direct, while the largest influence based on the standardised regression coefficients (β) is the multi-functionality variable IPPF (β = 0.23), natural resource capital and economic capital (β = 0.21), socio-cultural capital (β = 0.18), and physical capital (β = 0.12).

The only potential capital for agricultural development that has no effect is human capital. This is due to the condition of the HR capital data consisting of indicators of health, education, experience and regeneration showing relatively homogeneous data.

Table 5. Direct and indirect effects between research variables

Variable	Direct		Indirect		Total	
	Y1	Y2	Y1	Y2	Y1	Y2
X1	0.21**	–	–	0.13	0.21	0.13
X2	0.21**	–	–	0.12	0.21	0.12
X3	0.18*	–	–	0.11	0.18	0.11
X4	0.07tn	–	–	0.04	0.07	0.04
X5	0.12*	–	–	0.08	0.12	0.08
X6	0.23***	–	–	0.14	0.23	0.14
Y1	–	0.61***	–	–	–	0.61

tnnot real; *real; ***very real; ****P*-value below 0.001; X1 – natural resources capital (SDA); X2 – economic capital; X3 – socio-cultural capital; X4 – human capital (HR); X5 – physical capital; X6 – multifunction IPPF; IPFF – integrated plantation polyculture farming
Source: Authors' own processing

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IPPF is a hereditary business, so the experience and knowledge of IPPF are relatively the same. This is indicated by the average experience of implementing IPPF is around 21 years, and 70% get knowledge about IPPF from parents. This is also the case with education, most of which are elementary school graduates. These results indicate that the human resources of farmers do not affect the agricultural sector because the knowledge and experience of farmers is still limited to the business actors in the field of agriculture (on the farm). The human resources of farmers have not been able to become business actors who think comprehensively with the agribusiness paradigm from upstream to downstream whose production process is driven by the market demand, value added development, efficiency and others. Thus, business actors have not been able to become the main driver of IPPF agribusiness. This affects the income and ultimately affects the development of the business. Although it does not have a significant effect, as shown in Figure 3 and Table 5, the HR capital affects the sustainable IPPF indirectly, namely through other development capital.

DISCUSSION

IPPF multifunctionality. Based on the results in Figure 3 and Table 5, the first factor that has the strongest influence on the IPPF is reflected by the three observed variables (manifests) in the form of economic (Y1.1), social (Y1.2), and environmental (Y1.3) ones. Based on the obtained results, it is stated that the environmental (λ = 0.96), social (λ = 0.93), and economic (λ = 0.92) ones are strong determinants of the latent variables of IPPF. Thus, for the environmental, social, and economical variable, they have the greatest potential for the formation of IPPF. The results of the analysis of the SEM model show that the factor loading coefficient of the IPPF multi-functionality contribution is positive. If the value of the environmental, social, and economic contribution to IPPF is higher, the higher the level of sustainability of the IPPF in Tasikmalaya. This is in line with the multi-functionality of IPPF which has excellent performance in line with the plant canopy growing well with the preserved biodiversity and large green areas so that the incidence of erosion and flooding is reduced. Thus, the role of multifunctionality of farming has an influence on the sustainability of agricultural development.

The environment is the variable that most reflects the IPPF in a sustainable manner (λ = 0.96). The performance of the environmental dimensions in the IPPF multifunctionality is very good. This is based on the fact that the planting of perennials that follow the hilly contours of the land forms the highest to the lowest strata so as to form a well-structured and beautiful canopy (Herzberg et al. 2019; Zhang et al. 2020). IPPF farmers generally plant perennial/annual crops that have different growth periods and phases. Thus, it can form a canopy architecture and varied plant heights accompanied by preserved biodiversity and large green areas (Doanh et al. 2018; Trisurat et al. 2019; Sasaki et al. 2021). Besides looking beautiful, the planting pattern also plays a role in reducing the incidence of flooding and erosion. The beautiful scenery accompanied by hilly contours with winding road conditions attracts newcomers to take a break and enjoy the beauty of nature. The natural scenery offered is in the form of a green area that stretches from the IPPF landscape, because, besides being beautiful, it also provides comfort and freshness of the air.

