A one health exploration of the reasons for low cocoa productivity in West Sulawesi

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ABSTRACT

We conducted an interdisciplinary One Health study of potential links between agricultural, health and associated livelihood factors on the livelihoods of smallholder cocoa-growing families in West Sulawesi. Our 2017 survey of 509 cocoa smallholder family members in 120 households in Polewali-Mandar District, West Sulawesi, Indonesia showed that farmers face many challenges to improving their livelihoods, including land management, agricultural practices, nutrition and human health, animal health, aging and demographic changes. Price fluctuations, limited access to capital and poor health deterred farmers from applying agricultural inputs and resulted in levels of low cocoa production (275 kg/annum per household). While market demand for live goats in the region is substantial and expected to increase, uptake of mixed farming with goats by smallholders was low. However, most households kept chickens. Bank accounts were held by 31% of households. Inadequate sanitation and unsafe water were reported in > 50% households. Anthropometric measures showed that 42% of children under five years were significantly stunted and 32% of women were overweight. Joint, back pain and blurry vision were reported by 30% of adult respondents. High blood pressure contributed to complications in 20% of pregnancies. Primary health care provided by district health services mainly focuses on maternal and child health, leaving chronic health problems such as Type 2 diabetes, cataracts, arthritis and mental illness underdiagnosed, and if diagnosed, with inadequate treatment. Availability of food was a source of worry for 58% of households with 63% reporting limited food variety. Dietary diversity was low with an average of four out of ten food categories consumed in each household. Positive correlations were recorded for household cocoa productivity, land size, dietary diversity and perceptions that food availability and variety was sufficient. The results showed that an integrated One Health approach provides deep understanding of priority areas for improving livelihoods.

1. Introduction

Cocoa farming in Indonesia is no longer considered viable after reaching its peak in a late 20th century, largely driven by smallholder farmers in Sulawesi [1]. The main reasons for the decline in productivity since 2011 were put down to aging trees, high losses to pests and disease, exhaustion of soil fertility and the failure to adopt good agricultural practices (GAP) [2]. In addition, poorly funded provincial extension services failed to reach many farmers. The national government and industry responded to low productivity with the GERNAS program that included farmer training initiatives and improved planting materials [3] but cocoa production continued to decline [4,5]

suggesting that other factors might be in play.

This research used an integrated One Health Framework [6] to better identify the connections between factors that impact on productivity such as farmer vulnerability to poor health caused by unclean water sources, poor sanitation practices and associated diseases as well as the double burden of under and over-nutrition caused by poor diets and lifestyle [7,8]. The conventional disciplinary-silo approach to research does not easily address the complex challenges presented by interacting environmental, animal and human health systems. Rather, a One Health interdisciplinary team approach allows the disciplines (agriculture, health, economists, veterinary and social scientists) to bring different perspectives and create new knowledge [9].

Table 1
One health (integrated) research framework for investigating low productivity.

Farming	Potential Plant and crop factors	Potential Animal factors	Potential Human Health factors	Potential Human behaviour/susceptibility factors
Cocoa production	Plant management Farm management Number and size of blocks Water sources Pests/diseases Soil management and nutrient supply Market volatility Food security	Disease vectors (mosquitoes) Domestic animals Chickens Higher value livestock (goats, cattle) Wild animals	Tuberculosis Respiratory diseases Non Communicable Diseases Communicable diseases Restrictive joint pain (arthritis) Unknown health issues	Incentives to increase production Price volatility Fortress crop Labour availability Youth exodus to towns Education Access to finance Farmer knowledge Family size

Many uncertainties relating to the cause of low production of cocoa – need evidence to explore the possible factors associated with poor cocoa production.

Conceptualising cocoa farmer productivity using an integrated research approach highlights the many uncertainties associated with cocoa productivity (see Table 1).

The relationship between the health of soils, plants, humans and animal has long been recognised as "one and indivisible" [10] (p. 9), but research methods addressing this interdependency are relatively recent [11,12]. Terms such as One Health, Eco-health and Planetary Health, while expressed differently, have similar characteristics: (i) a close engagement with the communities of interest; (ii) multi-disciplinary, transdisciplinary or interdisciplinary collaborations; (iii) a systems approach; (iv) gender equity and (v) sustainability and knowledge transfer [13]. Table 1 is a research framework showing the inter-relatedness of the health of soil and crops, humans, livestock and the environment [14,15] as well as economic status. Reduced soil organic matter on farms [16] impacts nutrient availability and plant health, which in turn affects animal and human nutrition. Weakened plants, including tree crops, due to poor soil nutrition or aging, increase vulnerability to pest/diseases and leads to crop losses [17,18].

Studies confirm the relationships between livelihoods, education and human health; between poverty and poor health, inadequate diets and unregulated livestock practices [11,18–21]. Poor childhood nutrition leads to stunting and inhibits cognitive development and education. Human health limitations have a direct effect on work productivity. The WHO estimates that Indonesians lose 33,131 disability-adjusted life years (DALYs) of productive work time due to infectious diseases, maternal and childhood diseases, non-communicable diseases (NCDs) and injuries per 100,000 people [22]. Cocoa-growing relies on a high input of labour. In Papua New Guinea, for example, labour constitutes almost half of the cost of cocoa production (Grant Vinning, pers. comm.). In Indonesia, implications as a farmer ages include labor shortages.

This current research investigates multiple factors that have the potential to impact on cocoa productivity – family health status, food availability, nutrition and dietary habits, as well as water sources, sanitation and housing. We used surveys and key informant interviews to identify critical constraints to the livelihoods of smallholder cocoa farming households in Polewali-Mandar District, West Sulawesi.

2. Methods

Developing a meaningful engagement with the cocoa community in West Sulawesi was the first step and a main principle in our research. Meetings with the village leaders and interested community members were held to ask questions about their livelihoods. In addition, we met with the Departments of Health and Agriculture and Marine Resources and as well talked with village health volunteers ("Kader Posyandu") and extension officers. Agreement was reached at these initial meetings about the research methods including the administration of a livelihood survey and interviews with key informants.

2.1. Study population

Cocoa is a vital farm product of West Sulawesi, including the District of Polewali-Mandar that consists of 16 sub-districts, 167 villages and approximately 93,000 households, averaging four to five members in each. The average population density is 203 people/km^2. Each village consists of a number of hamlets. Ethnicity is mainly Mandar, with some Bugis and Pattae.

2.2. Sample selection

We used multi-stage sampling in Mapilli and Anreapi (Fig. 1), two sub-districts in Polewali-Mandar (Polman). These were selected because they have large cocoa farming populations with variable access to transport and health services. Two villages in each sub-district were then selected based on the criteria that the income of the majority of the households was generated by cocoa farming, and that the two villages varied in terms of accessibility to local towns (Polewali and Wonomulyo). Prior to data collection, a list of every household within each sub-village from the four selected villages was obtained from village officials or the local statistical bureau (BPS) in order to generate a sampling frame. Household numbers in each village are shown in Table 2. A computer-automated randomisation process was applied to select the households to be interviewed.

