
AGRI LOGIC
MANAGEMENT, CONSULTANCY AND RESEARCH

FARMER FIELD BOOK ANALYSIS

ISLA Programme Vietnam 2016/17 to 2020/21

March, 2021

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Introduction

- The companies Acom, Louis Dreyfus Commodities, Olam Vietnam Ltd and Simexco are partners in the ISLA landscape programme in Vietnam. With co-funding from ISLA, JDE Coffee and Lavazza, these companies implement landscape level projects in parts of their respective coffee supply chains. A component in each of these projects is the implementation of the Farmer Field Book (FFB). In the context the ISLA programme the FFB implementation serves multiple purposes:
  - Provide detailed multi-crop performance data to participating farmers and farmer groups;
  - Assist companies to obtain better insight into the performance of their suppliers; and
  - Provide insight into the degree to which the ISLA programme is meeting its objectives.
- Across 2 provinces 900 farmers kept daily records of their farming activities, investments and returns as well as their production assets and their tree stocks during the 2016/17 season. In the next seasons, Simexco and LDC opted to work with their own data management systems. From the 2018/19 to 2020/21 coffee seasons, 198 farmers in the Lam Dong supply chain of Acom and 150 farmers in the Dak Lak supply chain of Olam used the FFB for daily record keeping of farm management.
- With the FFB programme we generate 4 types of reports, the first 3 of which are not publicly available:
  1. Individual Farm Management Reports: Detailed performance reports on a per farm and per ha basis for each farmer in the programme;
  2. Farmer Group Reports: Detailed reports at farmer group level, which allow farmers to compare their own performance to that of their peers;
  3. Company Reports: Reports for each company, containing more in-depth statistical analysis on the level of their supply chain; and
  4. ISLA Programme Report: Overall report combining FFB data from different companies with in-depth programme level analysis.
- In this report, the ISLA Programme Report, we present the analysis of 5 years of FFB data of farmers in the Acom and Olam supply chains. Results from the first publication in 2017 where Simexco and LDC were included therefore differ from what is presented here.

Readers' guide

- To facilitate time-pressed readers, we start of with the **Conclusions** in the first section. Subsequent sections contain the background analyses on which the conclusions are based.
- The section **Household and Farm Profiles** outlines a charactersation of the FFB farmers and their farming system. It also includes a classification of farms across **Agro-Forestry Classes** which is used in some of the subsequent analyses.
- The **Farm Management** section deals with labor use, payment of workers, the gender wage gap, nutrient management, irrigation, the use of pesticides and specifically of products banned by sustainability standards and national law, and replanting of coffee.
- In the **Production** section we dive deeper into production and productivity figures, where deemed useful we split these by province and Agro-Forestry Class. We identify drivers for productivity.
- **Farm Economics** shows cost of production, revenue and profit margins, including Benefit Cost Ratios (BCR) and Return on Assets (ROA) ratios for farmers. Farm management variables that drive the RoA are identified.
- In the **Environmental Performance** section we discuss the Environmental Impact Quotient and coffee related carbon emissions and carbon sequestration
- **Recommendations** are provided in the final section.

In the remainder of the report when we refer to the coffee seasons by the calendar year that covers most of the season. So, the 2016/17 season is refered to as 2016.

The setup of the study was not intended to serve as an impact assessment. We track change over time, but in the absence of a control group, or sizeable co-horts of farmers moving into the programme at different points in time, we can not reliably attribute change to project interventions.

Conclusions

Conclusions: We observe positive change on most aspects, except on Return of Assets and irrigation water use

Description and units	2016	2017	2018	2019	2020	Change
Benefit Cost Ratio	2.73	2.98	2.53	2.64	2.70	
Return on Assets	10.9%	7.4%	8.8%	7.8%	6.9%	
Irrigation water (m^3/Mt coffee)	410	252	227	331	613	
Emissions (Mt CO_2e/ha)	3.61	2.67	3.05	2.41	2.31	
EIQ (#/Mt coffee)	5.5	1.5	0.5	0.5	1.6	
Use of banned pesticides (% of farmers)	7.0%	1.2%	0.5%	0.0%	0.3%	
Gender wage gap	8.4%	3.5%	3.3%	9.3%	4.9%	

Conclusions

- **Household and farm profiles:**
  - FFB records are kept by 346 farmers in 8 communes of 3 districts in Lam Dong and Dak Lak province.
  - Most farmers are male, the share of ethnic minority farmers is relatively high in Lam Dong.
  - 59% of farmers are over the age of 54, this may affect future supply availability.
  - Farm size distributions show significant differences, smaller Dak Lak-based farms tend to be more diversified.
  - Farmers in Dak Lak are increasingly diversifying, also on farms where diversification was high to start with. Diversification with non-coffee trees is increasing on roughly half of the farms in Dak Lak. In Lam Dong mono-cropping has reduced, but larger scale diversification is not (yet) observed.
  - Increased diversification correlates with lower coffee tree stocks, but coffee planting densities remain stable. Durian and avocado tree stocks show the strongest growth, but start from a low base value.

- **Farm management:**
  - Labour use has gone down per farm and per ha, but not per Mt GBE, indicating that yields have declined. On a per farm basis, the largest drops are on use of male hired labour (22%) and males in the household (12%).
  - We see what we think is a slight Covid-19 effect with lower than usual hired labour after the epidemic declaration was issued by the PM in week 5, but this dissipates again in week 12.
  - Nearly all of the decline in labour use is due to a reduction in harvesting. The weighted average rate for hired labour comes in at just over 308,000 VND/day, an increase of 32% after controlling for inflation since 2016, which outstrips the rate inflation by a considerable margin.
  - Despite more costly hired labour, we see no large shift in the share of farmers that use hired labour. Harvesting efficiency has improved significantly, off-setting the reduction in total labour used for it.
  - On average male workers earn slightly more per day. The gender wage gap has gone down, but tends to be higher on female-owned farms.

Conclusions

- **Farm management:**
  - The share of farmers who spray pesticides has reduced significantly in both provinces without any apparent ill effects on yield.
  - Use of the most dangerous pesticides has reduced significantly, violations of standard requirements are increasingly rare. Some mis-use of pesticides continues to be present but is on a down-ward trend.
  - Irrigation volume per tree and per Mt GBE was reduced significantly from 2016 to 2018, but in 2019 and 2020 when conditions were adverse, irrigation volumes picked up again.
  - Diversified farming systems use significantly more irrigation water, it is unclear how this affects the notion that using more shade can enhance climate change resilience.
  - In the Lam Dong FFB areas, irrigation is an incidental activity driven by seasonal weather patterns, while in Dak Lak nearly all farmers need to irrigate every year.
  - The occasional necessity of having to irrigate in Lam Dong seems to result in a group of farmers having to purchase water in times of need. In the most recent year, payments for water in Dak Lak also rose.
  - Weed management strategies have shifted over the past 5 seasons with strongly growing use of brush cutters replacing manual weeding.
  - Pruning is critical to maintain high yield levels, pruning more is associated with both higher yields and margins.
  - Nitrogen use has gone down significantly over time, coming closer to what we think are optimal levels. A yield drop in 2020 pushed up the Nitrogen Use Efficiency, but the trend from 2016 to 2019 indicates improved efficiency. The level of excess N application has gone down as did the share of farmers in this group.
  - Yield, profit margin and fertiliser cost by N-balance range indicate that further improvement in optimising fertiliser application is possible.
  - Phosphorus over-application has gone down steadily, while potassium has increased relative to N and P, but the K-balance remains negative. This may be a yield limiting factor.
  - Organic material applications are back to 2016 levels after a dip in 2017. The share of farmers using it has gone up slightly.
  - Rates of rejuvenation have declined in Dak Lak but are increasing in Lam Dong. Coffee tree stocks are either stable or growing in both provinces.

Conclusions

- **Production:**
  - Average production is 5.71 Mt GBE/farm, while yield is 2.61 Mt GBE/ha. Differences between Dak Lak and Lam Dong are large.
  - Normally, around half the farmers has a higher yield than the year before, the other a lower yield. Lam Dong shows an odd pattern in this regard where the ratio is closer to 70/30.
  - 55% of farmers have had 2 or 3 seasons with yield increases. Farmers with more seasons where yields increased tend to work smaller farms.
  - The 20% highest yielding farms are pruning significantly more, while stumping rate are mostly comparable.
  - In Dak Lak, 5-year mean coffee yields on Highly diversified farms are significantly lower, yet profits from other crops more than outweigh this.
  - We model yield and present groups of variables for location, socio-economic conditions and farm management and their effect sizes. Location effects are significant for all communes in Lam Dong province.
  - Farming households with one or more members of the Kinh majority group show higher yields. Sprinkler use also has a positive effect on yield, while diversified farms perform worse than Monocrop farms.
  - Pruning and K applications continue to be the management aspects that are limiting and where farmers can make the largest improvements.

- **Farm economics:**
  - Cost reduction was largest in Dak Lak, consequently, margin drop there was less severe than in Lam Dong, but cost savings could not off-set lower yields and coffee prices**.**
  - Production cost optimisation comes predominantly from lower fertiliser investment, but we see reductions across all categories, except for energy use in Lam Dong.
  - Relative cost changes over time compared to 2016, illustrate how farm management has changed. Less reliance on pesticides and optimisation of labour and fertiliser use.

Conclusions

- **Farm economics:**
  - Medium and highly diversified farms in Dak Lak deliver better margins for farmers compared to monocrop farms.
  - As a result of other crop income and cost reductions, the Benefit-Cost Ratio (BCR) has recovered in Dak Lak but gradually declines in Lam Dong.
  - The average rate of return on assets is down from 10.9% to 6.9%. Farmers with poor returns (<8%) used to produce just 14% of the total supply but this is now 54%.
  - A growing share of farmers earns less than the Living Wage, but on average coffee remains an attractive proposition compared other non-farming options.

- **Environmental performance:**
  - The environmental impact quotient per ha has dropped significantly from 17.5 to 2.2, indicating strongly reduced use of the most hazardous pesticides**.**
  - Reductions in toxic loading are seen across all types of agro-forestry classes, but monocrop farms continue to see significantly higher EIQ rates**.**
  - The role of fertiliser management is critical to controlling emissions from coffee production**.**
  - We find no relation whatsoever between emissions and yields, indicating that high(er) emissions are not a prerequisite for optimal yields**.**
  - Coffee can be a mitigating factor in climate change, removing more carbon from the air through biomass growth than it emits in production. Fertiliser management and diversification are key factors**.**
  - Similar to the finding on yield, we observe that margins are not related to footprint levels. This indicates that farms that act as carbon sinks are not more or less profitable than those that do not.
  - As a result of optimised nutrient management of nitrogen in particular, a growing share of farms are now acting as carbon sinks.

Recommendations

Recommendations

- **FFB implementation:**
  - Implementation of the FFB is relatively costly due to the high frequency of data collection. The FFB data collection cycle for the ISLA programme is now at an end. If future programmes are considering the FFB, or any other type of data collection programme, we recommend to assess carefully from the start if the involvement of a control group is required and can be arranged. The wealth and depth of data we have worked with it over the past 5 years is quite unique, but given the design of the programme, we can not with complete certainty attribute the large changes we have witnessed in both farm management and performance to the ISLA programme. This is a short-coming that could have been avoided.

- **Farm management:**
  - The five years of data analysed here, can be used to formulate recommendations at farm level that future programmes can take up.
  - Similar to earlier reports, we continue to find K applications being on the low side and N applications can probably go down some more on the farms where its use is highest. The latter depresses the Return on Assets and unnecessarily inflates the carbon footprint on some farms. Farmers may be hesitant to make significant changes to their nutrient management. We advise for each farmer to set aside 30 coffee trees where he tries out the recommendations (from his personal farm report the farmer can, possibly with help from the agronomist, determine how to change his fertiliser applications to better meet crop requirements. For the 30 trees that are part of such an on-farm test, volumes and types of fertiliser as well as yields need to be tracked and compared to the other trees.

Recommendations

- **Farm management:**
  - Similarly, we think that more or new training on how to determine nutrient requirements is needed. In the absence of soil tests, we advise to train farmers on how to determine the expected yield, prior to the first fertiliser application. A kg of fresh cherry contains about 0.5% N, 0.068% P and 0.6% K. With these values and the nutrient content of fertilisers the amount required can be calculated (with some additional N application to cover for N losses due to emissions and leaching into the ground water).
  - If soil tests are done, we advise to test out the recommendations on a small number of trees first and carefully evaluate the economic effects. In our experience not all soil laboratories provide good advice, often over-estimating how much fertiliser needs to be applied which can have severe detrimental economic effects.

- **Farm economics:**
  - In the presence of declining and/or volatile coffee prices, and the fact that highly diversified show better economic performance (in Dak Lak), the continued promotion of diversification, possibly at a larger scale, makes sense to us. Additionally, this will also have the effect of increasing sequestration, thereby contributing to greater carbon efficiency.

- **Environmental performance:**
  - Maintaining the large share of farms that act as carbon sinks is advisable in our view as roasters are increasingly looking to understand their carbon footprint and how it can be reduced. Ideally, the fertiliser management recommendations we provided above are rolled out on a much larger scale. Having in place a set-up that allows to track nutrient management, yields and carbon footprints on programme and non-programme farms would then allow for attribution of change to specific interventions.

Results
Household and Farm Profiles

Household profiles: FFB records are kept by 346 farmers in 8 communes of 3 districts in Lam Dong and Dak Lak province

Province	District	Commune	Nr of FFB farmers	Share of total
Dak Lak	Cu M'gar	Ea Drong	50	14%
		Ea Pok	50	14%
	TP Buon Ma Thuot	Tan Hoa	50	14%
Lam Dong	Di Linh	Gung Re	10	3%
		Tan Chau	50	14%
		Tan Lam	90	26%
		Tan Nghia	20	6%
		TT Di Linh	15	4%
Demo farms	Various districts		11	3%
Total			**346**	**100%**

- From the 2016 to 2018 season, 300 farmers kept daily FFB records. From 2019 onwards, 46 farms were added in Lam Dong province, 11 of which are so-called Demo farms where a number of interventions are being tested.
- The sample size is limited to a relatively small number of communes. While the samples are representative for the projects in which these farmers participate, they can not be considered representative for both provinces as a whole. For that the geographical distribution within each province is too limited.
- In the remainder of this report, we will on occasion analyse data by province as the farming systems and performance of farmers vary significantly between the two.
- Care should be taken to interpret our analysis not as representative for the 2 provinces as a whole, but rather as indicative for what changed over in the two projects.

Household profiles: Most farmers are male, the share of ethnic minority farmers is relatively high in Lam Dong

Aspect	Units	Dak Lak	Lam Dong
Gender	% male	87%	82%
Year of birth	Year	1964	1966
First year of growing coffee	Year	1995	1991
Ethnicity (male)	% kinh	100%	71%
Ethnicity (female)	% kinh	100%	69%
No. of female children in household (<16 years old)	#	0.24	0.47
No. of male children in household (<16 years old)	#	0.27	0.48
No. of people dependent on farm for their living	#	4.1	4.1
Land ownership	% red book	85%	99%
Education level (male)	% primary or higher	67%	76%
Education level (female)	% primary or higher	72%	71%
Decision-making	% with joint decision making	95%	58%
Participating in projects since	Year	2013	2013

- FFB farmers are predominately males in their early fifties who have been growing coffee since the mid-nineties.
- The majority of male and females in the households are of the Kinh ehtnic majority.
- We find a weak (R^2=0.21) postive correlation between belonging to the Kinh ethnic group and practicing joint-decision making with regards to farm management.
- Average farmers' age does not differ significantly between the provinces.
- The number of people dependent on the farm for their living is 4.1 persons on average in both provinces.
- Nearly all farmers have de-facto ownership of their land via the so-called red book. There is some renting of land observed among 15% of the farmers in Dak Lak.
- On average FFB farmers have engaged with a coffee project since 2013.