The social dimension is also a variable of the multifunctionality of IPPF which reflects a sustainable IPPF (λ = 0.93). The significant effect corresponds to the social dimension of the multi-functionality of the IPPF. This shows a very good performance from a social perspective. IPPF farmers have long experience in implementing IPPF, with an average of more than 21 years. IPPF is a farmer's business that has been passed down from one generation to the next, which has developed into a common norm as local wisdom (Kurnia et al. 2022). The development of location-specific innovations and/or local wisdom is also an option so that the innovations developed are easier to adopt. The decision to develop location-specific innovations and incorporate local wisdom was made because the farmers were already familiar with these practices and had a better understanding of their benefits The IPPF cropping pattern is a local wisdom because it is the result of a long journey from the adaptation process of farming to various factors such as the climate, soil, and economy and culture. Thus, IPPF has become a value system for the life of the dry land community that is integrated with religion, culture and customs. In addition, IPPF is not only an effort to earn income and protect the environment but also has a high social function as a space for farming activities, a participation space and a farmer group activity space.

The economic dimension of the multi-functionality of IPPF is also a variable that reflects the sustainable IPPF (λ = 0.92). This is a reflection of the economic dimension that shows good performance. This can be seen from the activities of the IPPF which have succeeded in increasing job opportunities, and the farmers' incomes have become more varied, continuous and stable. IPPF is a farming business that requires a great deal of labour.

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This is caused by cultivating more than one commodity of agricultural crop, including livestock businesses, so as to be able to create more job opportunities both on and off the farm. The IPPF cropping pattern has succeeded in providing stability, continuity and variability in the farmers' income, which is obtained from woody plants, plantation crops, horticultural crops, food crops and goats. However, the results of IPPF are not only used to meet the food needs of farmers and their families, but also to meet the social and commercial interests including environmental services.

Natural resources capital. Based on the results in Figure 3 and Table 5, the natural resource capital (X1) is the second factor that affects the IPPF, which is reflected by the observed variables (manifest), namely the land (X1.1), water (X1.2), vegetation (X1. 3), soil fertility (X1.4), and forage (X1.5). Land (λ = 0.94) is the indicator that most strongly reflects the capital, vegetation (λ = 0.93), soil fertility (λ = 0.93), forage (λ = 0.93), and water (λ = 0.92) variables. Thus, the influence of the land, vegetation, soil fertility, forage, and water have great potential to increase the sustainable IPPF in Tasikmalaya Regency. The direction coefficient shows a positive sign which means that the higher the natural resource capital, the better the natural resource management will lead to an increase in the chances of IPPF sustainability. This significant influence is in line with the performance of the SDA capital, which is in the very good category.

This shows that natural resource conservation can support the creation of a sustainable IPPF. In ecological studies, polyculture is in line with conservation efforts or efforts to protect the ecological stability (Weißhuhn et al. 2017; Morash et al. 2019). Patterned polyculture means trying to maintain a stable microclimate, strengthen the soil structure, maintain soil fertility, reduce the rate of water runoff so as to reduce the potential for surface soil erosion, and further help regulate the groundwater and maintain biodiversity (Cook-Patton and Agrawal 2014). Polyculture has similarities with natural forests related to the composition of vegetation, the influence on soil conditions and natural conditions (Mortenson et al. 2019). The most important aspect of vegetation is the arrangement of the canopy in layers, the types of plants, and the undergrowth. Meanwhile, the soil component contains the physical properties of the top layer, the ability of the polyculture system to maintain macro-fauna life and activities, maintain the stability and continuity of the pore space and encourage high water conductivity or infiltration rates.

The dimension of land in the SDA capital is also a variable that reflects the sustainable IPPF (λ = 0.94). This is a reflection of the environmental dimensions that show excellent performance. In addition, for the activities of terraces on hilly land and steep slopes, it has succeeded in reducing erosion so that it can maintain the depth of the topsoil.

The dimension of the vegetation in the natural resource capital that has good performance is also a variable that reflects the sustainable IPPF (λ = 0.93). The research location has avoided the risk of erosion, because one of the activities of the IPPF is to provide cover vegetation which, at the same time, increases the availability of soil organic matter to improve the physical properties of the soil through the decomposition process.

The dimension of the soil fertility in the natural resource capital has very good performance, which is one of the variables that reflects the sustainable IPPF (λ = 0.93). The soil fertility in the IPPF can increase, because the source of nutrients is obtained from organic matter sourced from livestock manure and leftover feed that has not been eaten. This source of organic material can be used to manufacture organic fertilisers that can be applied to cultivated agricultural crops. Thus, the nutrient needs of polyculture crop commodities can be fulfilled which, in turn, can support their sustainability.

The dimension of water in the SDA capital shows good performance, reflecting the sustainable IPPF (λ = 0.93). Cultivation of sheep/goats at the IPPF is met for forage needs from plants developed with a polyculture system. Thus, these plants can ensure the availability of forage for livestock on an ongoing basis.