The exhaustive sampling method included all the sub-villages/hamlets in each selected village and finally 120 households, distributed approximately equally between the four villages, were selected for the survey (Table 3). In each household, men > 15 years, women 15–49 years and children were interviewed and/or measured for anthropometric data.

2.3. Data collection

Prior to data collection, approval letters from provincial and district levels of government were obtained. Human ethics approval was given by the respective ethics committees of the Universities of Sydney and Hasanuddin. The core team visited villages and local government officials to inform them about the aims of the project. A consent information sheet was read to the farmer and verbal consent obtained prior to the interview. The survey captured responses to questions on health and livelihood on Samsung tablets using CommCare™ software, requiring discrete, quantifiable responses. Digitalised responses were uploaded by CommCare™ in real time into a secure server.

2.4. Health and livelihood survey

The health and livelihood questionnaire administered in Sulawesi was previously developed, piloted and completed in a 2017 survey of 6275 cocoa farmers in Bougainville, Papua New Guinea [23]. The questions in this health and livelihood survey for cocoa farmers were extracted from three questionnaires validated for low resource
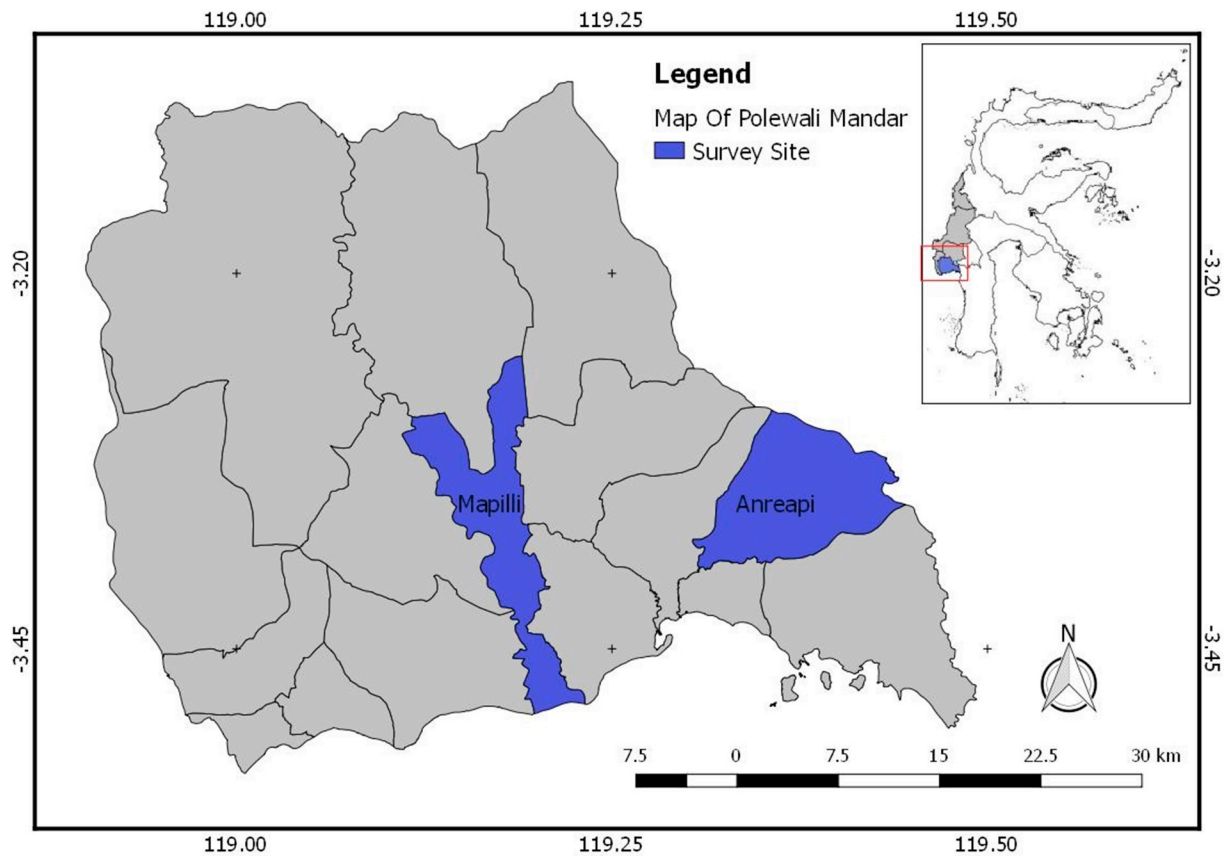
Fig. 1. The two subdistricts in Polewali-Mandar District included in the study.

Table 2
Total number of households in each of the four study villages from which random samples were selected.

Sub-district	Village	Sub-village (Dusun)	# Households
Anreapi	Duampanua	4	672
	Kelapa Dua	5	458
Mapilli	Landi Kanusuang	6	462
	Sattoko	4	146
Total		19	1738

countries: UNICEF Multiple Indicator Cluster surveys, the USAID Demographic and Health survey and the World Health Organization survey. Each question was reviewed for context, relevance and terminology, and modified as needed. Further, additional agricultural and cocoa questions were developed and incorporated. The questions were reviewed for context and relevance to the population of cocoa famers in West Sulawesi. The questionnaire was translated into Bahasa Indonesia and piloted with a small number of respondents and minor adjustments were made for clarification. The questionnaire was administered to the 120 households distributed between four villages Duampanua (28), Kelapa Dua (31), Landi Kanusuang (32) and Sattoko (29).

The questionnaire comprised sections for Household; Men (15 years

Table 3
The study targeted two cocoa-producing subdistricts by surveying a random sample of households in four villages.

Level	Selection method	Criteria	Selected
District (Kabupaten)	Purposive	Based on cocoa industry production	1 District: Polewali-Mandar (Polman)
Sub-district (Kecamatan)	Purposive	Major cocoa farming areas within Polman district	2 Sub-districts: Anreapi Mapilli
Village (Desa/ Kelurahan)	Purposive	Household population mainly work as cocoa farmers with variable access to transport or public facilities	4 Villages: Duampanua Kelapa Dua (less accessible) Landi Kanusuang Sattoko (less accessible)
Sub-village (Dusun)	Total sampling	All sub-villages covered	All sub-village (dusun) selected within the 4 villages
Household	Proportional random sampling	All households in each village have equal chance to be selected	Total of 120 HH selected
Household Members	Total sampling	Data collected with all eligible members of the household	Men > 15 years Women 15–49 years Children < 5 years

+), Women (15–49 years), Children, Women (mothers') anthropometric data (15–49 years) and Children's anthropometric data (under 5 years). Data captured included income sources, land ownership, water sources, water storage and availability, hygiene and sanitation practice, diet, food security, health care utilisation, chronic health conditions, family history of morbidity/illnesses and level of education. The number of bags of dry cocoa beans (each containing approximately 64 kg) produced by each household in the previous 2.5 years was used to estimate the average annual cocoa harvest per household. In households that included young children (59 months or less), weight and height were measured for children and mothers. Anthropometric data collection for the under-fives included measuring MUAC (Mid-Upper Arm Circumference) to detect energy deficiency.