Household profiles: 59% of farmers are over the age of 54, this may affect future supply availability

- Around 32% of farmers fall in the 45≥x<55 age group, while just 2% of the sample is younger than 35 years. At the other end of the age curve, 59% of farmers are over the age of 54 (Fig 1). This makes the coffee sector very different from the general Vietnam workforce, where 45% are younger than 35 years[1].
- The contribution to supply by age group follows largely the same pattern as the share of farmers in a particular age group, indicating that production is, on average, not much affected by age. It does seem that 45≥x<55 age group with 39% of farmers and 30% of production is lagging, but a subsequent Dunn test ($p<0.05$) rejects this hypothesis.
- Although production is comparable between age groups, it could still be that older farmers have lower yields, but that this is offset by them having larger farms, resulting in similar production levels. When we plot yield and coffee area by age group we see some variability, but none of the differences on either variable and between any of the age groups are significant ($p<0.05$).
- Looking 5 to 10 years ahead it is certainly wise to monitor the share of farmers across the age groups and perhaps it is already useful to stimulate younger farmers to enter the sector to avoid being caught out by the bulk of farmers that will retire at some point.

Fig. 1

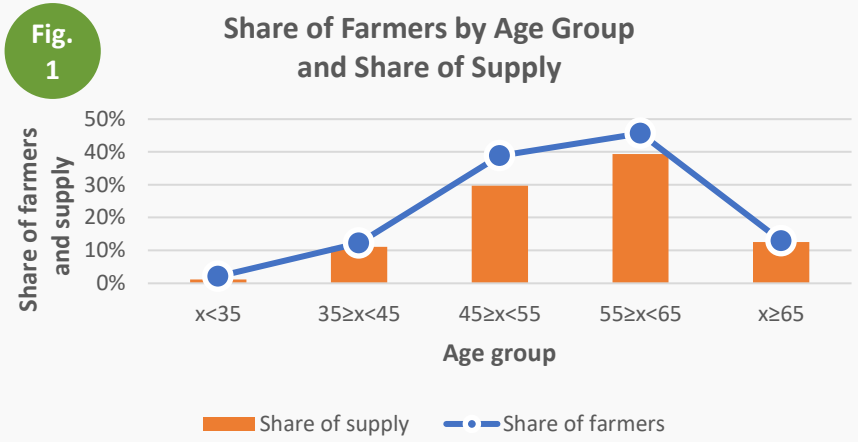
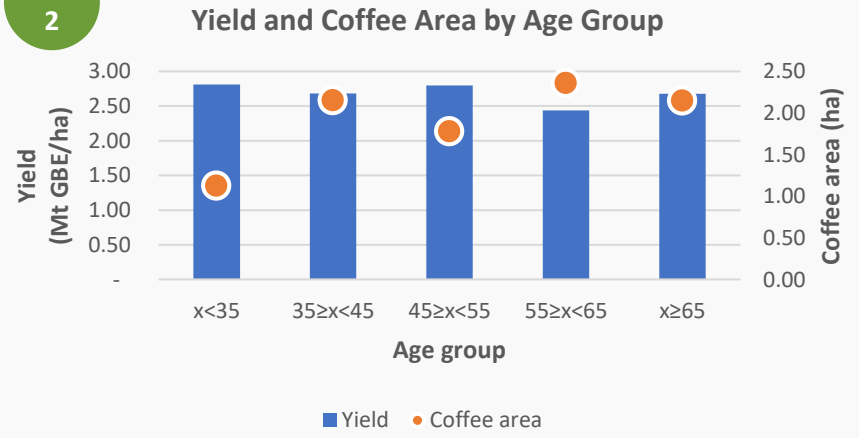


Fig. 2



Farm size distributions show significant differences, smaller Dak Lak-based farms tend to be more diversified

- Mean coffee farm size across the sample comes in at 2.14 ha while the median is just 1.5 ha, indicating a skewness to the right.
- In Dak Lak farm size does follow a normal distribution with a mean farm size of 1.12 ha and a median of 1.0 ha with the majority of farmers falling into the 0.5<x≤1.0 ha farm size bracket. In Lam Dong distribution is more skewed with a mean of 2.92 ha and a median of 2.0 ha. Here the majority of farmers have from 1.5 up to 2.5 ha (Fig 1).
- When we plot the level of diversification, as expressed by the non-coffee trees as a share of the total tree stock on a farm, we see that diversification is much more common in Dak Lak, particularly on smaller farms (Fig 2).
- In some of the following sections we will analyse data by their Agro Forestry Class (AGF). We will use the definition Monocrop farm (MCF;<15%), Medium diversified farms (MDF; 15%≤x<30%) and Highly diversified farms (HDF; ≥30%), where the percentages refer to the non-coffee tree share of total on-farm tree stocks (Fig 2 & 3).

Fig. 1 Farm Size Frequency Count by Province in 2020

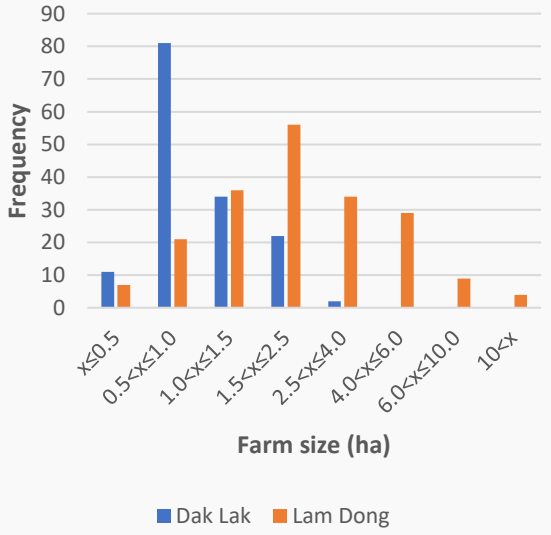


Fig. 2 Share of non-Coffee Trees versus Farm Size by Farmer and Province

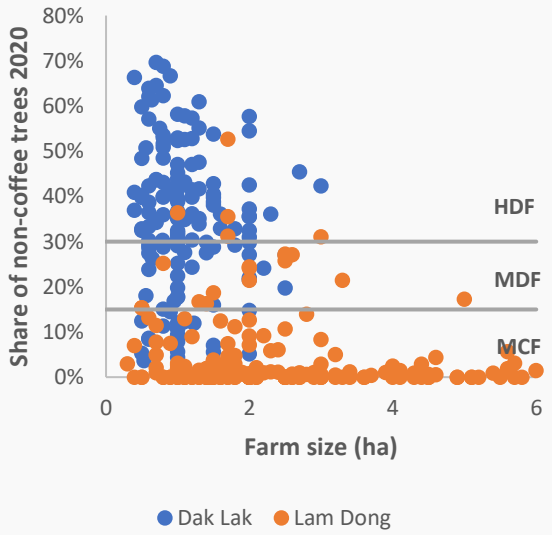
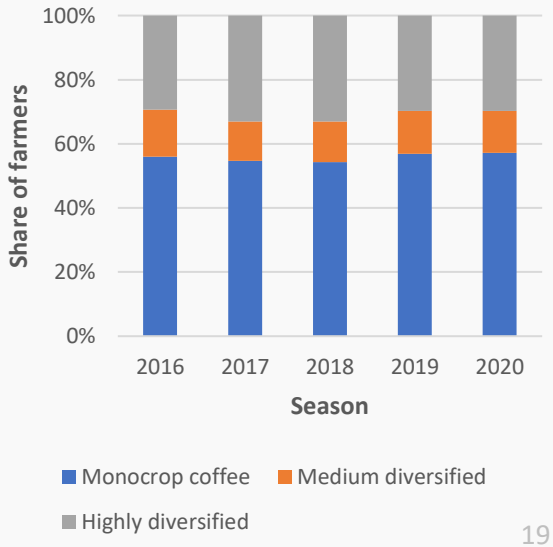
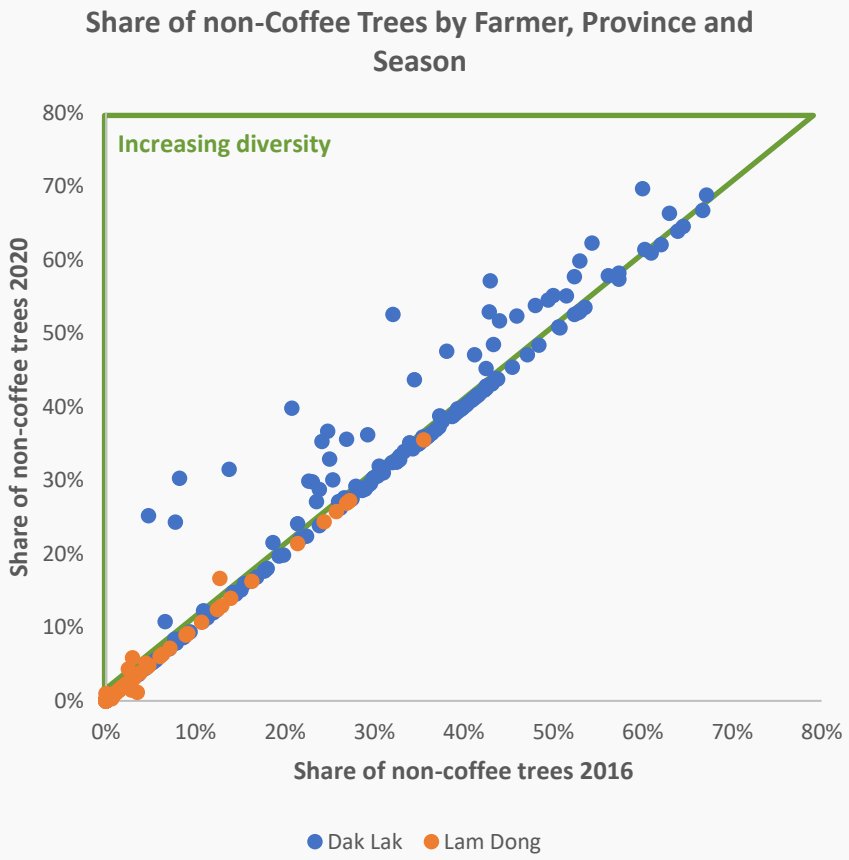


Fig. 2 Share of Farmers by AGF Class and Season



Farm profiles: Farmers in Dak Lak are increasingly diversifying, also on farms where diversification was high to start with

- Average farm sizes and tree stocks differ significantly between farms, with the larger farms being located in Lam Dong and more diversified farms in Dak Lak ($p<0.05$).
- Comparing the share of non-coffee trees on farms in Lam Dong and Dak Lak from 2016 to 2020 shows that diversification continues unabated in Dak Lak. Nearly half of the farms have a greater share of non-coffee trees in 2020 than they had in 2016.
- In Lam Dong this is far less prevalent, with just 4% of farmers moving in this direction. We should note that the sample in Lam Dong is probably biased towards “Pure-play coffee farmers” in areas within the province with larger than average coffee farms.
- We typically see that diversification is driven by economic necessity, i.e. obtaining more income from a limited amount of land. Where land is not so much limited it is probably more economical to focus on single crop and do that really well, which may explain the limited degree of diversification we see in Lam Dong.
- We suspect that in other areas in Lam Dong where either land holdings are smaller and/or growing conditions less optimal for coffee, we would find a higher level of diversification.



Farm profiles: Diversification with non-coffee trees is increasing on roughly half of the farms in Dak Lak. In Lam Dong mono-cropping has reduced, but larger scale diversification is not (yet) observed.

- In Dak Lak we see a shift over time with 48% of farmers having increased the share of non-coffee trees on the farm. Among this group, the average share of non-coffee trees reaches 38% of total tree stocks (Fig 1).
- Given that farms in Dak Lak were already more diversified to start with, even on those few farms there where diversity decreased, the share of non-coffee trees still comes in at 29% of the on-farm tree stocks. This in marked contrast to Lam Dong, where on farms with decreasing diversification the share of non-coffee trees reaches only 1% of on-farm tree stocks. In Lam Dong such change has been rare, with just 2% of farmers making this move. Still, also in Lam Dong changes can be observed, the share of farms that only have coffee, and no other tree species, has gone down from 50% in 2016 to 41% in 2020 (Fig 3).
- Most of the additional diversification takes place on farms that were already diversified to begin with.

Fig. 1

Change in Level of Tree Stock Diversity by Province from 2016 to 2020

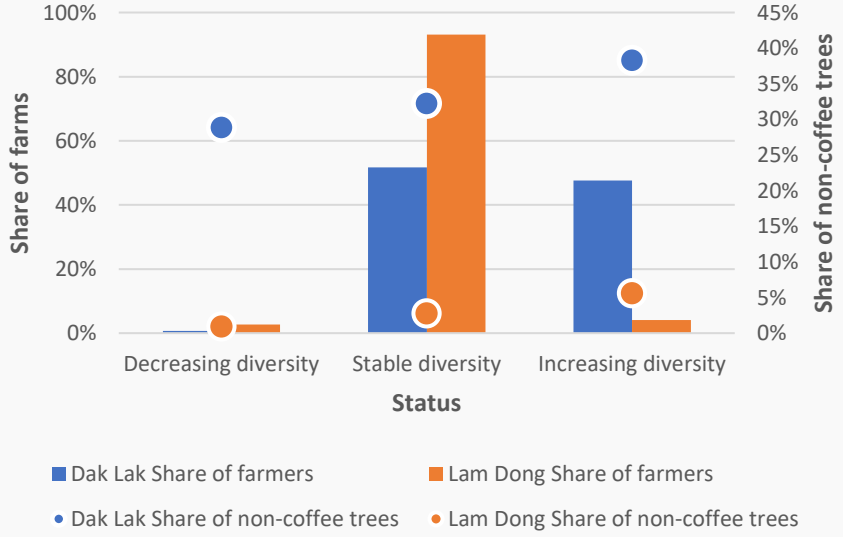
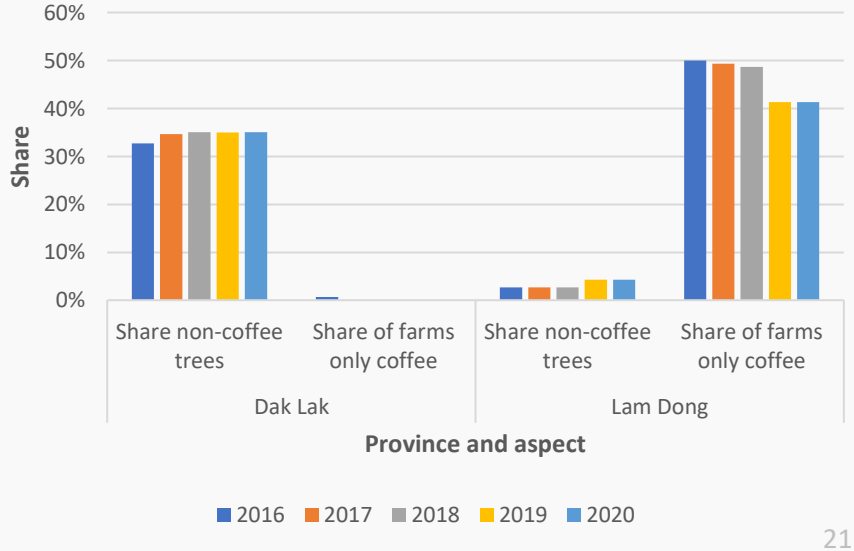


Fig. 2

Share of Non-Coffee Trees and Share of Farms with Only Coffee by Season and Province



Farm profiles: Increased diversification correlates with lower coffee tree stocks, but coffee planting densities remain stable. Durian and avocado tree stocks show the strongest growth, but start from a low base value.