The dimension of water in the SDA capital that has good performance, which is a variable reflecting the sustainable IPPF (λ = 0.92). The polyculture planting system in the IPPF, which cultivates seasonal and annual crops, has increased the process of absorption of water into the soil during the rainy season and releasing it slowly through spring in the dry season.

Economic capital. The economic capital (X2) is the third factor that has a significant effect on the sustainable IPPF. The economic capital reflected by the observed variables (manifest) are the cash (X2.1), credit (X2.2), and savings (X2.3). The savings (λ = 0.97) is the indicator that most strongly reflects the variable of economic capital, followed by the cash (λ = 0.94) and credit (λ = 0.93). Thus, the effect of savings, cash, and credit has the potential to increase the sustainable IPPF in Tasikmalaya Regency.

The direction coefficient shows a positive sign which means that the higher the economic capital increases, the more sustainable the IPPF will be. Economic capital performance seen from the dimensions of cash, credit, and

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savings obtained a good level of performance. The economic capital of IPPF provides opportunities for farmers to earn cash and increase their ability to pay credit (Riaz et al. 2012). In addition, economic capital can increase the opportunity to have savings by cultivating various agricultural commodities and livestock businesses. In other words, the economic capital can support the creation of a sustainable IPPF (Arvidsson Segerkvist et al. 2020).

The cash dimension in the economic capital that has good performance is a variable to reflect the sustainable IPPF (λ = 0.94). The condition of the land planted with various types of plants with highly varied plant ages allows farmers to harvest at any time. From the seasonal calendar, it can be seen that, every month, farmers can harvest coconut and woody plants. The harvesting of rice crops takes place from March to May. Meanwhile, the corn harvest is from September to November, and the Durian harvest starts in December and continues from January to March with the peak harvest occurring in February. The banana harvest takes place from May to August with peak production occurring in June and July. The mangosteen harvest occurs in September to December. Thus, the sustainability of IPPF can be guaranteed because farmers generally have cash to meet the cost of farming, both for the purchase of seeds/seedlings, animal feed, fertilisers, medicines for livestock, pesticides, including enough money to pay for labour costs and for family consumption.

The dimension of the savings in the economic capital that has good performance is a very large variable to reflect the sustainable IPPF (λ = 0.97). The sustainable income of farmers from the IPPF mentioned above has increased the farmers' ability to save. In addition to savings in the form of money in the bank, IPPF farmers also have savings in kind, namely sheep or goats and woody plants that can be used when there is an urgent need.

The credit dimension on the economic capital that has good performance is a variable to reflect the sustainable IPPF (λ = 0.93). The credit facilities available in Tasikmalaya Regency are adequate, and farmers are able to optimise the available credit facilities. However, the available credit facilities have not come from formal banking, but most of them (70%) are obtained from the collectors and dealers of the IPPF production which are paid at harvest time. In addition, farmers also get loans from fellow farmers and from relatives (family).

Socio-cultural capital. Socio-cultural capital (X3) is the fourth factor that affects the integrated plantation polyculture farming. Socio-cultural capital is reflected by the observed variables (manifest), namely the institutional (X3.1), mutual trust (X3.2), cooperation (X3.3), and norms (X3.4). Institutional (λ = 0.96) is the indicator that most strongly reflects the variables of the socio-cultural capital, mutual trust (λ = 0.95), cooperation (λ = 0.95), and norms (λ = 0.94). Thus, the influence of the institutions, mutual trust, cooperation, and norms have the greatest potential to increase the integrated plantation polyculture farming in Tasikmalaya Regency. The direction coefficient shows a positive sign which means that the increasing socio-cultural capital causes the IPPF to be more sustainable. The performance of the socio-cultural capital in the IPPF has a good performance. The good cooperation of all parties involved, who trust each other in accordance with the prevailing norms in society and institutions, is required to support the sustainability of IPPF.

The institutional dimension of the socio-cultural capital that has good performance is a very large variable to reflect the sustainable IPPF (λ = 0.96). The performance of the socio-cultural capital on the institutional dimension shows good performance as reflected in the active participation of the farmer groups and Combined Farmers Group to seek information which is then conveyed to the farmers (Włodarczyk-Marciniak et al. 2020; Bulitta and Duguma 2021). In addition, farmer groups and the gapoktans have provided marketing facilities and collaborated with other parties to facilitate the capacity and ability of the farmers. The IPPF farmers in the research locations, in addition to acquiring knowledge and skills from generation to generation, also acquired IPPF knowledge and skills from farmer groups. This is because farmer groups have regular group meetings and are accompanied by Field Extension Officer.