Dietary diversity was evaluated in the Household section of the questionnaire by allocating foods consumed by household members into ten categories (starchy staples, pulses, nuts/seeds, dairy products, meat/fish, eggs, dark green vegetables, vitamin A-rich vegetables/fruit, other vegetables, other fruit) and recording the total number of the food groups consumed regularly in the household. To evaluate perceptions about the sufficiency and variety of food available to each household and whether households used credit or loans to obtain food, respondents were asked if they were worried about availability of food, whether they had experienced food insufficiency for a day and night, if food variety was limited, if credit was used for food etc. and the responses were scored as 1, often; 2, sometimes, 3, rarely, and 4, never.

2.5. Analysing the survey data

The health and livelihood survey data were downloaded from the CommCare™ server and analysed using SPSS (IBM, Ver 19). Descriptive statistics, frequencies, percentages, Spearman's rank correlations and cross-tabulations were employed, in addition to one-way ANOVA and Levene's test of homogeneity. Tukey b or Games-Howell (for non-homogeneous data) post-hoc tests were applied to separate means. Chi-square tests were applied to assess the significance of deviations from expected distributions.

2.6. Key informant interviews with stakeholders

Semi-structured interviews were conducted with government staff responsible for delivering health and agricultural services, including seven officers at the Polewali-Mandar District Health Office (Dinas Kesehatan), eight in each of two community health centres (Puskesmas) and five at the District Agriculture Office (Dinas Pertanian). Veterinarians, representing both national and district governments and farmers practicing cocoa/goat mixed farming, as well as stakeholders in the goat value chain provided feedback on the potential of developing cocoa/goat mixed systems. Additional interviews were conducted with sustainability managers representing 10 cocoa trader/processors and international NGOs in partnership with smallholders and farmer co-operatives. Questions covered the constraints and opportunities faced by stakeholders and smallholder cocoa farmers. Verbal consent for participation was obtained and recorded manually. Interviews were conducted in Bahasa Indonesia or in English with the assistance of an interpreter. Data were extracted according to themes, common points and experiences or contrasting across the set of interviews, plus documentation of information obtained about the structure of service delivery and the market system.

3. Results

3.1. The Health and livelihood survey

3.1.1. Household characteristics

The median age of the household members across the participating households was 30, with 82% of the study population under 50 years of

Table 4
Family member sociodemographic characteristics. All age groups in 120 households were assessed (% in parentheses).

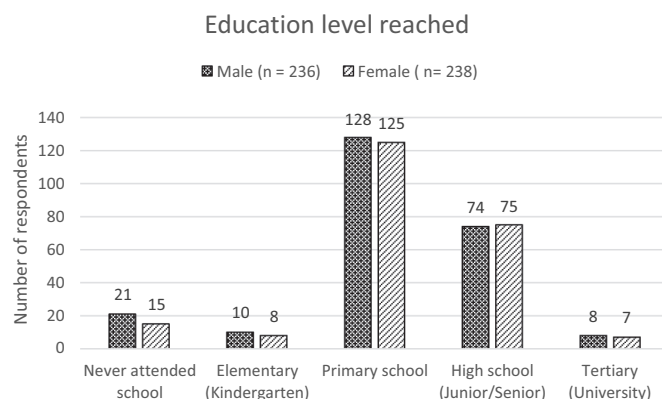| Cocoa farmer and family members sociodemographic characteristics	Male $n = 256$	Female $n = 253$	Total $n = 509$	p-value (X^2 test)
Age groups				
< 5 years	23 (9.0)	18 (7.1)	41 (8.1)	0.852
6–14 years	56 (21.9)	52 (20.6)	108 (21.2)	
15–49 years	132 (51.6)	134 (53.0)	266 (52.3)	
50–60 years	26 (10.2)	25 (9.9)	51 (10.0)	
> 60 years	19 (7.4)	24 (9.5)	43 (8.4)	
Age, Mean (SD) in years	29.5 (20.5)	30.5 (20.3)	30.2 (20.4)	0.932

Fig. 2. Highest education reached by respondents (> 5 years old), $n = 474$. Chi-square test (female/male), $p = .660$.

age and an equal gender distribution (Table 4). The proportion of family members under 5 and over 60 years was similar, comprising about 8% in each group.

Most respondents attended primary school, while only 35% attended high school (Fig. 2) with no significant gender difference.

While the criteria for selection in the study population was that the main source of household income was from cocoa, just over half of household members of working age made a living from cocoa. Some supplemented this with small businesses or trades (e.g. carpentry). Over one-third (36%) of respondents had no direct income and were dependent on household income from the farm (Fig. 3).

3.1.2. Human health and nutrition

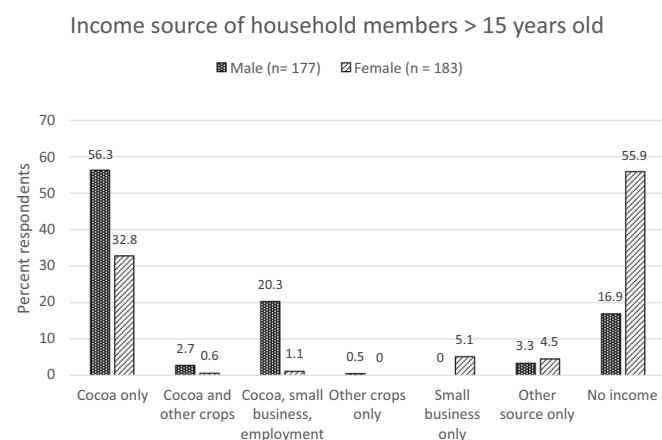Aches and joint pains, blurry vision and teeth problems were

Fig. 3. Income source of household respondents (%): males > 15 years old, females 15–49 years old. Chi-square (female/male), $p = .00$.