- Coffee tree stocks have been stable from 2016 to 2020, showing up to 3% increase over that time frame on Medium Diversified Farms, and sit around the 1,000 trees/ha mark, followed by pepper *(Piper nigrum)* and cassia *(Cassia siamea)* (Fig 1).
- The largest rates of change in planting densities are found for Durian (*Durio zibethinus),* Avocado *(Persea americana)* and Midnight horror *(Oroxylum indicum).* Especially among the Medium diversified farms do we find high rates of change in planting of non-coffee species (Fig 2).
- Also relevant to note is that where farmers with Monocrop farms opt to plant non-coffee trees, they limit themselves to Durian and Avocado (Fig 2).

Fig. 1

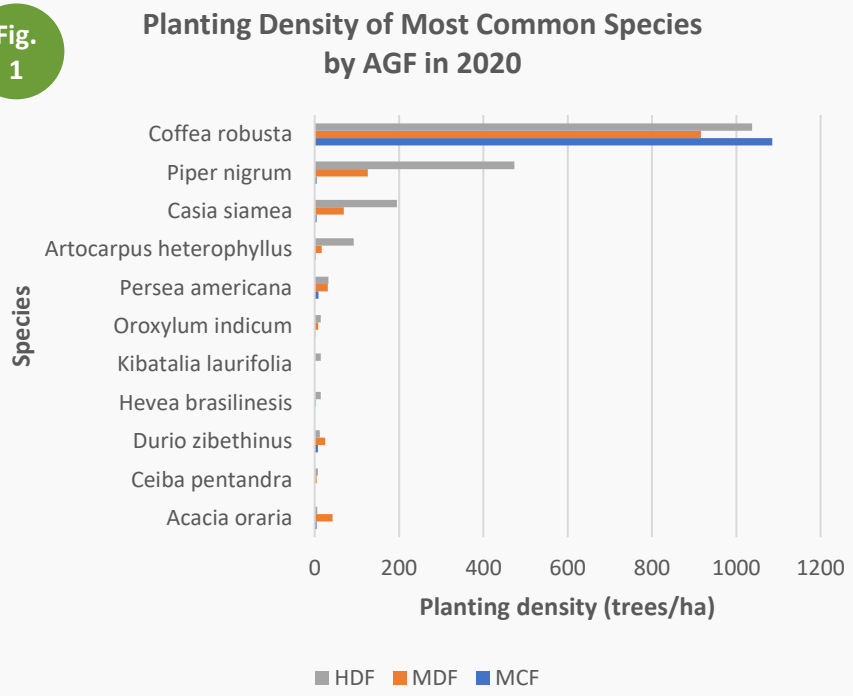
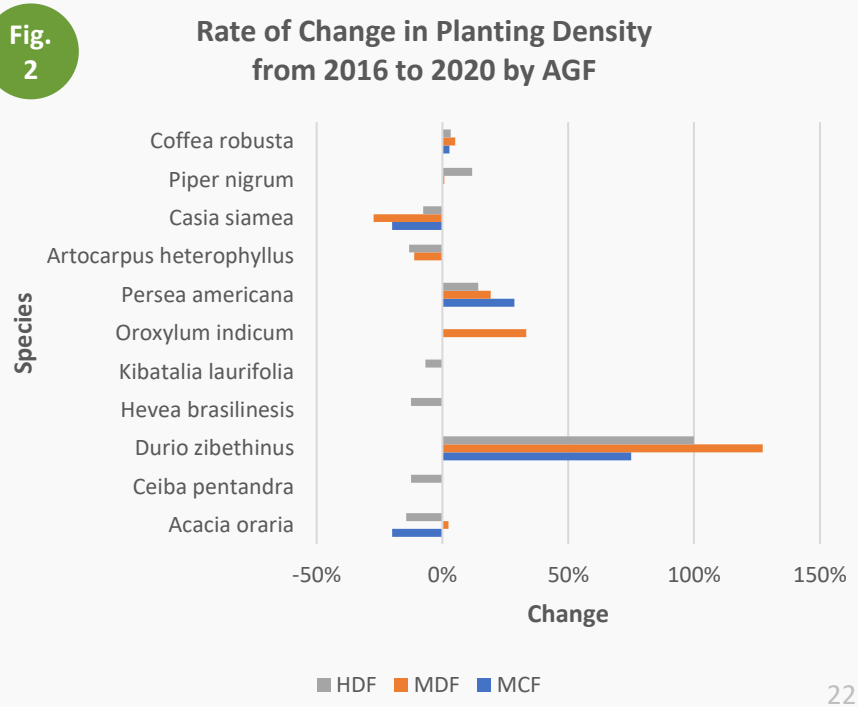
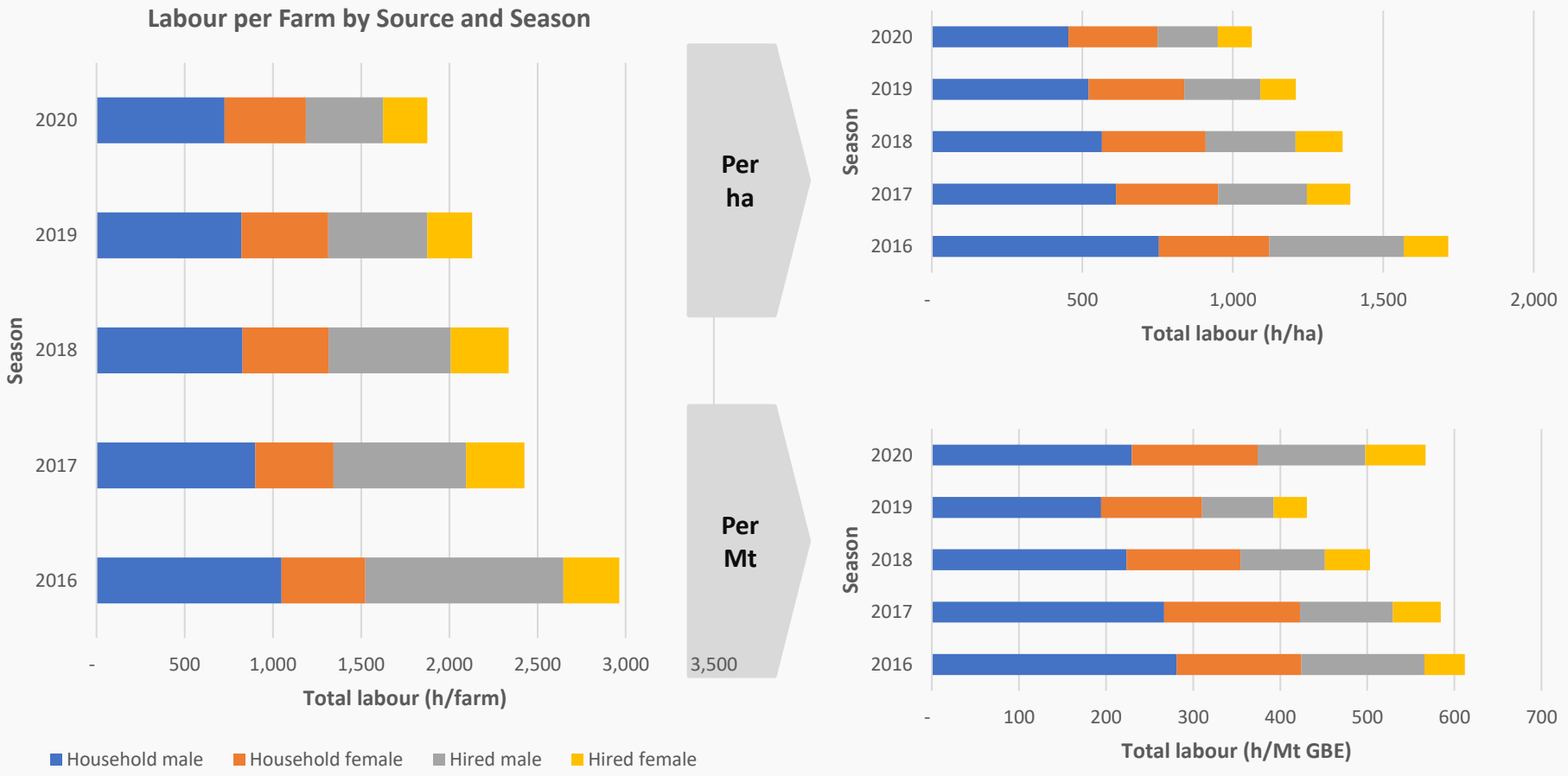


Fig. 2



Results
Farm Management

Farm management: Labour use has gone down per farm and per ha, but not per Mt GBE, indicating that yields have declined. On a per farm basis, the largest drops are on use of male hired labour (22%) and males in the household (12%)



Farm management: We see what we think is a slight Covid-19 effect with lower than usual hired labour after the epidemic declaration was issued by the PM in week 5, but this dissipates again in week 12

- Determining the effects of Covid-19 is tricky as all farmers were subjected to the same global emergency.
- On February 1st (week number 5) Vietnam recorded its first recorded domestic transmission of Covid-19, earlier cases were all "imported". In response, the country went into emergency mode with the signing of an epidemic declaration by the Prime Minister.
- We plotted weekly total and hired labour use, comparing the 2016-2019 average with 2020 (Fig 1&2).
- We see a shift in week 2 resulting from drier weather and one in week 45 because of a slightly delayed harvest. Otherwise, the total labour lines look similar. Weekly oscillations in 2020 are more pronounced, but that's an effect of averaging the 2016 to 2019 values, which smooths them out.
- A third difference is more intriguing. What does seem to have happened is that farmers practiced distancing by reducing the amount of hired labour they use (Fig 3). For a period of about 7 weeks after the first domestic Covid-19 transmission in week 5, hired labour is noticeably lower than in earlier seasons (Fig 2). Thereafter the 2020 line again tracks the 2016-2019 average.
- We also analysed the occurrence of child labour, but this is negligible in all seasons and shows no significant increase ($p<0.01$) in the 7 week period when hired labour was reduced, or over the 2020 season as a whole.

Fig. 1

Weekly Total Labour Mean From 2016 to 2019 Versus 2020

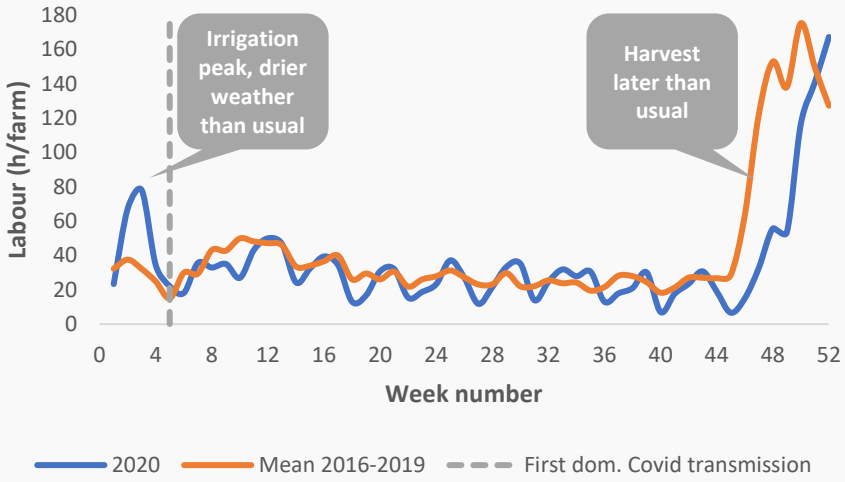
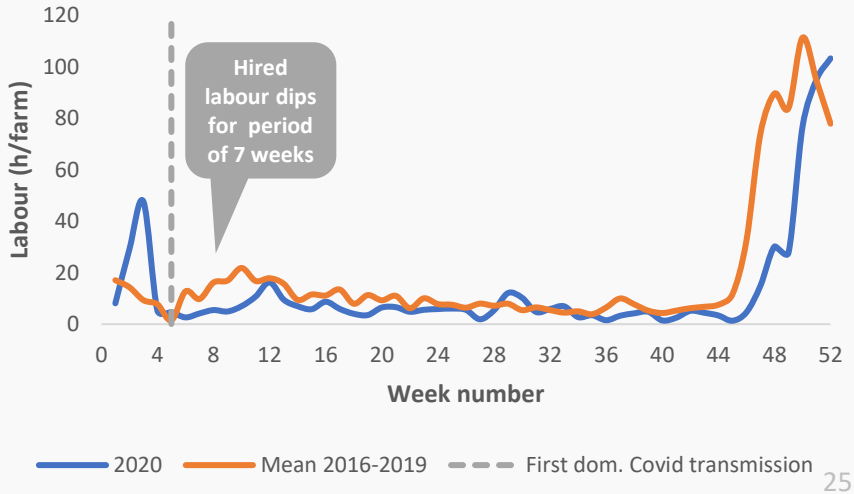


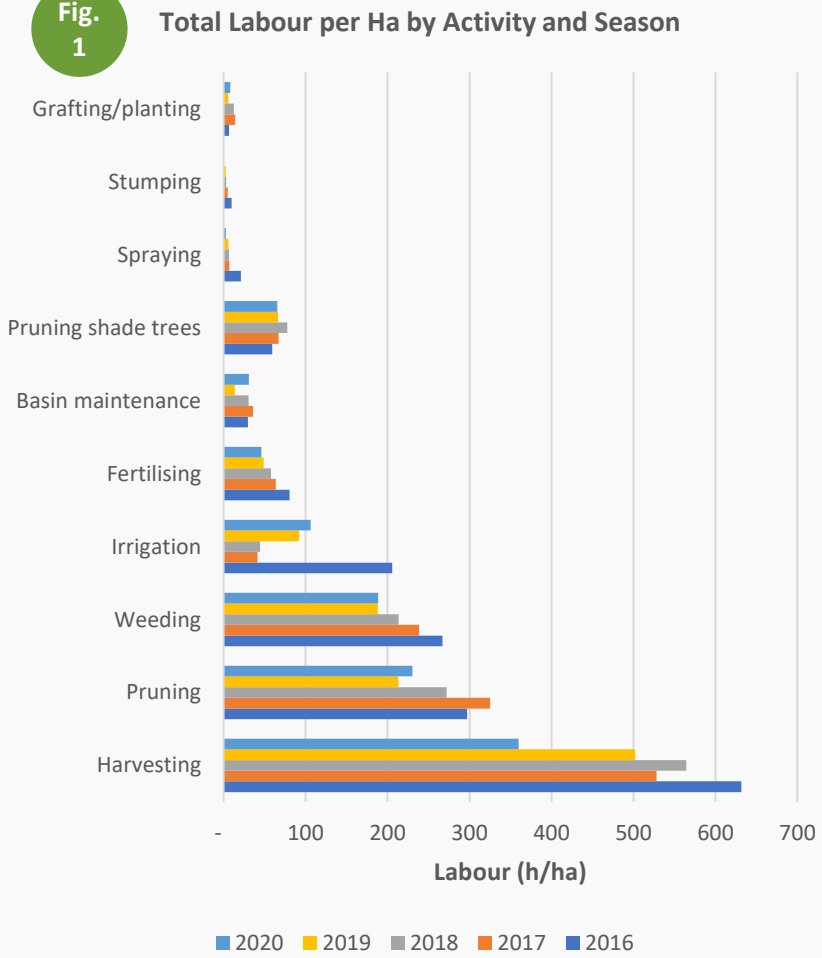
Fig. 2

Weekly Hired Labour Mean From 2016 to 2019 Versus 2020



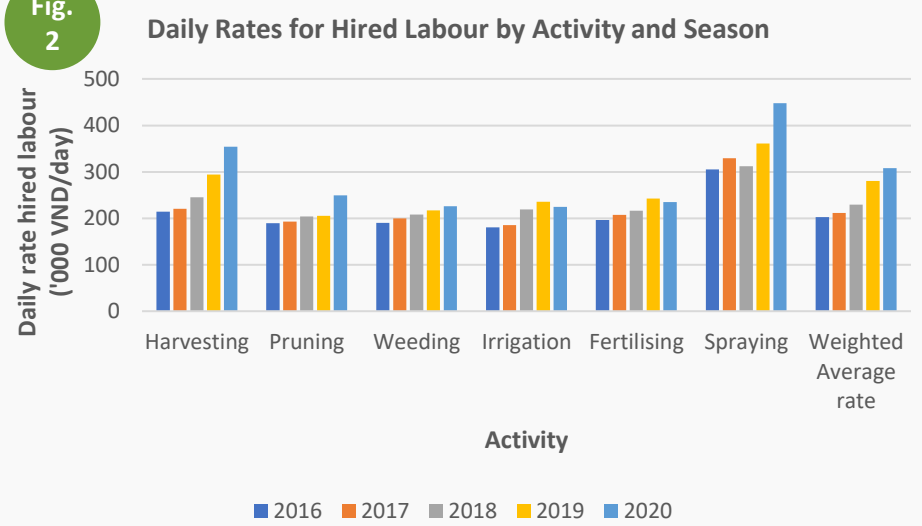
Farm management: Nearly all of the decline in labour use is due to a reduction in harvesting. The weighted average rate for hired labour comes in at just over 308,000 VND/day, an increase of 32% since 2016

Fig. 1



- Nearly all of the decline in labour use is due to a reduction in harvesting labour time as yields have gone down (Fig 1).
- We see an increase in the use labour for irrigation. Many farms in Lam Dong only irrigate in years with adverse weather conditions, the increase in irrigation labour suggests that weather conditions during last year's flowering period were sub-optimal.
- The change in rates for hired labour is significant ($p<0.05$). The weighted average rate comes in at just over 308,000 VND/day in 2020 (Fig 2). An increase of 32% after accounting for inflation.