The dimension of mutual trust in the socio-cultural capital that has good performance is a variable to reflect the sustainable IPPF (λ = 0.95). The dimension of mutual trust has good performance because it is farmers who always try to comply with the agreements that have been agreed upon and always convey information in accordance with reality. The attitude of mutual trust is manifested by the IPPF farmers by always respecting each other among the members of the farmer group. In addition, mutual care and honesty are built between farmers on the basis of cooperation to achieve shared hopes and goals.

The dimension of cooperation between farmers on the socio-cultural capital that has good performance is a variable to reflect the sustainable IPPF (λ = 0.95). Cooperation between farmers is the best indicator in the socio-cultural capital which includes cooperation both internally and externally. IPPF farmers in the research location have social piety which is manifested in the form of helping each other and prioritising the

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interests of others (altruism). In addition, IPPF farmers always share information and help each other with other farmers. The nature of this gotong royong which refers to a communal spirit of mutual cooperation and assistance, is built on a consistent commitment to social ties which are very important to establish cooperation for the sustainability of IPPF.

The norm dimension on the socio-cultural capital that has good performance is a variable to reflect the sustainable IPPF (λ = 0.94). The IPPF farmers have the attitude and obedience of the farmers in religion, the attitude of helping each other with other farmers who are experiencing problems and the attitude and obedience of the farmers to the mutually agreed rules, which simultaneously supports the sustainability of IPPF. Norms both written and unwritten, which are in accordance with religious rules, local wisdom (local culture and rules made together in farmer groups, are always adhered to by IPPF farmers, which are aimed not only for economic interests, but also for protecting the environment (Arifiani et al. 2019).

Physical capital / infrastructure. Physical capital/ infrastructure (X5) is the fifth factor that affects the integrated plantation polyculture farming. The physical capital reflected by the observed variables (manifest) are technology (X5.1), transportation (X5.2), communication (X5.3), and information (X5.4). Communication, transportation and information are the indicators that are equally strong reflecting the variables of the physical capital/infrastructure (λ = 0.93), followed by technology (λ = 0.92). Thus, the influence of communication, transportation, information and technology has great potential to increase the sustainability of IPPF in Tasikmalaya Regency. The direction coefficient shows a positive sign which means that the increasing physical capital/infrastructure can further increase the sustainability of IPPF in Tasikmalaya Regency. The performance of the physical capital/infrastructure is in a good category, which indicates that communication, information, technology and transportation in Tasikmalaya Regency support the development of IPPF so that it can be sustainable.

Although the location of the IPPF is relatively far from the highway so that transportation access is relatively difficult, but with improvement in the communication system via mobile phones, it is not difficult for IPPF farmers to communicate so that they can easily get the needed information, including those related to cultivation technologies and processing of IPPF results. This is in line with the results of research by Haileslassie et al. (2016) which states that the infrastructure is very influential on the smoothness of farming systems in dry land, as well as the results of research by Caffaro et al. (2020) which states that ease of communication determines the speed of information and the farmers' level of technology adoption.

The communication dimension on the physical capital/infrastructure that has good performance is a variable to reflect the sustainable IPPF (λ = 0.93). Currently, communication facilities have become a basic need for the community, including IPPF farmers, almost all of whom have mobile phones. IPPF farmers can communicate with each other between farmers and with other parties, making it easier for farmers to get the required technology/innovation information, obtain production facilities and to check price information before selling their IPPF results. The transportation dimension in the physical capital/infrastructure that has good performance is a variable to reflect the sustainable IPPF (λ = 0.93). Although the location of the IPPF is relatively far from the highway, the road conditions are adequate for various modes of transportation, both two-wheeled and four-wheeled, as a medium for transporting farm inputs and outputs to support the sustainability of IPPF.

The dimension of information on the physical capital/infrastructure that has good performance is also a variable to reflect the sustainable IPPF (λ = 0.93). IPPF farmers get the information they need from agricultural extension officers, farmer group administrators, fellow farmers and assistants from universities. Farmer groups in the research location have succeeded in becoming a source of information and technology for their members so that they can increase the productivity, income and create a better life for their members. Thus, it is easy to get information, IPPF farmers become more innovative and adoptive to technological changes. This suggests that people who are actively seeking new information and ideas are usually more innovative than people who are passive, let alone sceptical (do not believe in something new).