Table 5

Percentage of adult men (15+ years) and women (15–49 years) household members with health conditions in 4 villages.

| Health condition	Male (%) (n = 156)	Female (%) (n = 123)	Total (%) (n = 279)
Chronic illness /condition			
Ever diagnosed arthritis	1.9	0.8	1.4
Experiencing pain, aching, stiffness Or Swelling in or around the joint within 12 months	33.3	28.5	31.2
Experienced back pain	34.0	23.6	29.4
Experience cough > 3 weeks	6.4	6.5	6.4
Experienced chest pain	16.7	9.8	13.6
Experience tight chest, wheezing, hard to breathe	12.8	12.2	12.5
Diagnosed depression	1.3	0.8	1.1
Diagnosed diabetes	1.3	0.0	0.7
Diagnosed depression/mental health problem	1.3	7.3	3.9
Ever had eye exam	10.2	4.8	7.9
Diagnosed cataract from eye exam (male n = 16, female n = 6)	26.7	0	0.9
Experiencing blurry visions	33.3	22.0	28.3
Acute illness/condition			
Experience accident and injury within 12 months	12.8	5.7	9.7
Experienced mouth and teeth problems	20.5	26.8	23.3
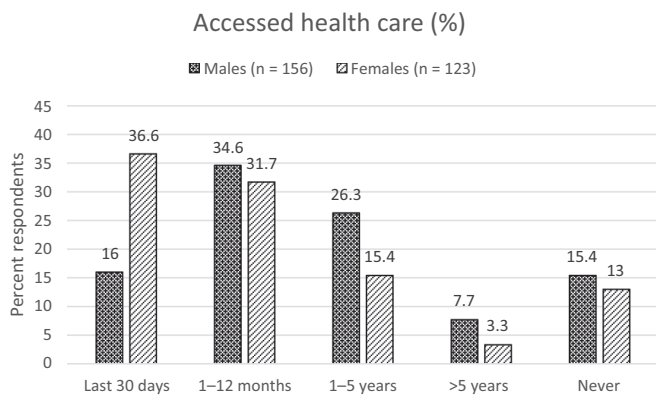
Fig. 4. Proportion (%) of household members (males, > 15 years old; females 15–49 years old) who accessed healthcare.
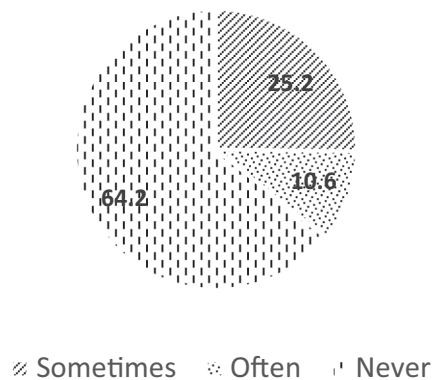

Fig. 5. Self-reported work time reduced among male respondents (%) due to physical health limitation (n = 156).

common in both men and women (Table 5), although a formal diagnosis of arthritis, depression, diabetes or eye health problems was rare. More women than men had accessed healthcare in the previous month, while 15% of all respondents had never accessed a healthcare service (Fig. 4). Health care was available to those who needed it for almost all respondents (98%). Work time on the farm was limited by health-

Table 6

Maternal and child nutritional status determined in mothers (15–49 years) and young children (0–59 months) in four villages.

Anthropometric data (mean)	Village				Total	p-value X^2 test
	D	K	L	S		
Women 15–49 years						
N	36	33	27	27	123	
Age in years	31.1	32.5	30.3	32.2	31.6	0.85
Height in cm	151.3	147.7	147.6	148.2	148.8	0.01
Weight in kg	54.2	50.2	51.6	51.5	52.0	0.39
MUAC in cm	27.2	26.6	27.0	27.4	27.0	0.81
Nutritional status (%)						
Underweight	8.3	21.2	7.4	7.4	11.4	0.78
Normal	55.6	48.5	63.0	63.0	56.9	
Overweight	19.4	12.1	18.5	11.1	15.4	
Obese I	5.6	12.1	7.4	11.1	8.9	
Obese II	11.1	6.1	3.7	7.4	7.3	
Chronic energy deficiency status (%)						
Chronic energy deficiency	13.9	21.2	3.7	7.4	12.2	0.17
Normal	86.1	78.8	96.3	92.6	87.8	
Children 0–59 months						
N	8	13	10	7	38	
Age in month	39.4	23.9	28.1	24.3	28.3	0.27
Height in cm	84.5	79.9	77.6	77.4	79.8	0.69
Weight in kg	11.1	10.2	9.2	9.5	10.0	0.64
MUAC in cm	15.1	14.6	13.7	14.7	14.5	0.37
Weight for age (%)						
Severely underweight	25.0	0	0	0	5.3	0.11
Underweight	25.0	7.7	30.0	28.6	21.1	
Normal	50.0	92.3	70.0	71.4	73.7	
Height for age (%)						
Severely stunted	25.0	0	10.0	28.6	13.2	0.04
Stunted	62.5	23.1	10.0	28.6	28.9	
Normal	12.5	76.9	80.0	42.8	57.9	
Weight for height (%)						
Severely wasted	0	7.7	0	0	2.6	0.57
Wasted	0	0	10.0	0	2.6	
Normal	100	92.3	90.0	100.0	94.7	
MUAC indicators (%)						
Severe acute malnutrition	0	7.7	20.0	0	7.9	0.55
Moderate acute Malnutrition	0	7.7	10.0	0	5.3	
Acute malnutrition at risk	0	7.7	20.0	14.3	10.5	
Normal	100	76.9	50.0	85.7	76.3	

MUAC = Mid-Upper Arm Circumference; D = Duampanua, K = Kelapa Dua, L = Landi Kanusuang, S = Sattoko.

Table 7
Number of households consuming each of 10 food types (or categories) on a regular basis in Duampanua (D), Kelapa Dua (K), Landi Kanusuang (L) and Sattoko (S) (%).

Food type	D	K	L	S	Total	p value (X^2 test)
N	28	31	32	29	120	
Starchy staples	68.8	65.6	65.6	67.6	66.9	0.99
Pulses	25.0	18.8	25.0	26.5	23.8	0.89
Nuts/seeds	21.9	28.1	28.1	44.1	30.8	0.24
Dairy products	18.8	3.1	15.6	11.8	12.3	0.25
Meat/fish	90.6	90.6	93.8	55.9	82.3	0.000
Eggs	25.0	18.8	25.0	26.5	23.8	0.89
Dark green vegetables	71.9	71.9	68.8	61.8	68.5	0.78
Vit A-rich vegetables /fruit	46.9	28.1	31.3	41.2	36.9	0.37
Other vegetables	15.6	21.9	34.4	38.2	27.7	0.14
Other fruit	43.8	31.3	40.6	31.3	36.2	0.56

related problems with high rates of absenteeism among 11% males (Fig. 5).

A total of 123 mothers and 38 children were surveyed and measured (Table 6). Overweight and obesity in adult females were high (32%), with no significant differences between villages.

> 25% of children were underweight, with the prevalence of stunting being 42% in the total sample (Table 6). The proportion of wasting among children was 5%, while acute malnutrition was higher (24%).