Fig. 2



Farm management: Despite more costly hired labour, we see no large shift in the share of farmers that use hired labour. Harvesting efficiency has improved significantly, off-setting the reduction in total labour used for it

- Despite a 32% increase in the weighted average daily rate for hired labour, the share of farmers using hired labour has barely moved: 92% in 2016 versus 89% in 2020 (Fig 2).
- We do find that for specific activities hired labour use has shifted somewhat: Harvesting labour in particular, which became 20% more costly compared to the previous season in both 2019 and 2020 (Fig 1), sees a steady decline from a peak of 92% of farmers using hired labour for harvesting in 2017 to 73% in 2020 (Fig 2). Given that yields changed by a smaller rate, we expect the harvesting efficiency, i.e. the amount of cherries harvested per hour worked, to have increased. This is indeed the case, with a steady increase from 27 kg/h in 2016 to 41 kg/h in 2020 (Fig 3). We suspect this change may also be driven by declining coffee prices.
- Another notable change is that while 24% of farmers used hired labour for spraying in 2016, this has dropped to just 4% in 2020. This is primarily driven by a significant reduction in pesticide applications and not by shifting from hired labour to household labour for this activity.

Fig. 1 Change of Daily Rate on Previous Season by Activity

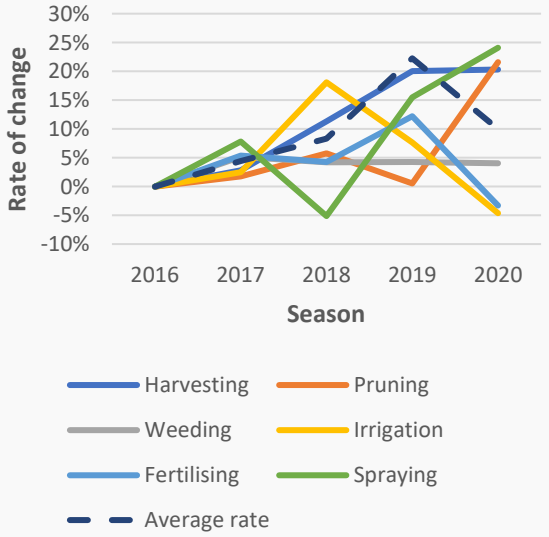


Fig. 2 Share of Farmers Using Hired Labour by Activity and Season

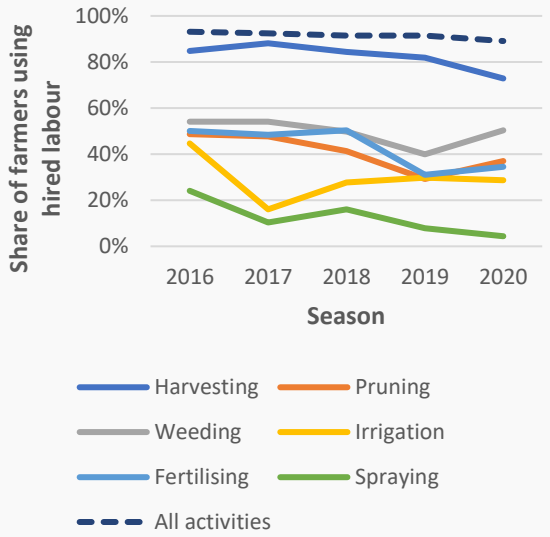
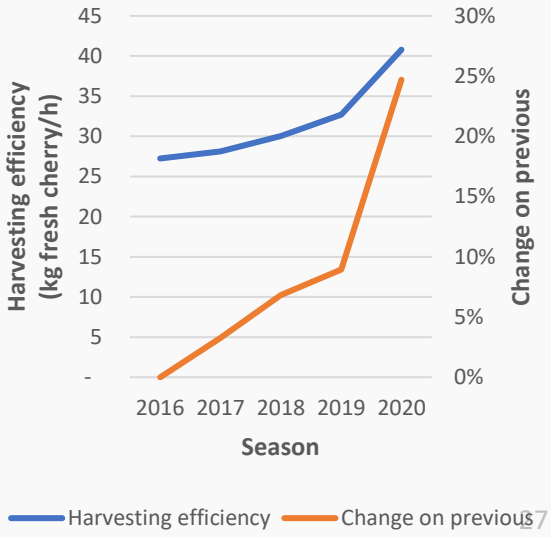


Fig. 3 Harvesting Labour Efficiency by Season and Change on Previous



Farm management: On average male workers earn slightly more per day. The gender wage gap has gone down, but tends to be higher on female-owned farms

- Average daily rates for male hired labour are a bit higher than for female hired labour (314,000 VND/day versus 299,000 VND/day), both sexes have seen a large rate increase in 2020, but less than what we observe in 2019 (Fig 1).
- The gender wage gap is calculated by subtracting the median rate for women from the median rate of men and dividing this by the median rate for men. Back in 2016 this reached 8.4% and after some fluctuations is now 4.9% (Fig 2).
- It appears to matter what the gender of the farm owner is. On male-owned farms we see a consistent downward trend on the gender pay gap, to the point where women were paid more in 2020 than men, while in 4 out of 5 years, female-owned farms show greater gender pay gaps (Fig 3).

Fig. 1

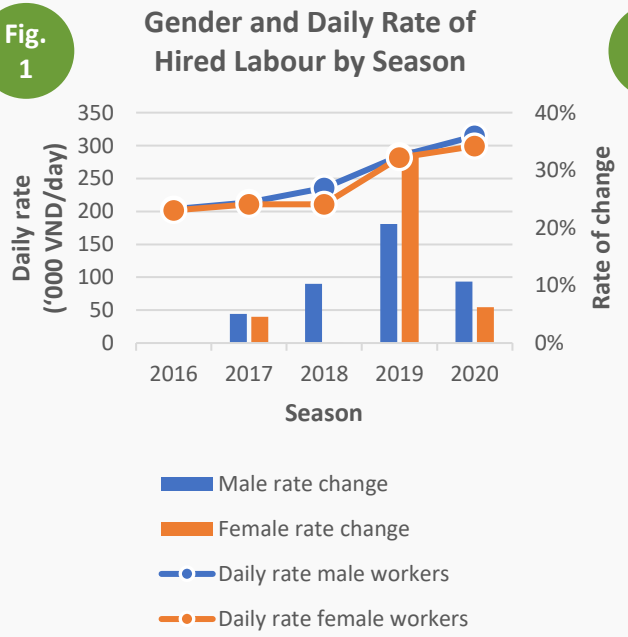


Fig. 2

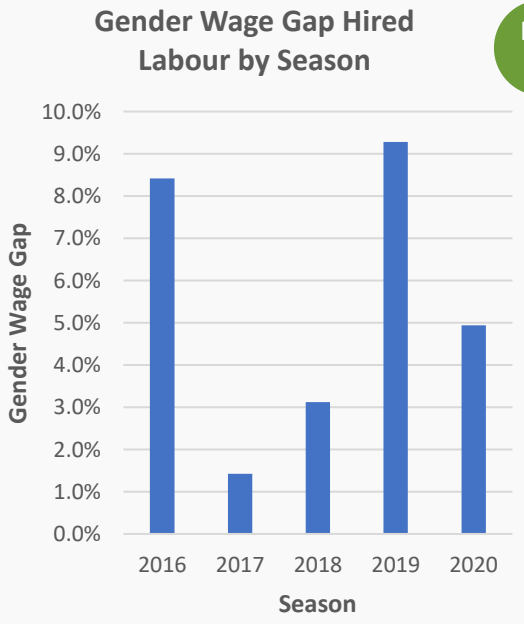
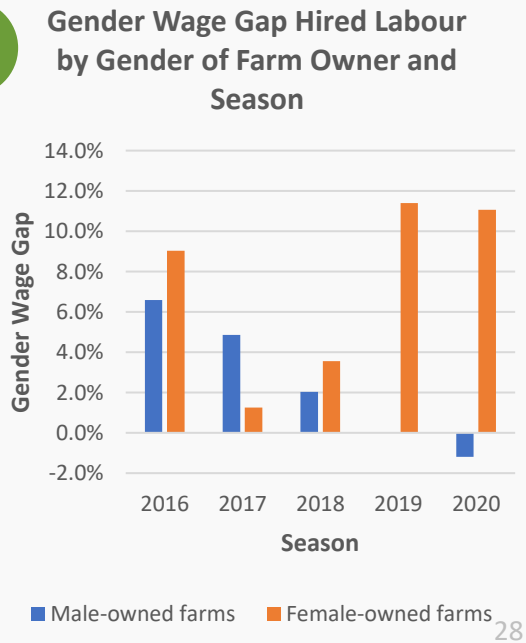


Fig. 3



Farm management: The share of farmers who spray pesticides has reduced significantly in both provinces without any apparent ill effects on yield

- In Dak Lak, 43% of farmers were spraying pesticides in 2016, this has gone done steadily over the past season to the point where no pesticides were used at all in 2020 (Fig 1). Insecticides and fungicides tend to be used by the largest group of farmers (Fig 3).
- In Lam Dong, prevalence of spraying pesticides is much higher, with 71% of farmers that spray in 2016, but also there a strong reduction is observed, with 34% continuing the use of pesticides in 2018.
- Worthwhile to note is that strong reduction in the use of pesticides in both provinces does not appear to have an ill effect on yields (Fig 2). Of course, we can not know the counter-factual scenario of what would have happened to the yields of farmers who sprayed, had they not done so. Still, the fact that none of the Dak Lak farmers sprayed while yield levels are comparable to previous years gives a strong indication that spraying is probably not needed on most farms.

Fig. 1 Share of Farmers Spraying Pesticides by Season and Province

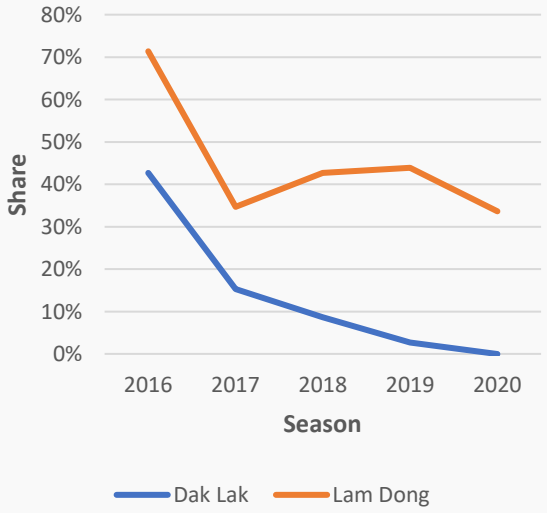


Fig. 2 Yield by Use of Pesticides, Province and Season

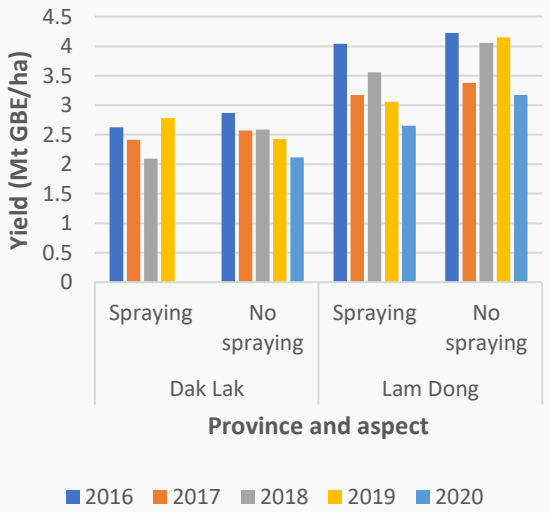
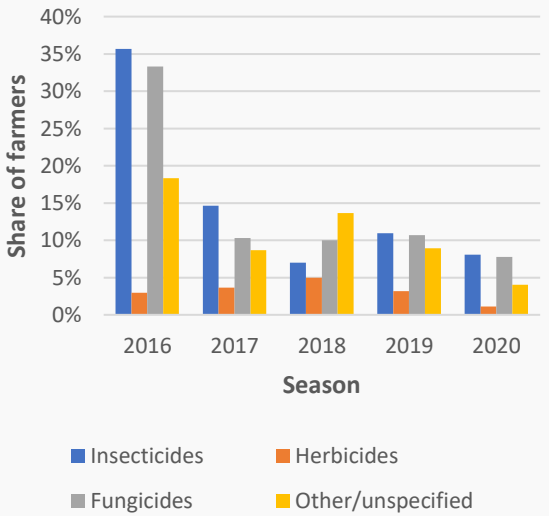


Fig. 3 Share of Farmers Using Types of Pesticides by Season



Farm management: Use of the most dangerous pesticides has reduced significantly, violations of standard requirements are increasingly rare. Some mis-use of pesticides continues to be present but is on a down-ward trend

- Spraying materials that farmers indicate to have used in the FFB are compared, based on their Active Ingredient, to lists of Highly Hazardous Pesticides (HHPs) from the Pesticide Action Network, lists of Active Ingredients banned by Rainforest Alliance and 4C and national legislation in Vietnam. Back in 2016, we still found 7% of farmers using pesticides banned by standards, this has gone down to zero in 2019 and 0.3% (i.e. a single farmer) in 2020.
- Likewise, the use of HHPs has declined significantly ($p<0.05$; Fig 1).
- We continue to see 5% of farmers that spray using pesticides that are not fit for the purpose to which they are applied (e.g. spraying an insecticide to control a fungal disease), but this is also on a downward trend (Fig 2).