The technological dimension of the physical capital/ infrastructure that has good performance is also a variable to reflect the sustainable IPPF (λ = 0.92). The continuous improvement of an integrated polyculture technology for plantation crops and livestock carried out by IPPF farmers is a driving force for IPPF sustainability, especially in the use of goat and sheep livestock waste as compost for polyculture crops and the use of IPPF forage as animal feed. However, IPPF farmers stated that they still need guidance and assistance to improve their mastery of technologies for processing livestock waste

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into organic fertilisers. Until now, farmer groups and the gapoktans have been able to become a source of technology for farmers which they get from agricultural extension officers and assistants from universities.

The effect of the sustainable IPPF on the welfare level. The second hypothesis about the effect of sustainable IPPF on the welfare of IPPF farmers is answered by first making a structural equation based on Figure 3 and Table 5 as follows:

$$Y2 = 0.61Y1,\ R^2 = 0.61 \quad (3)$$

Based on Figure 3, Table 5 and Equation 3, it is known that sustainable IPPF significantly affects the level of welfare of the farmers in Tasikmalaya Regency, at a confidence level of 99% and R^2 at 61%. This means that the more sustainable the IPPF, the better the level of welfare of the farmers. Where the integrated farming system of livestock crops has a positive effect on the welfare of farmers. The welfare of the community, in this case, the IPPF farmers, is the condition of meeting the material, spiritual and social needs of citizens so that they live properly and are able to develop themselves, so that they can carry out their social functions (Law No. 11 of 2009, concerning Social Welfare). Therefore, in this study, welfare is analysed with 2 (two) aspects, namely the economic aspect and the social aspect. Meanwhile, the concept of sustainable IPPF in this study refers to the concept of sustainable development which consists of three dimensions, namely economic, social and environmental dimensions.

The performance of the sustainable IPPF in Tasikmalaya Regency is in the good category. All the dimensions that make up the IPPF's sustainability performance, namely the economic, social and environmental dimensions are also in the good category, even the environmental dimension is in the very good category. Thus, it can be stated that the IPPF in Tasikmalaya Regency has: *i*) taken good care of the environment, so as to reduce the risk of erosion, landslides and floods; *ii*) provide income that can meet al. the farmers' expenses, both for the production costs and family consumption, on an ongoing basis; and *iii*) maintain and pass on local wisdom (local culture) to the next generation from the previous generations. This is carried out based on the IPPF norms which manage land for income while maintaining the environment and local values. In addition, IPPF has succeeded in making its farmers prosperous, both economically and socially. Based on the description of the variable the Sustainable IPPF Performance in Tasikmalaya Regency for the good category, it shows that the values of these variables are above the average or expected level. Meanwhile, the very good category means that the values are far above the average or expected level.

CONCLUSION

The sustainable IPPF in Tasikmalaya Regency in this study was theoretically designed, farmers were surveyed and then the data were analysed using a SEM analysis. Based on the results of the SEM analysis, it was concluded that from the 5 (five) potential development capital categories, namely the natural resource capital, economic capital, socio-cultural capital, human capital and physical capital (infrastructure), only human capital had no significant effect on the sustainable IPPF, while the other development capital categories had a significant effect. Meanwhile, the multi-functionality of the IPPF also had a significant effect on the sustainable IPPF. Furthermore, it was also shown that the sustainable IPPF had a significant effect on improving the welfare of the farmers. The IPPF model for the welfare of the farmers was carried out through the development of specific local superior commodities, increasing the added value and cooperation, developing access to credit, the regeneration of the farmers, sustainable assistance and infrastructure improvements. The gap between the research conducted and previous research that has been carried out lies in the IPPF development model in Tasikmalaya Regency by conducting a comprehensive analysis. Based on previous research, the research that has been conducted had not analysed the factors that have a comprehensive influence on the development of integrated polyculture plantation farming.

The limitation of this research is that it had not used the Penta Helix approach among government, academia, industry, non-governmental organisations in developing collaborations and partnerships on the sustainable IPPF model. Therefore, for future researchers, it is necessary to include other variables that are not included in this study. Of course, we hoped that the additional variables will affect the sustainability of IPPF, such as government policies, as well as the addition of indicators for each social capital. In addition, we hope that further researchers can develop a Penta Helix approach among government, academia, industry, non-governmental organisations in developing a sustainable IPPF model. This certainly can encourage collaboration and beneficial partnerships between the multiple parties. The implications of this research are expected to contribute to the literature on sustainable IPPF by providing a comprehensive anal-

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ysis of the factors that influence the multi-functionality and welfare of the farmers involved in IPPF. Apart from that, this research can provide practical recommendations for sustainable IPPF development in Tasikmalaya Regency. For the society, this research has social implications for improving the quality of life and the environment of IPPF farmers and the surrounding community.

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