3.1.3. Diet

The number of food types, out of 10 food categories, regularly consumed in individual households was low but similar between the four villages (Table 7; Fig. 6); however, consumption of fish or meat in Sattoko was significantly lower than in the other villages (Table 7). Over half of the households regularly consumed green leafy vegetables, such as cassava leaf stew, but consumption of other vegetables, pulses, eggs, dairy products and fruit was low.

3.1.4. Cocoa yields

Table 8 shows cocoa production/household/per annum for each of the four villages. Production was generally very low, but significantly higher in Landi Kanusuang than Kelapa Dua. Cocoa production among individual households were extremely variable in all of the villages. While production in some households was negligible, a few produced over 2 metric tons per annum.

The average land holding for the whole sample was about 1 ha (Fig. 7). The vast majority of smallholders owned their land, and while cocoa provided the most important source of income, not all of the land was used for cocoa.
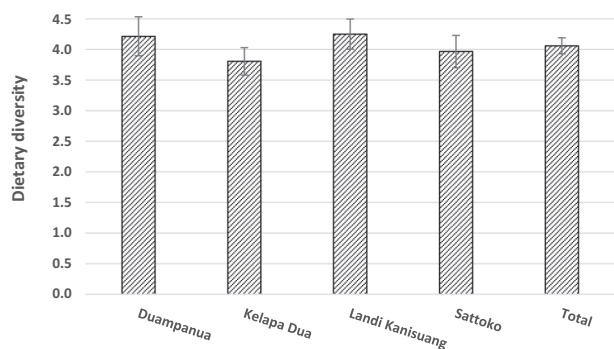

Fig. 6. Mean number of food types (out of ten categories) consumed by households (dietary diversity) in four villages ($n = 120$). SE is indicated by bars. No significant difference occurred between villages (ANOVA).

Table 8
Mean, minimum and maximum cocoa production (kg dry beans/household/annum):120 households in four villages[1].

Household land holding	D	K	L	S	Total
Mean production (kg dry beans/ household/ annum)[2]	227[ab]	159[a]	460[b]	241[ab]	275
Minimum production (kg)	5	5	10	10	5
Maximum production (kg)	2304	947	2048	1254	2304

[1] D = Duampanua ($n = 29$), K = Kelapa Dua ($n = 31$), L = Landi Kanusuang ($n = 32$), S = Sattoko ($n = 29$)

[2] Means followed by the same letter are not significantly different (ANOVA, Games-Howell, $p < .05$).
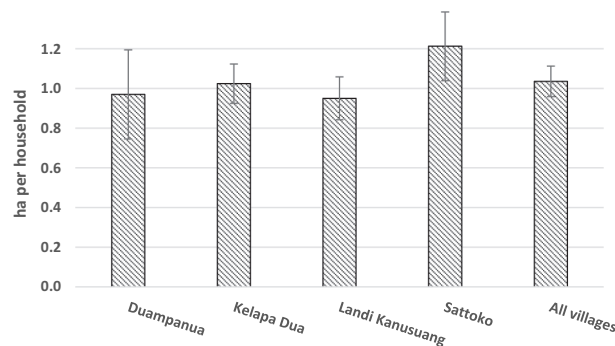

Fig. 7. Mean (SE) land area per household in four villages ($n = 120$).

3.1.5. Links between productivity and food availability or variety

Most households had two or fewer sleeping rooms (Table 9). Household size ranged from 1 to 8 people with an average of 4.2 per household across the four villages. A majority of houses were built of wood, while 59% had wooden or bamboo floors. Overall only 31% of households had a bank account with fewer bank accounts in the more remote villages of Sattoko and Kelapa Dua. Phone ownership was common and the majority of households in all villages owned some form of transport.

Types of livestock owned by households varied significantly between villages. Households in Mapilli kept higher numbers of goats and cattle than those in Anreapi, which mainly kept chickens (Fig. 8).

Just over half of the households (55%) had access to clean drinking water (including bottled, piped water and protected spring/well), leaving a substantial number with unclean drinking water (unprotected spring/well, borehole and surface water) (Table 10). The two villages in Mapilli were heavily dependent on river water (59% of households), while Duampanua and Kelapa Dua relied on piped or spring water. Of the 31% obtaining water from a spring, over half had to walk 15 min or more to the water source (data not shown). Over half of the households (55%) depended on pit latrines and 9% had no access to a latrine (Table 10). Hand washing facilities were almost universal.

Over half of the households worried about food availability (Fig. 9). Two thirds said they had limited food variety available. About one quarter of respondents had recently had no food for a 24-h period.

Spearman's rank correlation tests between pairs of variables for all 120 households indicated significant correlations occurred between land area and scores for food.

availability or variety. Correlation coefficients for these variables tested with cocoa yield per household were also significant (Table 11). No correlation occurred between any of the variables examined and the number of additional crops to cocoa (0–3 crops per household), including cloves, vegetables, coconut, durian, langsat and coffee (data not shown).

Table 9

Cocoa farmer household characteristics: 120 households in four villages. Note: D, Duampanua; K, Kelapa Dua; L, Landi Kanusuang; S, Sattoko.

Household characteristics	Village				Total	p-value[1]
	D	K	L	S		
N	28	31	32	29	120	
Family size						
Median (SD)	4.3 (1.8)	4.2 (1.5)	4.6 (1.7)	3.7 (1.7)	4.2 (1.7)	0.16
Min-max	1–8	2–7	2–8	1–7	1–8	
Have bank account (%)						
No	57.1	77.4	56.3	86.2	69.2	0.02
Yes	42.9	22.6	43.8	13.8)	30.8	
House floor materials (%)						
Cement/ceramic/carpets	32.1	25.8	65.6	37.0	40.8	0.01
Bamboo/parquet/polished wood/wood planks	67.9	74.2	34.4	62.1	59.2	
House wall materials (%)						
Wood planks/plywood	82.1	87.1	50.0	65.5	70.8	0.01
Bricks/brick with cement	17.9	12.8	50.0	34.5	29.2	
Number of sleeping rooms (%)						
2 or less	67.9	74.2	84.4	82.8	77.5	0.39
> 2	32.1	25.8	15.6	17.2	22.5	
Owned at least one phone (%)						
No	10.7	16.1	25.0	34.5	21.7	0.13
Yes	89.3	83.9	75.0	65.5	78.3	
Own transportation (%)						
No	25.0	29.0	12.5	17.2	20.8	0.37
Yes (bicycle, motorcycle, car, etc.)	75.0	71.0	87.5	82.8	79.2	0.37