Fig. 1

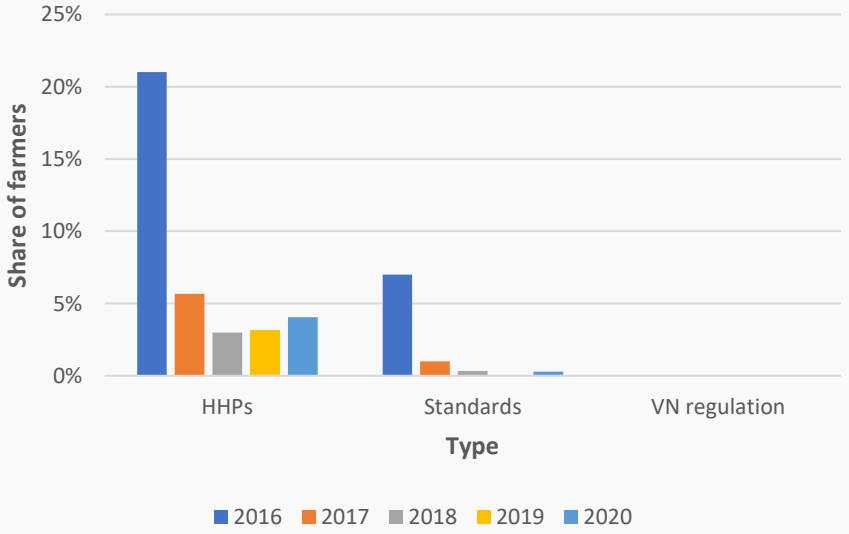
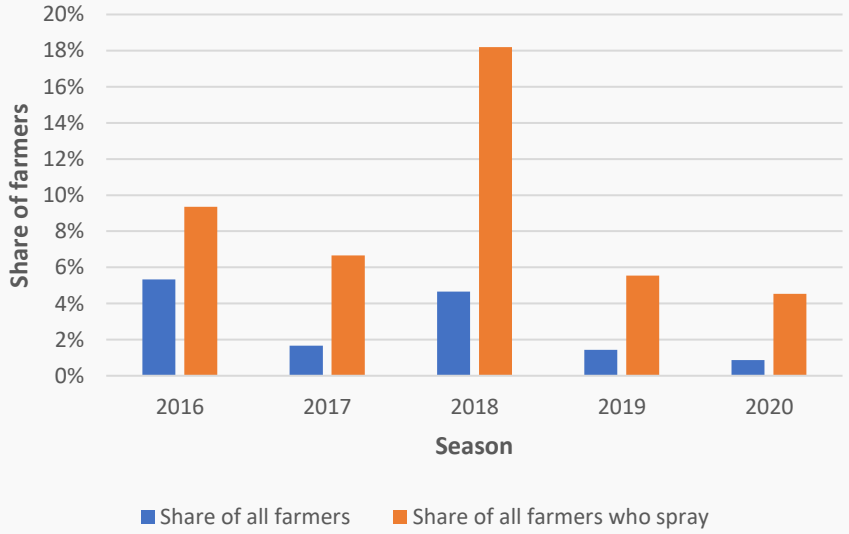


Fig. 2



Farm management: Irrigation volume per tree and per Mt GBE was reduced significantly from 2016 to 2018, but in 2019 and 2020 when conditions were adverse, irrigation volumes picked up again

- Irrigation volumes are estimated by farmers themselves, by keeping track of the time their pump is running and multiplying that by their pump's capacity. This is not the most accurate measure, but in the absence of wide-spread use of flow meters, it is the best we can do. On the upside, we do see a strong correlation (0.58) between water volume pumped and energy use, indicating that the recorded values are internally coherent.
- Across the sample, farmers applied 1,020 l/tree (in total, spread over multiple rounds; Fig 1), but although both provinces show the same trend, the actuals per tree in Dak Lak are about double from what they are in Lam Dong in very dry years (2016 and 2019, 2020).
- The first season was an exceptionally dry one, resulting in high irrigation volumes. In the subsequent two seasons conditions were more favourable, but in 2019 and more so in 2020 adverse weather conditions during flowering resulted in higher irrigation water applications in both provinces (Fig 2).

Fig. 1

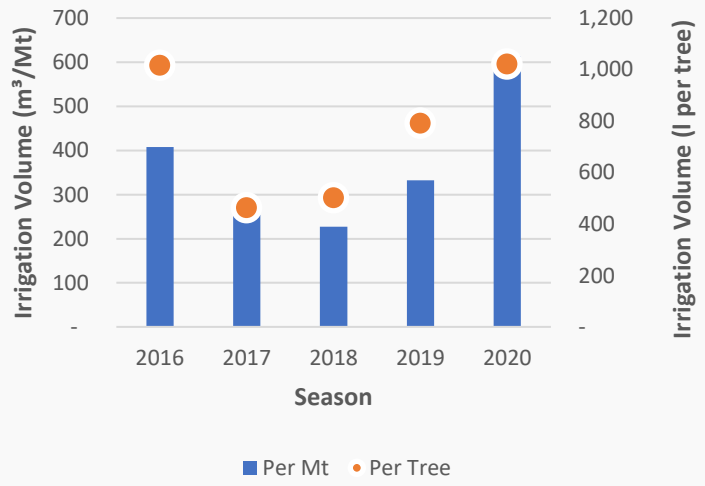
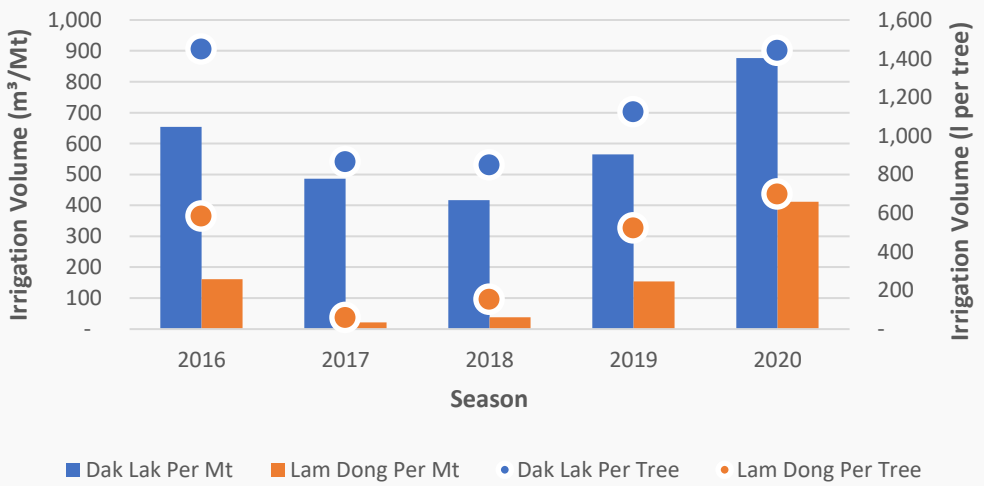
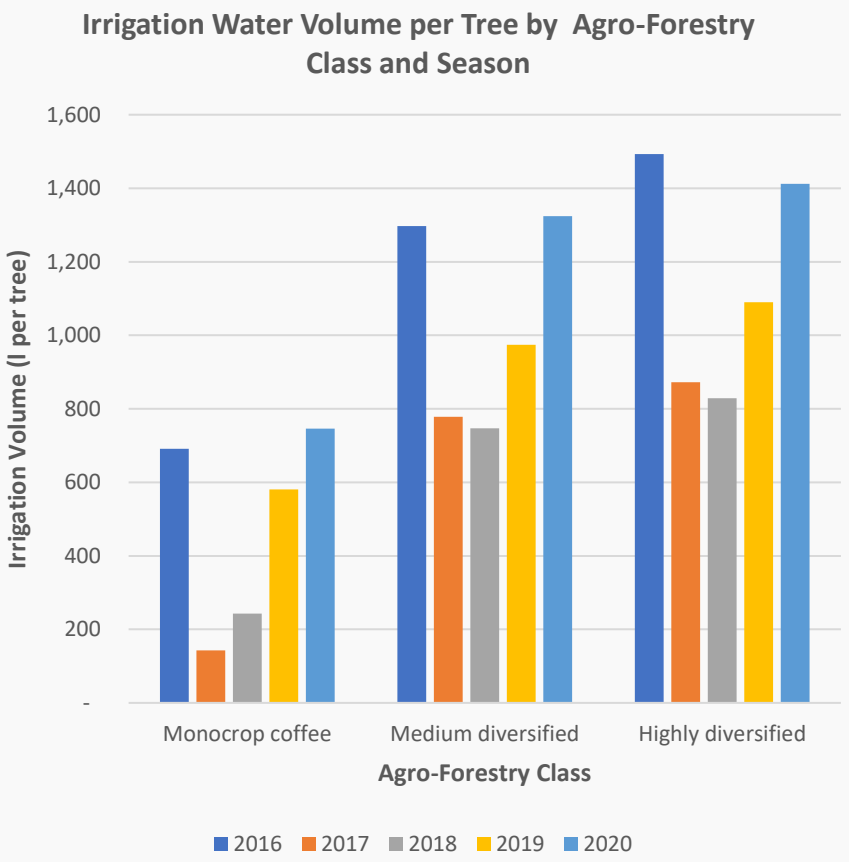


Fig. 2



Farm management: Diversified farming systems use significantly more irrigation water, it is unclear how this affects the notion that using more shade can enhance climate change resilience



- A central tenet of many climate change resilience programmes in coffee is that by increasing the level of shade, farms can be made more climate change resilient.
- At first glance this makes sense, and under certain conditions it may well apply. What we found however, is that when we build a regression model with irrigation water use (in l/tree) as the dependent variable and use the location (province) and Agro-Forestry class as explanatory variables, we find that more diversified farming systems are associated with higher irrigation water use ($p<0.01$), while controlling for location. The latter is critical, as Dak Lak farmers tend to have to irrigate more and also have more Highly Diversified farms.
- It may well be that the increase in tree stocks, and associated leaf area, contributes to greater rates of evapotranspiration, necessitating higher rates of irrigation.
- We can't be completely sure of this, but what is interesting in this respect is that when we add total labour per ha for pruning of shade trees to the model, it also comes out as significant ($p<0.05$), but with a negative coefficient. This indicates that more pruning of shade trees (which reduces the leaf area and hence potential evapotranspiration) is associated with lower irrigation water use.
- Given the growing importance of identifying suitable climate change adaptation strategies the topic of shade management seems to require more attention.

Farm management: In the Lam Dong FFB areas, irrigation is an incidental activity driven by seasonal weather patterns, while in Dak Lak nearly all farmers need to irrigate every year

- Figure 1 shows the farmers in the sample, sorted by their irrigation water use from small to large. On the vertical axis we plot the share of total irrigation water used by each individual. What this shows, amongst others, is that in 2017 and 2018 the first 130 and 105 farmers in the ranking respectively did not irrigate at all (hence 0% of the water use), but in drier years the annual distribution curve rises from the first farmers on. The non-irrigating farmers in those years are exclusively located in Lam Dong province.
- The consensus on optimal irrigation water volumes in Vietnam coffee is still under debate. What Figure 2 shows is that in none of the years we find a significant yield effect of irrigation, i.e. more irrigation water is not associated with higher yields. We suspect, that ample room for improvement of water-use efficiency remains.

Fig. 1

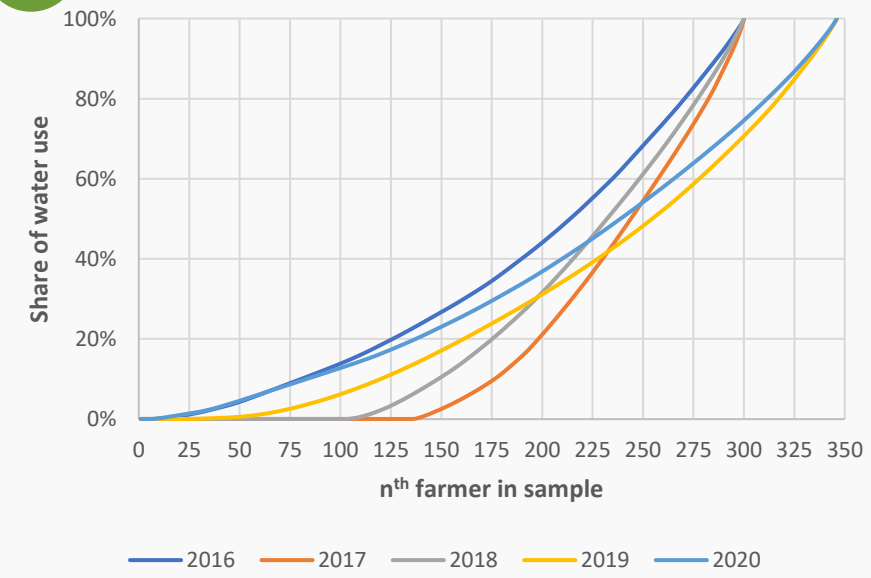
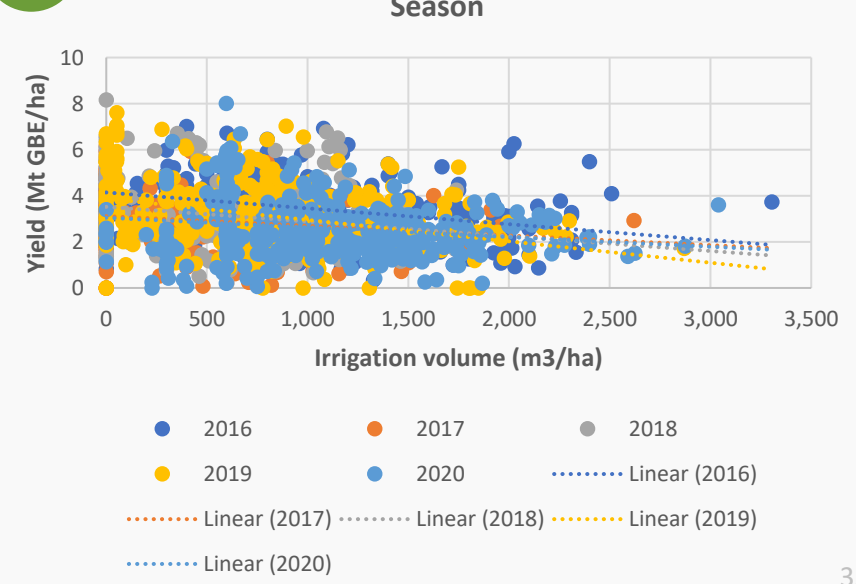
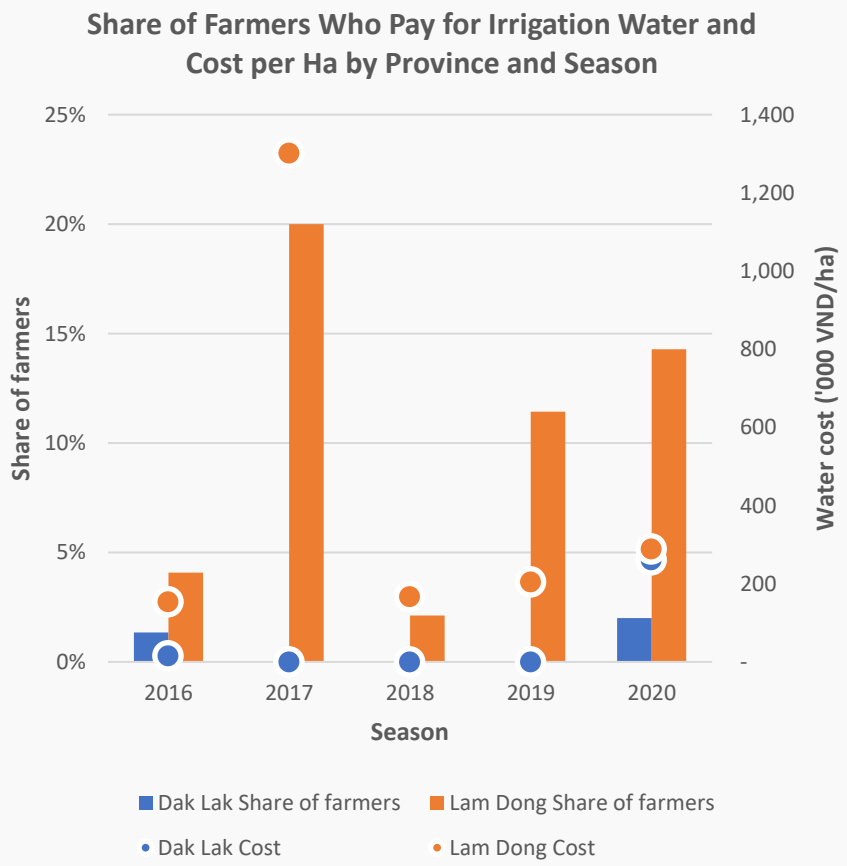


Fig. 2



Farm management: The occasional necessity of having to irrigate in Lam Dong seems to result in a group of farmers having to purchase water in times of need. In the most recent year, payments for water in Dak Lak also rose.

- We plotted the share of farmers by season that indicate to have spent money on buying water (or renting wells, which amounts to the same thing). Generally this group makes up less than 5% of those farmers that irrigate, but in 2017, 2019 and 2020 it exceeded 12% in Lam Dong.
- Amounts spent are not large in comparison with fertiliser or labour costs, but it could indicate that on some farms either water is becoming in short(er) supply and/or that farmers who previously did not need wells of their own may consider investing in them in the future.
- Another thing that stands out is that in 2020, for the first year in Dak Lak, farmers spent on average 288,000 VND/ha on water purchases, while in previous seasons this cost was either zero or very close to it.
- At this point we can conclude if this was a anomaly specific to the 2020 season or whether this is the start of period where water availability becomes a greater concern.
- We suggest that those interested in this topic monitor farmers' water payments to maintain a view on how the situation develops.



Farm management: Weed management strategies have shifted over the past 5 seasons with strongly growing use of brush cutters replacing manual weeding

- With hired labour becoming more costly, and by implication therefore also the opportunity cost of household labour, combined with lower coffee price, we find that farmers are economising on their labour investments.
- After harvesting, weeding is the activity that typically takes farmers most time. We would therefore expect to see reductions in labour for weeding. This proves to be the case: from 2017 to 2019 labour use for weeding went down by 10% to 12% each season.
- Of course, the need for weed control does not subside with higher labour costs, we see that farmers have shifted their weed management strategy towards greater use of brush cutters, as exemplified by the 9-fold increase from 2016 to 2020 in expenditures on fuel for weed control (Fig 2).
- This shift is broad-based, the share of farmers that indicate to have incurred energy costs for weeding went up about 5-fold from 9% to 46%

Fig. 1 Weeding Labour and Change on Previous Season by Season

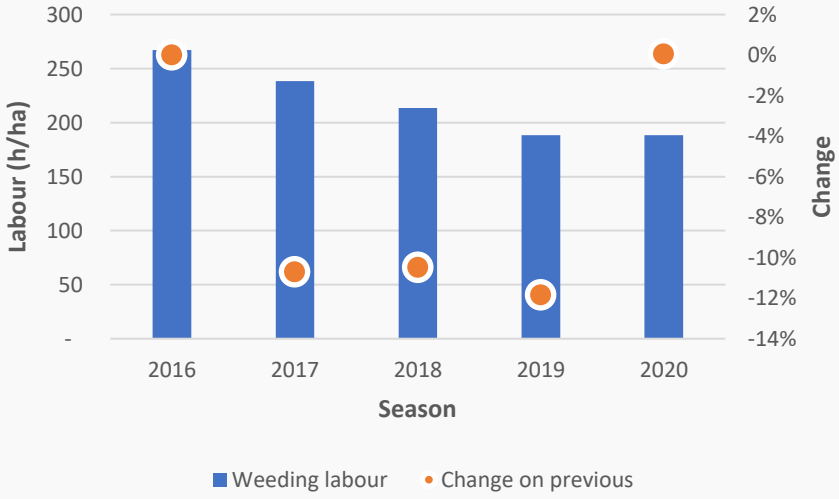
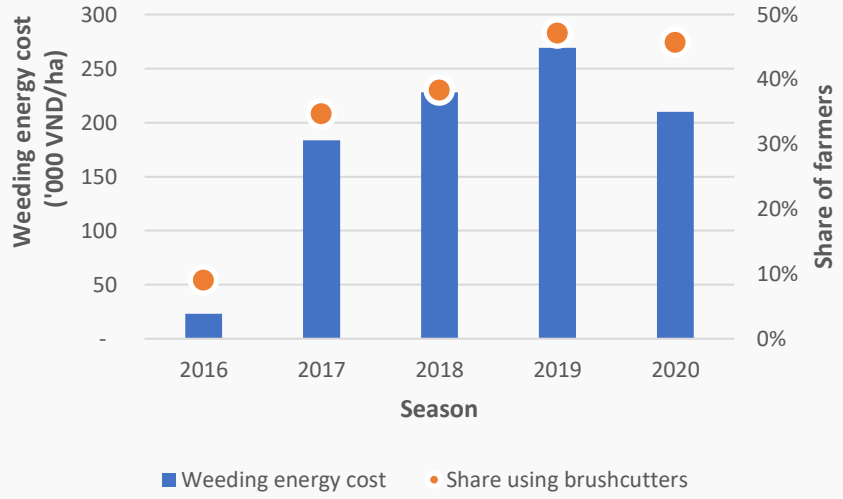


Fig. 2 Weeding Labour and Change on Previous Season by Season



Farm management: Pruning is critical to maintain high yield levels, pruning more is associated with both higher yields and margins

- In any of the five seasons at least 98% of farmers conduct pruning, which is the one of the most important things a farmer can do to stimulate production. As Robusta coffee cherries grow on 1 year old branches, stimulating the growth of these by judicious pruning is critical to remain productive.
- To look at long term effects we pooled farmers in five groups, with roughly 20% of the sample in each group, based on their pruning labour per ha. We then plot the 5 year average yield for each group (Fig 1). A Kruskal-Wallis test of normality for yield data across these groups is rejected ($p<0.01$), so we apply a Dunn test for stochastic dominance to determine if we find significant differences in the median yield values between groups.
- Letters in the graph indicate if yield levels differ significantly between groups ($p<0.01$).
- We find that most group comparisons by yield level are significant, such that more pruning is associated with higher long-run average yields ($p<0.01$).
- The only groups that do not differ in yield levels from one another are groups 3 and 4 and groups 4 and 5.
- The yield differential between the group that prunes least and those that prune most is 0.85 Mt GBE/ha with a mean difference in pruning labour investment of 463 hours, or 58 days.
- It could be that the additional pruning investment outweighs the margin (revenue minus total costs) differential that results from having higher yields, but we find the same pattern of significant differences on margins that we find on yields (Fig 2).

Fig. 1

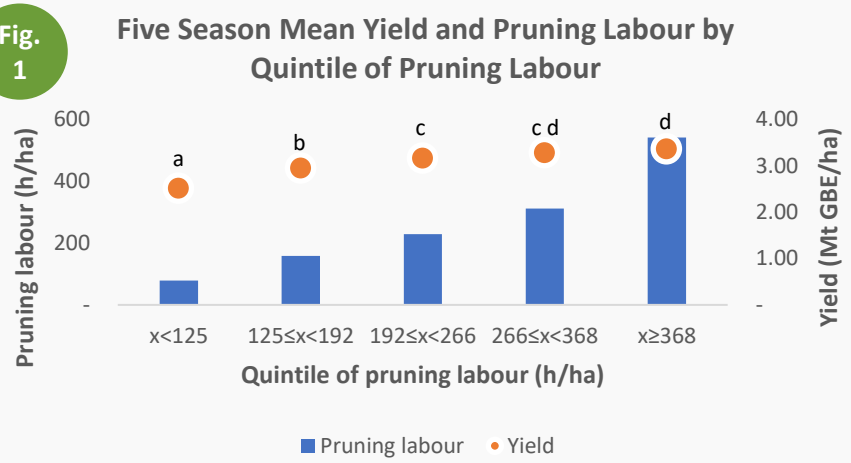
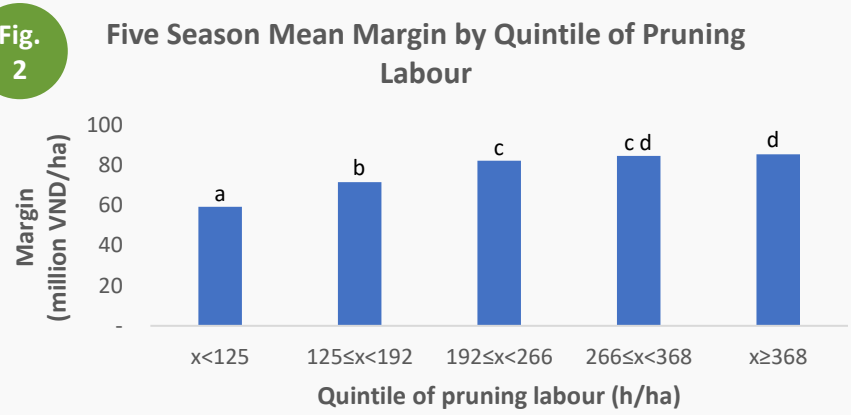


Fig. 2



Farm management: Nitrogen use has gone down significantly over time, coming closer to what we think are optimal levels. A yield drop in 2020 pushed up the NUE, but the trend from 2016 to 2019 indicates improved efficiency

- The nutrient balances are calculated by subtracting the amounts of nitrogen (N), phosphorus (P) and potassium (K) contained in the fresh cherry harvest from the volume N, P and K applied through fertilisers, compost and manure. This calculation does not take into account of the efficiency of uptake, availability to the tree and losses from leaching.
- For N we suspect an over-application of up to 100 kg/ha should be enough to compensate for such losses.
- N application in kg/ha has gone down significantly over time ($p<0.01$). Each pair-wise comparison (e.g. 2016 versus 2017, 2016 versus 2018, and so on) differs, except when comparing 2017 to 2018 and 2019 to 2020.
- Consequently, if we calculate the Nitrogen Use Efficiency (NUE), i.e. the amount of N used to produce 1 Mt of green coffee. We see a reduction from 136 kg to 98 kg/Mt GBE from 2016 to 2019, indicating improved efficiency.
- A challenge with optimising NUE is that fertiliser applications are made far in advance of the harvest. If yields turn out to be lower than expected at the time of applying fertiliser, the NUE may suffer.
- We think that helps explain the jump in NUE from 2019 to 2020. N applications per ha in 2020 were similar to that of 2019, but yields dropped, resulting in a higher NUE rate.

Fig. 1

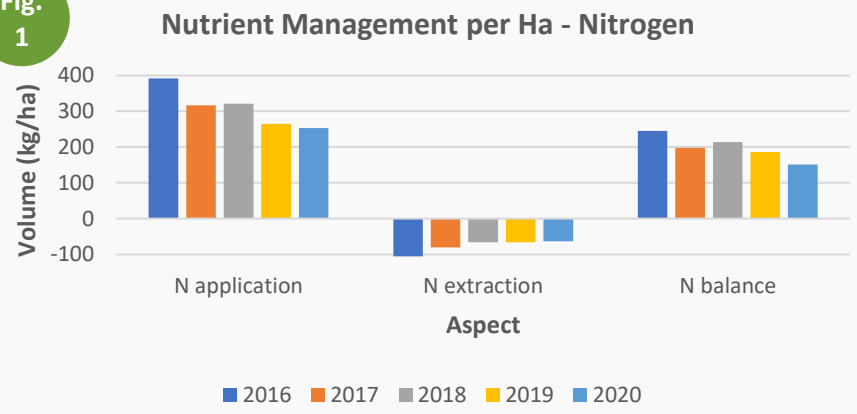
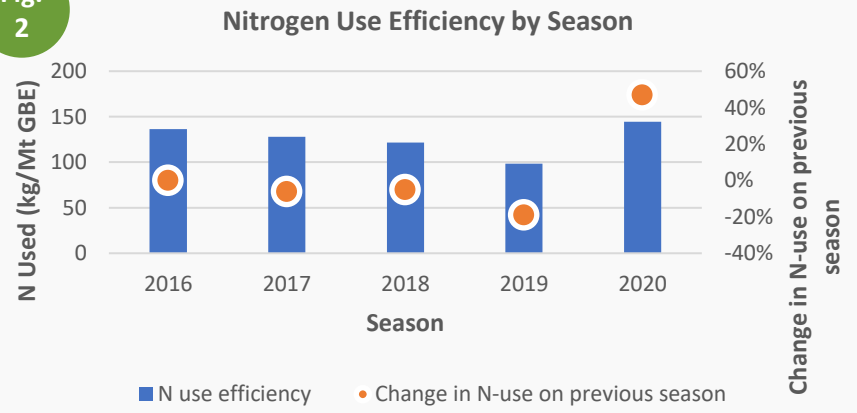


Fig. 2



Farm management: Improvements in N management are visible. The level of excess N application has gone down as did the share of farmers in this group

- In Figure 1 we plot N-balance observations by season and farmers rank, sorted from small to large. We see that over-application still occurs but has gone down. In 2016, we saw 54% of farmers with over application of N (defined as having an N-balance of >100 kg/ha). This share has dropped over the seasons and in 2020 came in a 35% (Fig 2), a significant reduction ($p<0.05$).
- Roughly a third of farmers remove more N during harvest than the apply, significantly more than the 22% in 2016 ($p<0.05$), while the share of farmers in or close to the optimal range has increased by 7 percentage points (or 15%) to 2016.
- The 36% of farmers in 2020 that under-apply N do so to a significantly lower degree than in 2018 and 2019. In those years the mean N-balance of the group that under-applies N was -104 and -112 kg/ha compared to -76 kg/ha in 2020.

Fig. 1

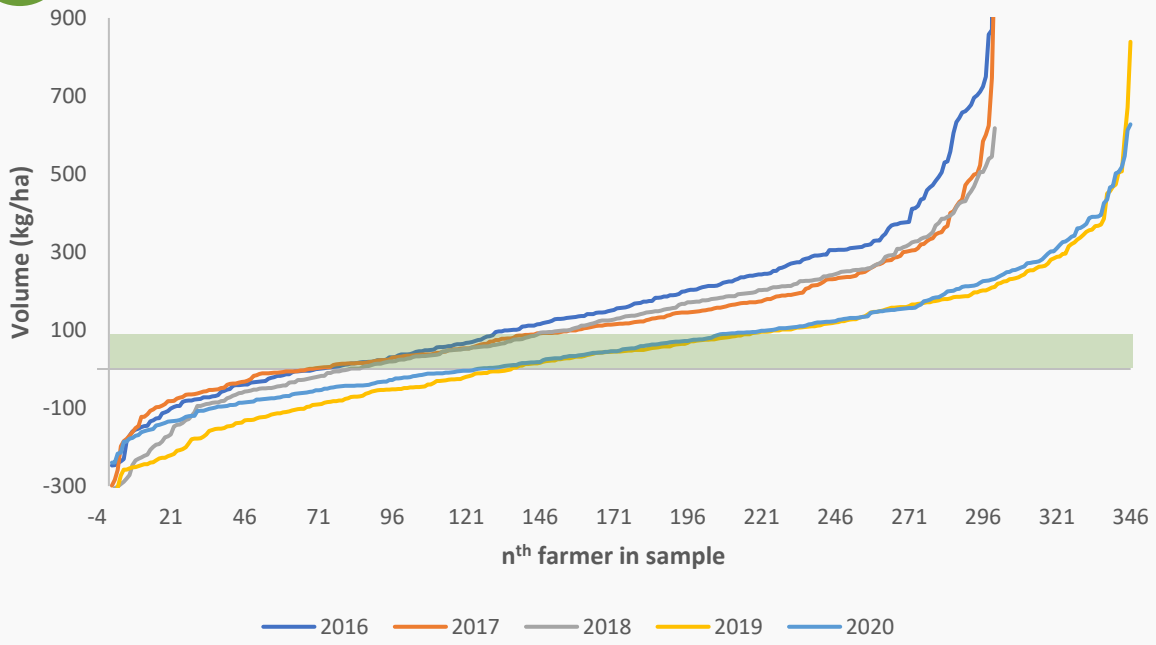
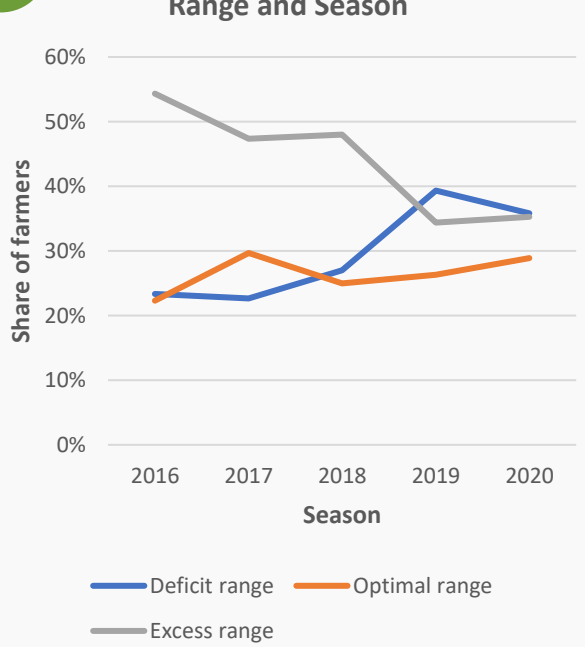


Fig. 2



Farm management: Yield, profit margin and fertiliser cost by N-balance range indicate that further improvement in optimising fertiliser application is possible

- In Figure 1 we plot yield levels by the N-balance range. As removal of N is driven by yield levels, it is not surprising to see high yield levels among the farmers in the deficit range. What is interesting to note is that yield level differences between the farmers in the optimal and excess range are minimal in all season expect for 2016.
- Figure 2 shows the fertiliser cost and profit margin, again by N-balance range. Here we find that too high fertiliser costs among farmers in the excess range depresses their profit margins.
- Margins among farmers in the deficit range are substantially higher, but multiple season deficits on a farm would likely result in yield drops as soil nutrient buffer stocks are depleted. Most farmers move between range types from one season to the next, so we can not determine the yield effect of being in the deficit range for a larger number of seasons.