[1] ANOVA used to test family size data in the four villages; other p values obtained from X^2 tests.
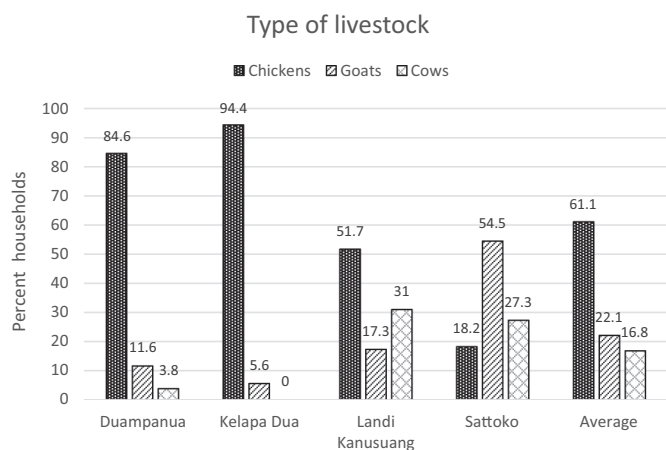

Fig. 8. Type of livestock kept by households (%) in four villages in Polewali-Mandar District. Chi-square test (Distribution of livestock type), $p = .00$. Distribution of households: Duampanua (28), Kelapa Dua (31), Landi Kanusuang (32), Sattoko (29).

3.2. Key informant interviews with stakeholders

3.2.1. District government primary health care services

District health staff revealed limited opportunities to educate villages about water, sanitation and nutrition due to difficult access to remote communities and a reluctance of families to report illnesses. Previous education may play a role as most adults have been educated only to primary school level. Facilities for treatment of mental health in the district are lacking which might account for mental health problems being under-reported. Despite 2014 national legislation introducing more progressive laws on mental health, outlawing shackling for example, District office health staff had not received training for mental health management in the previous five years. Additionally, villagers link mental health problems with black magic - treatment is sought from traditional healers or Islamic religious leaders.

Early detection of eye problems has not been identified as a health issue and consequently has received little attention. Serious eye disorders once diagnosed by a health professional are referred to the

Table 10

Household water and sanitation facilities – 120 households in four villages (% households).

Sanitation facility	Village[1]				Total	p-value X^2 test)
	D	K	L	S		
N	28	31	32	29	120	
Water source (%)						
Bottled water	7.1	0	3.1	0	2.5	0.00
Piped[2]	28.6	51.6	28.1	6.9	29.2	
Protected spring/well	39.3	29.0	6.3	20.7	23.3	
Unprotected spring/well	14.3	16.1	12.5	0	10.8	
Borehole	10.7	0	6.3	0	4.2	
Surface water[3]	0	3.2	43.8	69.0	29.2	
Other source	0	0	0	3.4	0.8	
Toilet facility (%)						
Open defecation	0	3.2	28.1	3.4	9.2	0.00
Latrine (own)	85.7	80.2	45.8	85.9	74.3	
Latrine (shared)	14.3	16.6	26.1	10.7	16.5	
Type of latrine (%)						
Pit	60.7	66.6	60.9	53.6	60.5	0.72
Septic	39.3	33.3	39.1	42.8	38.6	
Sewer	0	0	0	3.6	0.9	
Hand washing facility (%)						
Observed	96.4	93.5	81.3	96.6	91.7	0.22
Not in dwelling/not observed/not permitted	3.6	6.5	9.7	3.4	8.3	

[1] D, Duampanua; K, Kelapa Dua; L, Landi Kanusuang; S, Sattoko

[2] To compound or dwelling.

[3] Pond, river etc.

district hospital. The maternal and child health program is more developed and has successfully trialed a mobile phone application which village midwives use to upload pre- and post-natal data. Incidence of high blood pressure in pregnant women in the district is higher than the national average, while 20% of pregnancies have complications. Employing traditional birth attendants is illegal but remains common. However, birth attendants are allowed to assist qualified midwives if requested by the mother. Transport for women in labour and availability of beds for delivery remain inadequate, especially in more remote villages like Sattoko.
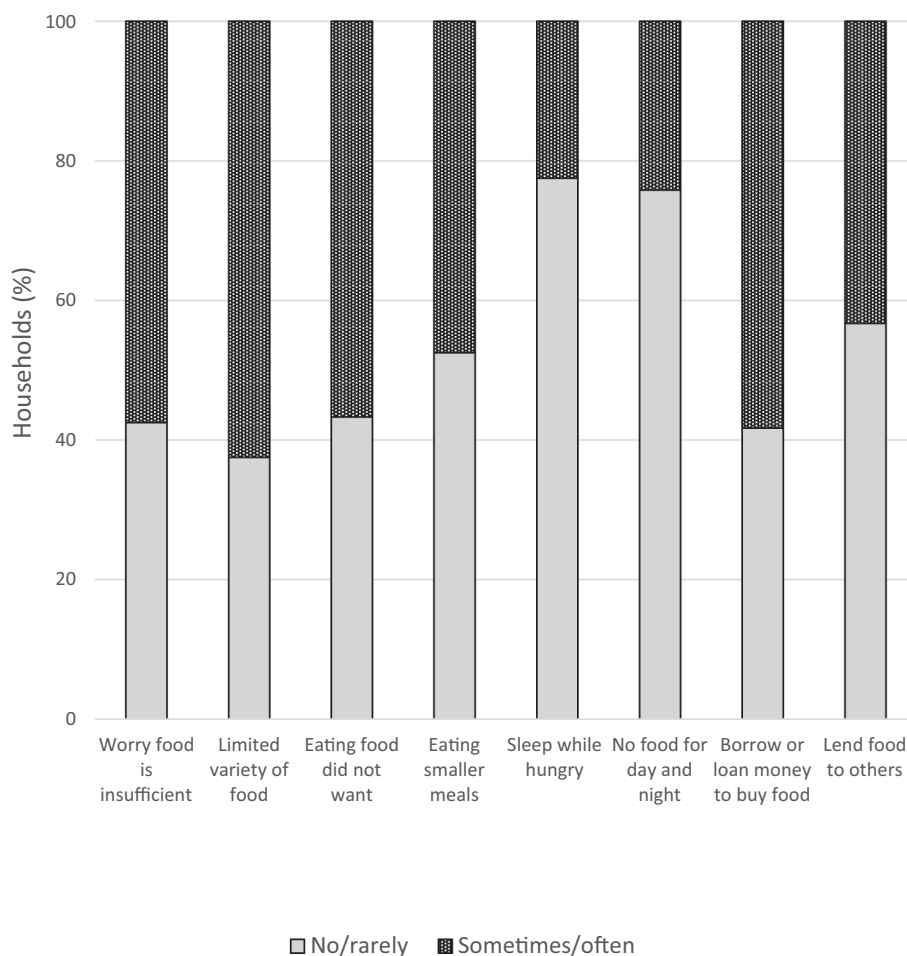
Fig. 9. Family experience for food availability and variety (% households, $n = 120$). See Supplementary Table a for data from each of the four villages. Bottom (light shading), no until rarely; Top (dark shading), sometimes until often.