Fig. 1

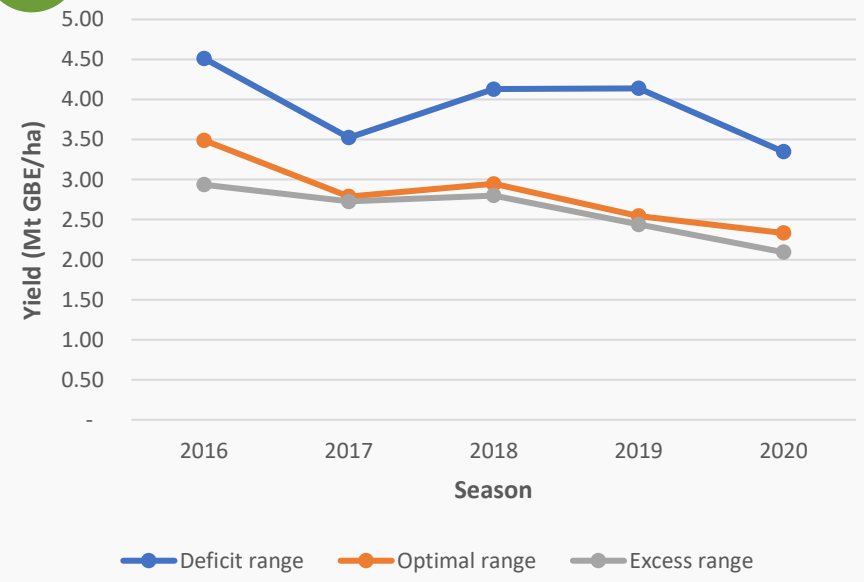
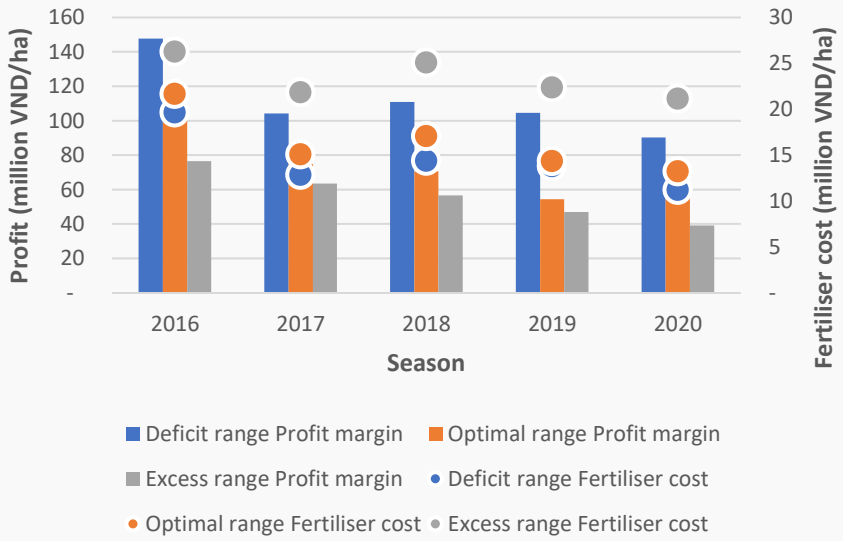
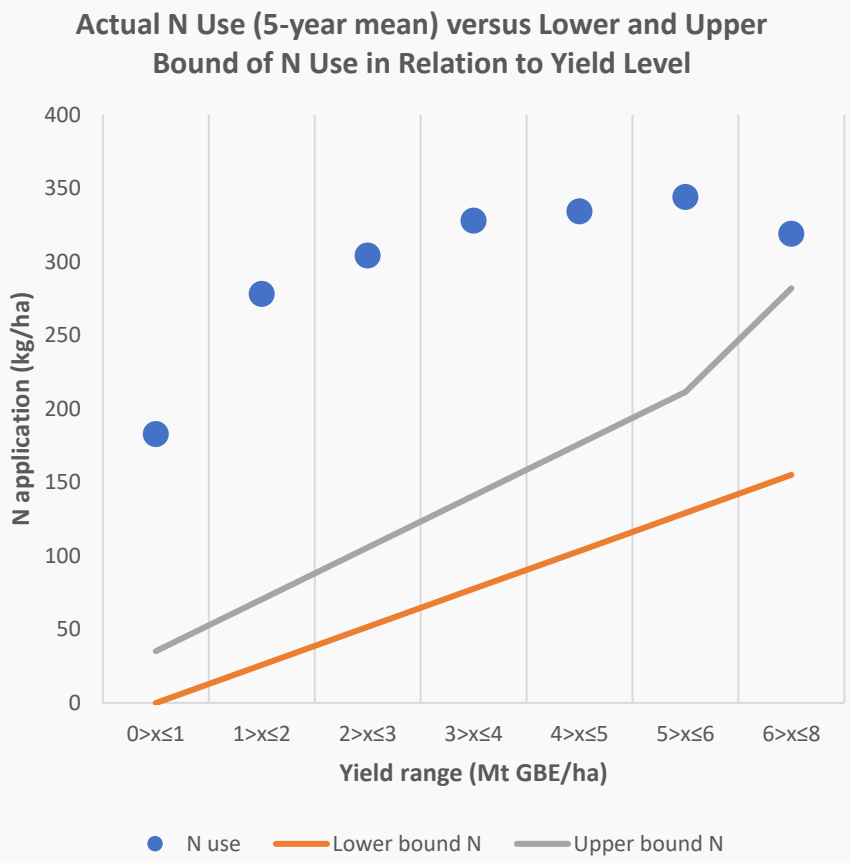


Fig. 2



Farm management: Over-use of N is present at all yield levels but more pronounced at lower yield levels

- Here we plot the yield level from 0 to 8 Mt GBE/ha versus the 5-year mean N usage per ha by range of yield.
- We also plot what we think is an optimal range. We define the optimal range as follows: the lower bound of N application is set at the level where the removal of N through harvesting is equal to the application from fertilisers, manure, etc, for the lower level of the displayed yield range. We calculate this using a value of 0.55% of N per kg of fresh cherry and convert this value to GBE.
- The upper bound is defined as the N removal for the upper bound of the displayed yield range plus 50% of N to account of application and uptake losses. This is to some degree an arbitrary number as we do not know exactly what share of N is used by the trees to form other biomass than cherries, how much of the application is actually available to the tree.
- With these thresholds, we find that over-use of N is more pronounced at low to mid yield ranges and tails off as yields increase, but is present under the above assumptions at all yield levels.



Farm management: Phosphorus over-application has gone down steadily, while potassium has increased relative to N and P, but the K-balance remains negative. This may be a yield limiting factor

- In line with recommendations in earlier company reports and the first ISLA programme report[6] the over-application of P has, on average gone down significantly from +105 kg/ha to +63 kg/ha (Fig 1).
- Potassium application has moved around from year to year, but displays a downward trend. Given the removals of potassium continuously exceed applications, this may well be a limiting factor (Fig 2).
- Indeed, yield modelling shows that larger K applications correlate with higher yields together with a number of other agricultural practices such as pruning. So, we think it remains advisable to stimulate farmers to carefully consider their K application and ideally run some tests on their own farm with higher k applications on a small number of trees to observe the yield response and adjust management accordingly.

Fig. 1

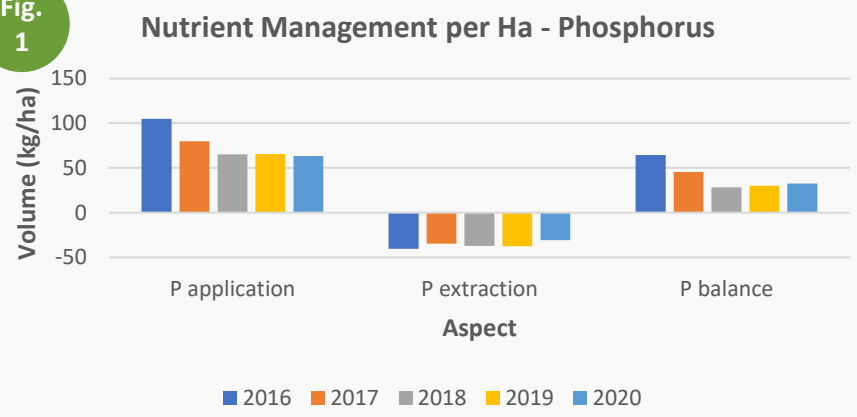
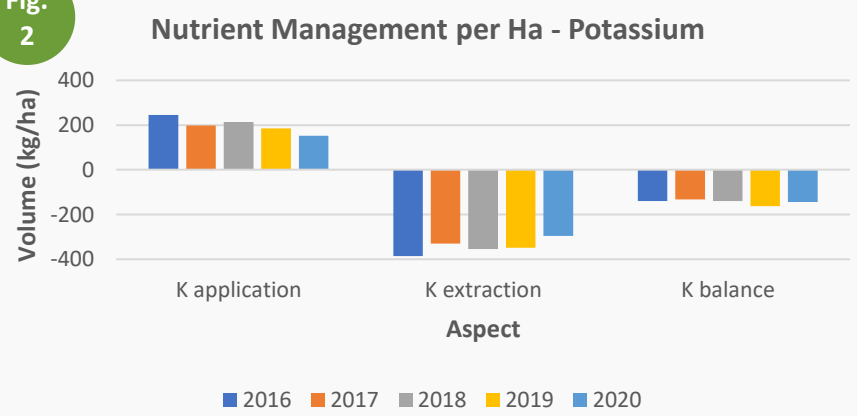


Fig. 2



Farm management: Organic material applications are back to 2016 levels after a dip in 2017. The share of farmers using it has gone up slightly

- Average organic material (manure, compost) application display a downward trend (Fig 1), both in terms of volume applied and the share of farmers applying it.
- If we split the organic matter application levels by AGF class, we see that monocrop coffee farmers had the highest organic matter application levels during the 2016 and 2017 seasons (Fig 2). This phenomenon is driven by a number of farmers in Lam Dong who use significant volumes of manure in addition to their regular fertiliser applications.
- The correlation between manure application and yields is not significant ($p<0.05$), probably because on many farms, nutrients as such are not a limiting factor (with the possible exception of K) and other practices like pruning have a greater effect on yield levels.
- We also analysed the 5-year mean yield by the number of seasons farmers applied organic material on their farm (Fig 3), but also here we find no significant difference between the categories. Farmers with 4 and 5 years of organic material use seem to have higher yields, but the sample size is too small to draw conclusions from.

Fig. 1 Share of Farmers Using Organic Matter and Volume Applied by Season

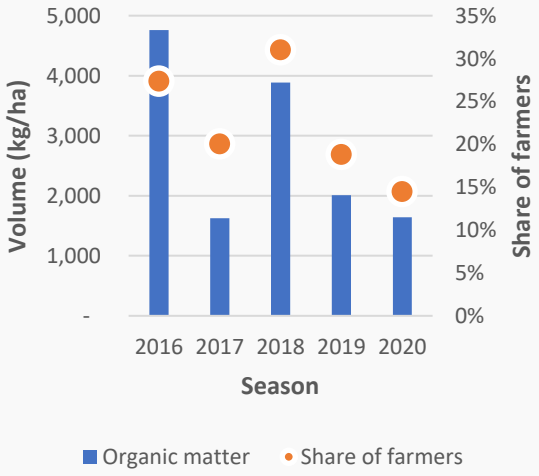


Fig. 2 Share of Farmers Using Organic Material and Volume Applied by Agro-Forestry Class and Season

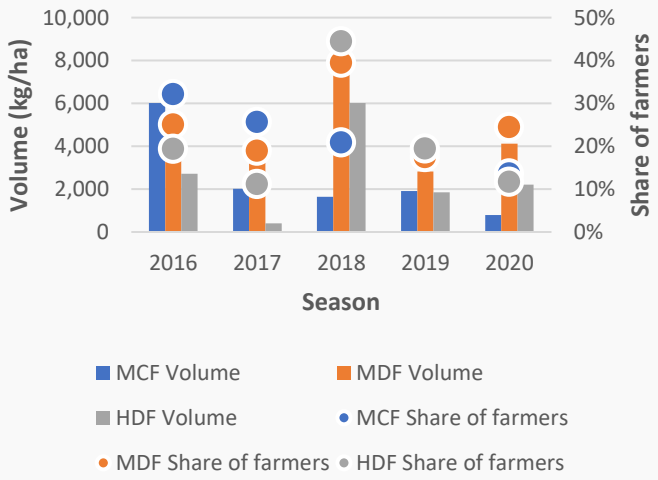
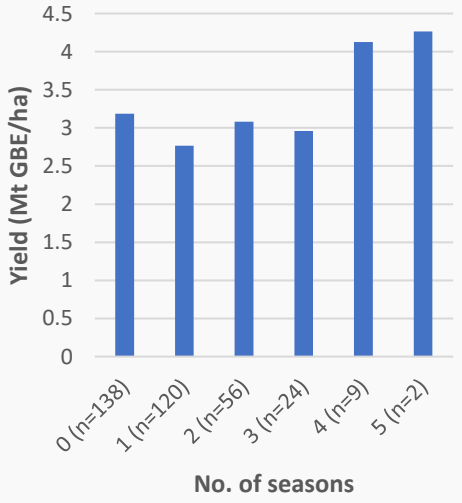


Fig. 3 Yield by Number of Seasons Organic Material was Used



Farm management: Rates of rejuvenation have declined in Dak Lak but are increasing in Lam Dong. Coffee tree stocks are either stable or growing in both provinces

- Some stakeholders in the Vietnam coffee sector are concerned about ageing plantations and an expected decline in production. In the FFB data we do not find a strong correlation between estimated year of planting coffee and yield. We also do not observe large-scale replacement of ageing trees with new ones. This suggests that farmers follow a strategy of gradual replacement.
- We calculate the rejuvenation rate by dividing the number of coffee trees (the sum of seedlings and grafts) used as material in the activity (re-)planting by the total coffee tree stock in a given season.
- The planting rate sits at around 3.6% in most seasons and the 5-year mean is 2.3%. Perhaps lower than what we would want, at a rate of 5% farmers would be on a 20-year productive cycle, which is typically considered optimal for high yielding Robusta coffee.
- Farmers can use seedlings or grafts to rejuvenate their farms. With grafts, production can resume more quickly and the genetic makeup of the graft is identical to that of the tree from which it was obtained. Initially seedlings were preferred by farmers, but increasingly grafts are being used. The data does display an odd jump in the share of grafts used in 2017, when 80% of all rejuvenated trees were grafted. If we ignore this anomaly, we find a gradual move over time towards more grafting. Both of the projects have trained farmers on grafting. We do not know how the uptake of grafting was outside of the projects, but we think there is a high likelihood that we are looking at a project effect here.