Materials such as counselling cards and educational leaflets are distributed to community health centres but lack supportive training in their use. Lack of training in managing Tuberculosis (TB) and Human Immunodeficiency Virus (HIV) patients was also cited, although most community health centres have laboratory facilities for detecting/diagnosing TB.

Nutrition programs focus on under-nutrition, although reducing salt intake is encouraged in the wider community. Problems related to overweight and obesity have received less attention. BMI, blood pressure and other parameters are recorded at the village posts known as

Posbindu. Awareness of the effects of unsafe pesticide practices is low. Village volunteers treat conditions not requiring a doctor. For more serious health conditions people visit the Puskesmas (community health centre) located in each sub-district. The village volunteer system is unstructured and relies mainly on the direction of the village midwives.

3.2.2. Goat value chains: traders and government services

In West Sulawesi, goats are raised predominantly by smallholders with a small number of local breed goats kept tethered or free roaming.

Table 11

Spearman correlation coefficients for household data on cocoa productivity, land area, dietary diversity and perceptions of food availability and variety (120 households).

	Household variable					
	Cocoa yield	Land size	Perception food is sufficient	Perception variety of food is adequate	Less need to obtain credit for food	Dietary diversity[a]
Cocoa yield	1.000					
Land size	0.532**	1.000				
Perception food is sufficient	0.181*	0.293**	1.000			
Perception variety of food is adequate	0.201*	0.180*	0.668**	1.000		
Less need to obtain credit for food	0.056	0.186*	0.481**	0.406**	1.000	
Dietary diversity[1]	0.207*	0.323**	0.098	0.093	0.130	1.000

* $p = .05$.
** $p = .01$.
[a] Determined as the number of food groups out of ten categories regularly consumed in households.

A smaller number raise non-local breed goats in pens with cut-and-carry feeding. Integrated mixed farming involving goats is as yet uncommon in West Sulawesi. Substantial demand for live goats for ceremonial purposes is found in West Sulawesi, South Sulawesi and Kalimantan with a 25–30% price increase during Idul Adha (slaughter day). Live goat demand drives inter-island movement of goats with goats from West Sulawesi consigned by ferry to Kalimantan. This market is expected to increase. Regulations for animal movement between district and province designed to prevent disease transmission exist (such as animal health certification before transport) but adherence is variable. West Sulawesi has infected status for anthrax and *Brucella mellitensis* among other pathogens and has had avian influenza epidemics. Also, kid mortality is high in penned goats. Practices of goat traders are largely unregulated. However, no formal goat meat supply chain exists and there are no slaughterhouses for goats in West Sulawesi. Goat meat is not regularly eaten in West Sulawesi or South Sulawesi, and this is not expected to change as consumer preference remains for beef, chicken and fish. The few restaurants in major centres with goat meat dishes are thought to have a local arrangement with a goat trader for source and slaughter.

Integrated cocoa-goat mixed farming with use of tree prunings and cocoa pods for feed is a means to address the main constraint of feed supply for penned goats. However, informant feedback indicated that success of a mixed cocoa-goat enterprise would require improved farmer knowledge on goat management and health and raising of larger size goat breeds that require a higher level of nutrition and care than the local breed.

3.2.3. Cocoa value chain: trader/processors and NGOs

The key informants working with cocoa sustainability programs cited tree age, low soil pH (commonly < 5.5), poor management practices, pests/diseases (which cause yield losses exceeding 30%), price volatility and climate change as the main factors responsible for low farm productivity. In addition, farmers are shifting to other occupations or other provinces, or converting to maize, cloves, black pepper and palm oil. Price drops and the uneven distribution of income from cocoa over the year are significant deterrents to farm investment. Severe dry seasons have resulted in tree deaths. In addition, current government policy encourages greater efforts in food crop production, which attract subsidies.

Cocoa sustainability programs operate through multi-stakeholder partnerships [24] between international trader/processors, NGOs and farmer cooperatives. In Polewali-Mandar, Amanah Cooperative partnered with the NGO Rikolto is one of the larger farmer organisations. Membership of the cooperatives provides benefits to farmers in the form of training in GAP, financial management and safe pesticide use, market access and bonuses/premiums for compliance to sustainability standards set by certification bodies or companies, such as Nestle and Mondelez. Individual bar codes (such as Cocoa Trace) provided to each farmer selling beans at buying units improves transparency and shortens the supply chain. However, many farmers are reluctant to break ties with local collectors/traders or are in debt to them. Interviewees confirmed that a substantial portion of premium payments for certified cocoa beans is absorbed by certificate holders to meet costs related to the internal management system, leading to dissatisfaction among some farmers [4]. Some programs encourage farmers to establish nurseries as a business to raise and sell seedlings of improved clones (which are propagated by grafting). If profitable, such satellite businesses could encourage youth to take an interest in cocoa farming. Curricula and training are provided to vocational high schools by Rikolto, Mars Inc. and others. Availability of improved cocoa varieties is limited, however, as official certification of improved varieties by national government and approval of outlets for seedling sales is necessary.

4. Discussion

In West Sulawesi, as elsewhere, health services provided by the provincial and district governments are variable. While the Government has implemented a WHO-designed maternal and child health program, other aspects of primary health care such as the detection of early childhood illness, vector borne diseases, non-communicable diseases, water safety, sanitation, nutrition and environmentally safe practices are under-developed. Scarce resources result in government-employed mid-wives taking on roles outside their skill set and training. Limited resources also push the Government to rely on village health volunteers (Kader Posyandu) for early detection and health promotion. Furthermore, access to health care for villagers living in more remote areas is limited.

The results show that just over half of the population aged between 15 and 49 years are in their productive years with an equal proportion over 60 years and children under 5 years (16% taken together) suggesting a workforce with capability to improve their livelihoods in terms of age. However, the results also show that livelihoods are multi-dimensional and not addressed solely by increasing cocoa production and incomes. Sen [25] highlights the interdependence that exists within communities including non-monetary dimensions such as access to health care, clean water, shelter and education. In 2010 the *Human Development Report* [26] identified the following six dimensions as a way of examining poverty: nutrition, health status, education, housing conditions, access to work and personal security. We found only one third of adults in the cocoa farming households were educated beyond primary school and only 31% of households owned a bank account. A substantial number live in sub-standard accommodation with about half having access to clean water. Most depended on a pit latrine, while 9% had no access to a latrine. Low incomes impacted on food security with over half of the households (58%) worrying about the availability and variety of food. These results are similar to the results of a 2014 study of cocoa farmers in Soubre, Cote d'Ivoire [27].

4.1. Health constraints to livelihood and productivity

In our survey in West Sulawesi, absence from work due to ill health was reported by 36% male respondents, with 11% frequently absent (Fig. 5). The impact of poor health on labour productivity is often un-recognized and under-valued, yet over 33,000 DALYs are reported from Indonesia (see Introduction).

Joint and back pain (Table 5) impact the intensive labour needed on a cocoa farm. Since there are no eye health programs at the sub-district or village levels existing eye problems are not surprising. Cataracts are diagnosed at a late stage. Common chronic health problems such as diabetes, arthritis and mental illness are noteworthy by their absence rather than frequency, suggesting a lack of diagnostic and treatment services rather than an indication of health. Diabetes II has increased substantially in Indonesia, including Sulawesi, in recent years [22] Surprisingly 14% of adult participants said they had never accessed any health care.

4.2. Nutrition

Indonesia Food Security Law No 18/2012 aspires individuals to 'access sufficient, diversified, safe and nutritious food delivered mainly from domestic production' [28]. The results show that in Polewali-Mandar the majority of households do not have reliable nutritious food (Fig. 9). Notwithstanding the dissemination of nutritional education by community health centres, vegetable and fruit consumption is low (Table 7; Fig. 6). This has been recognised with NGOs encouraging vegetable growing and consumption for nutrition and income diversification.

In Polewali-Mandar, the prevalence of stunting in children under five is 33% compared to the national average of 15% [29]. Our sample

was relatively small, but 42% of under-fives were stunted. High prevalence of stunting is reported in other hard-to-reach farming communities in countries such as Tigray Ethiopia or Nawa Region Cote d/Ivoire [30,31]. Inadequate feeding practices in early childhood have been identified in Indonesia [32]. Studies identify the following determinants of stunting: low income, prolonged breastfeeding without additional supplements (> 12 months) [33] inadequate childcare [34] infection, low animal-based food intake, and unsafe water intake [35]. These determinants were significant in our study population. These children will likely be delayed developmentally, have cognitive deficiencies that impact their education, infections and in later life develop chronic diseases such as diabetes, cardiovascular disease cancer, mental disorders and obesity [36].

The WHO estimates that about 2.8 million people die annually as a consequence of being overweight [37]. The prevalence of overweight and obesity (BMI $\geq 25\,kg/m^2$) among females in our study (32%) was higher than the 2013 results of the National Basic Health Survey (26%) and West Sulawesi Health Survey (21%); however, underweight in females in our sample (11.4%) was similar to the West Sulawesi Province level (11.6%) [38]. Incidence of high blood pressure is also reported to be high in Polewali-Mandar District, contributing to complications in pregnancies. The co-existence of overweight adult women and under-nutrition in early childhood have been observed in South Asia and Asia Pacific regions [39].The 'thrifty phenotype hypothesis' [40] suggests strong links between low birth weight and later chronic conditions such as obesity caused by poor nutrients during fetal and infant growth. In addition, dietary changes in rural areas (from traditional food based to western diets) may also play a role [41]. Other factors associated with under- and over-nutrition include poorly educated mothers and household poverty [42].

4.3. Links between food availability, diet and cocoa productivity

Since the decline in cocoa prices and production, smallholders who exclusively rely on cocoa are now more vulnerable to poverty and livelihood threats, including low levels of education, food purchases, poor diets (nutrition) and access to finance. The Living Wage (Income) approach is a useful indicator of the cost of supporting a decent living standard [43]. Smallholder cocoa farmers in West Africa earn less than a living wage and our evidence suggests this may also be true in Sulawesi.

While mean yields per household were very low (Table 8), dependence on cocoa for income was high in our sample population with 57% obtaining income from cocoa farming directly or indirectly, in addition to the 36% household members with no reported income (Fig. 3). Positive correlations between cocoa farm yields, dietary diversity and reduced worry about food sufficiency or variety (Table 11) demonstrate links between agricultural productivity (income), food security and sourcing diverse nutritional sources.

Lack of available capital and price volatility deter cocoa smallholders from investing labour and farm inputs into their farm. Decreases in cocoa prices in the commodity market after farmers have applied pruning, fertilizers and other investments can mean that yields six months later, when the pods are ready for harvest, do not return profits. Diversification into nurseries for seedling sales, services such as grafting [3], or companion crops, such as cloves, black pepper and durian (or other fruit trees used as cocoa shade), could supplement incomes for farmers. Mixed farming, such as cocoa/goat systems, has particular benefits as local resources available on the farm can be used and recycled. Declining soil organic matter content is a critical problem on cocoa farms [16] that can be redressed with manure from livestock, while legume shade and groundcover plants on the farm can supply feed. Animal products, including eggs and meat from chickens and ducks, are valuable supplements to the diet [14,20,44,45]. However, our interviews with government veterinarians indicated that stronger adherence to regulations in livestock transport for disease control

(important to a One Health strategy) is needed. West Sulawesi has infected status for some livestock diseases. One Health also incorporates protecting water sources and safe use of farm chemicals.

On cocoa farms, women perform key roles in harvesting, drying and selling to collectors, yet most do not attend training programs. International NGOs, such as Swiss Contact, working with trader/processors are initiating vegetable growing by women to enhance family nutrition as well as supplement incomes. This provides strong links between nutrition (and health), additional income sources and improves gender balance.

5. Conclusion

Our research shows the diminishing capacity of cocoa farmers in West Sulawesi to improve their livelihoods; this experience is similar to other hard-to-reach cocoa farming communities in low and middle income countries, such as Bougainville, PNG, where poverty and inequality including poor health, inadequate food, and access to clean water are the norm [46]. Our surveys confirm that poor education, health and nutrition are major constraints to improving livelihoods as well as cocoa production and cause health problems in adults and children alike. Childhood diseases including malnutrition and stunting are prevalent as well as the increasing burden of obesity in adults. These conditions are preventable using a One-Health approach [9].

The multifactorial challenges faced by cocoa farming communities in our study are addressed in the 17 Sustainable Development Goals adopted by the United Nations General Assembly in 2015. But the goals will not be attainable if rural communities themselves are not fully engaged in efforts to reduce poverty and improve livelihoods. In addition, health, agricultural and other local government services could work in concert with communities to deliver integrated programs that recognise the interconnectedness of the different components of village life. The knowledge and skills of researchers and development experts are undoubtedly required, but without equal partnerships with rural communities, the goals will fall short. Rural communities have their own fundamental knowledge about themselves and their community and culture, but these attributes are often neglected. Empowering communities to address the challenges facing them - diversification, improving incomes, clean water, sanitation, eradicating vector borne diseases, rubbish disposal, crop management, market understanding and more - will foster respect and strengthen partnerships rather than weaken them.

Ethics approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee.

Declaration of Competing Interest

The authors declare they have no conflict of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.onehlt.2019.100107.

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