Fig. 1

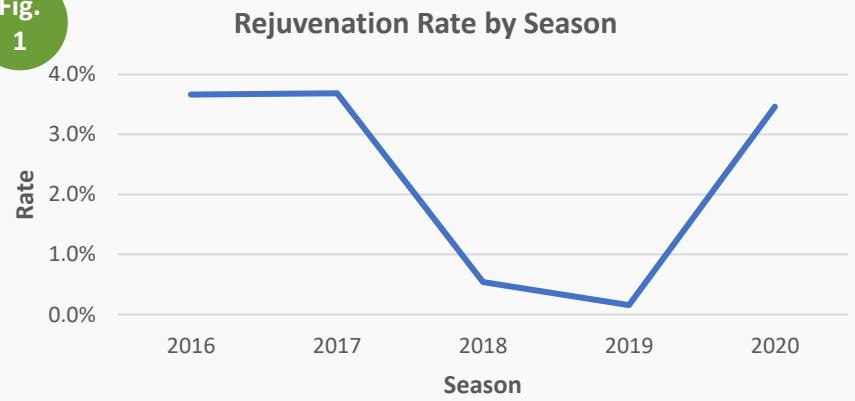
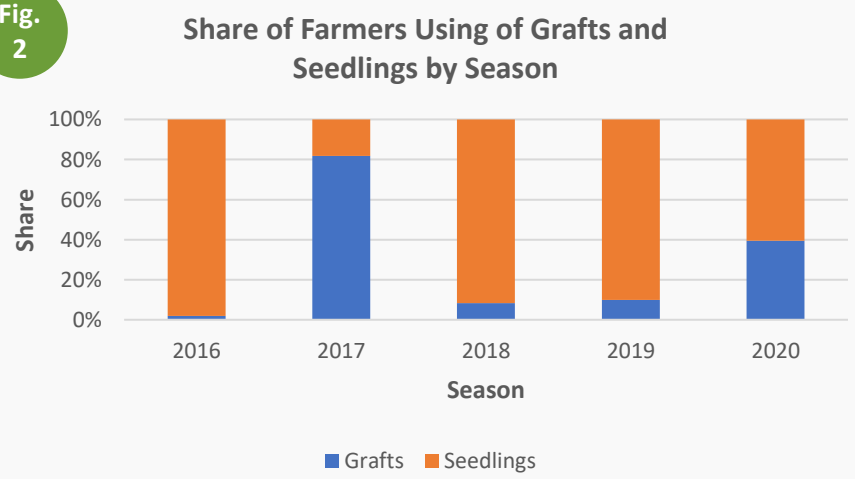


Fig. 2



Results
Production

Production: Average production is 5.71 Mt GBE/farm, while yield is 2.61 Mt GBE/ha. Differences between Dak Lak and Lam Dong are large

- In many origins one can find a significant correlation between farm size and productivity in which larger farms tend be less productive. This is not the case in Vietnam, which indicates that farmers with larger land holdings have sufficient capital and managerial acumen to manage larger scale operations.
- Production and yield levels in both provinces were at their lowest in the most recent season. In Lam Dong we observe something of a bi-annual bearing pattern, while in Dak Lak we see a weak downward trend over time.
- It appears that the most recent season was not a great one. Given the jump we saw in both the share of farmers that irrigated and the volume of irrigation water applied in 2020, it seems that unfavourable weather conditions are at least partly to blame for this.

Fig. 1

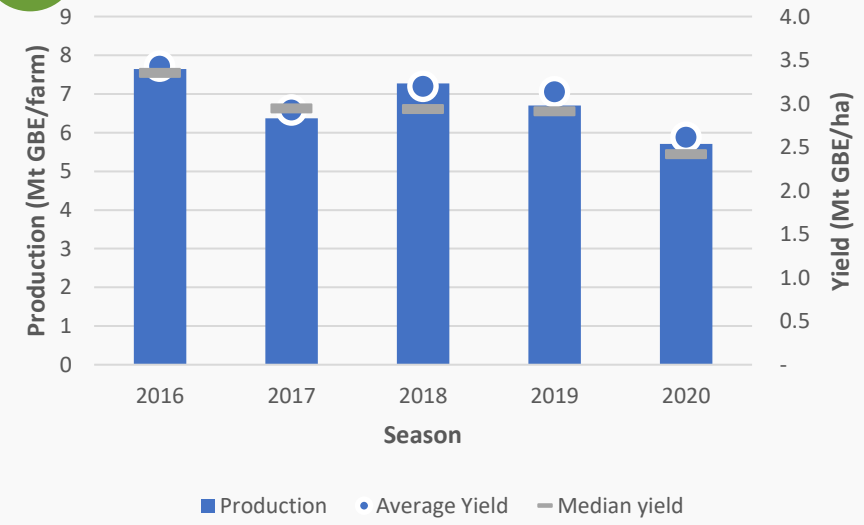
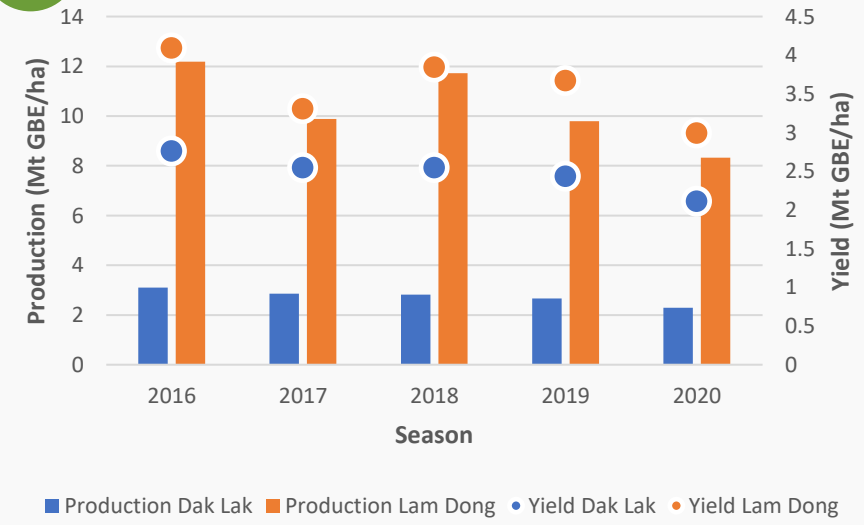


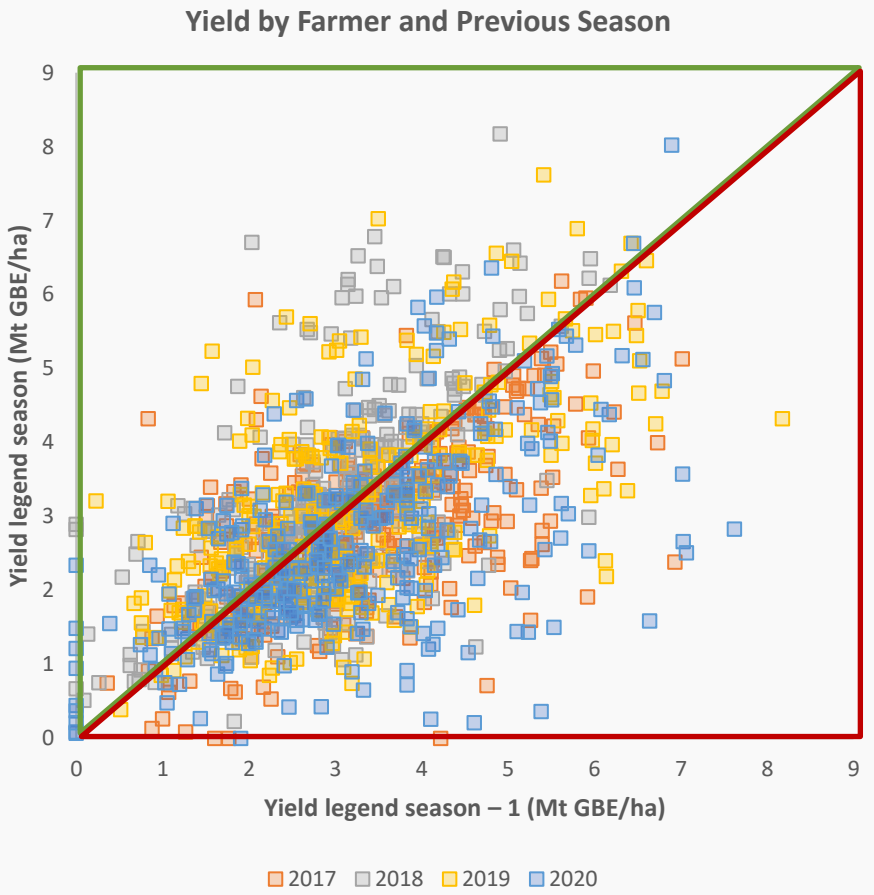
Fig. 2



Production: Normally, around half the farmers has a higher yield than the year before, the other a lower yield. Lam Dong shows an odd pattern in this regard.

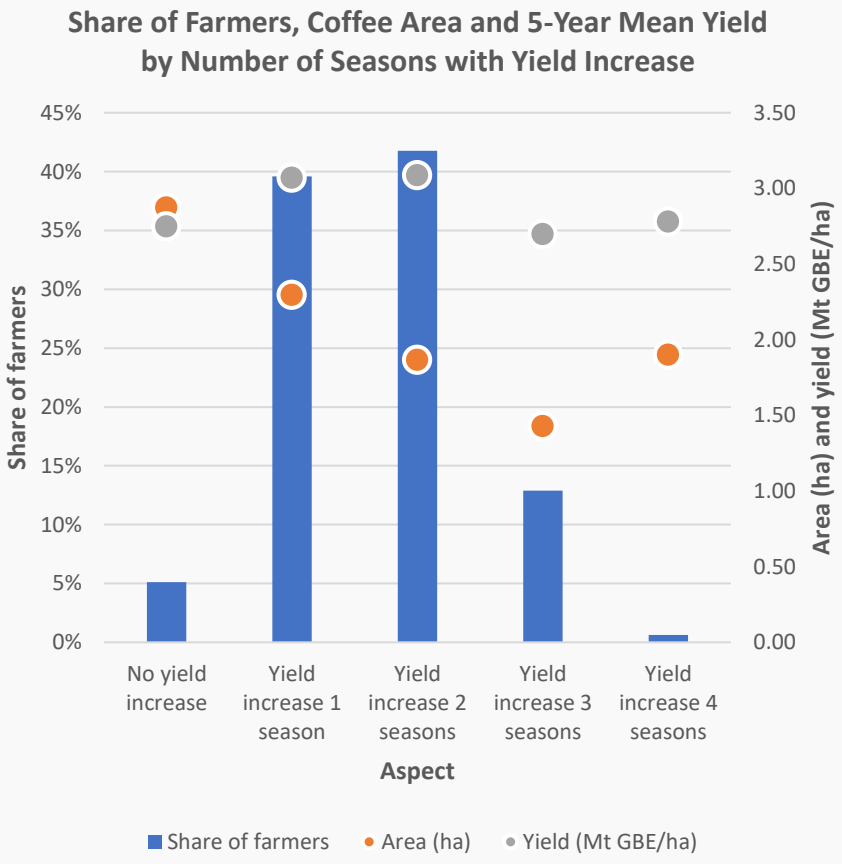
- The figure plots the yield in the one season compared to that in the previous season. The 2017 series therefore shows the 2016 yield in the x-axis and the 2017 yield for the farmers on the y-axis.
- The average yield decline we see in 2020, is broad-based with more than 70% of farmers in both provinces having lower yields in 2020 compared to 2019.
- Also note the shift in Dak Lak, whereas in earlier seasons the division between farmers with higher and lower yields was roughly 50/50, in 2020 it was closer 30/70. This strengthens our view that environmental influences are likely to blame.

Share of farmers		Season			
Province		2017	2018	2019	2020
Lam Dong	Higher yield	7%	77%	32%	22%
	Lower yield	93%	23%	68%	78%
Dak Lak	Higher yield	48%	47%	46%	27%
	Lower yield	52%	53%	54%	73%



Production: 55% of farmers have had 2 or 3 seasons with yield increases. Farmers with more seasons where yields increased tend to work smaller farms

- To better understand yield movements across seasons, we compared 5 year yield data for each farmer and analysed the number of seasons in which the yield was higher then the preceding season.
- Given that we have 5 seasons of data, the maximum number of seasons in which the yield was higher than in the one before is 4 seasons.
- In this category we have just 3 farmers (or 1% of the sample. We show it in order to be complete, but given the small sample in this group, they are not included in subsequent analysis.
- We hypothesise that on smaller farms, which tend to be more intensively managed, it is more likely to find a larger number of seasons in which yields increased.
- This turns out to be the case. Coffee areas are significantly smaller ($p<0.05$) with each additional season of yield increase (excluding the small group with 4 season increase).



Production: The 20% highest yielding farms are pruning significantly heavier, while stumping rate are mostly comparable

- We divide the farmers in 5 groups based on their yield level, such that each group has about 20% of the farmers in it. We then plot the yield levels. We generally see greater yield swings from one season to the next among the top-20% of highest yielding farms, but in each season their yield level easily exceeds 4 Mt GBE/ha (Fig 1).
- To better understand what sets the top 20% of farmers in terms of yield apart from the bottom 20% in terms of yield, aside from their location, we select pruning and stumping as management variables because these can have large positive (pruning) and negative (stumping) effects on yields in a season. Of course stumping should contribute to higher yields in later seasons as rejuvenated trees become productive again, but within a season it will have a depressing effect on yield.
- We find that investment in pruning as measured by the number of labour hours/ha is at least 50% higher on the top 20% of farms in all but the 2016 season. From 2017 onwards, stumping efforts do not help to explain the reason why yield are so much lower among farmers in the bottom 20%.

Fig. 1

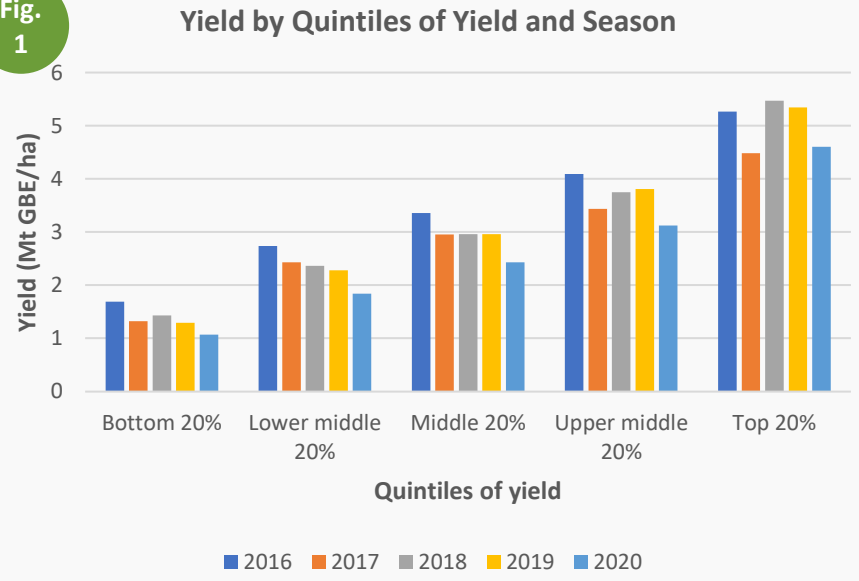
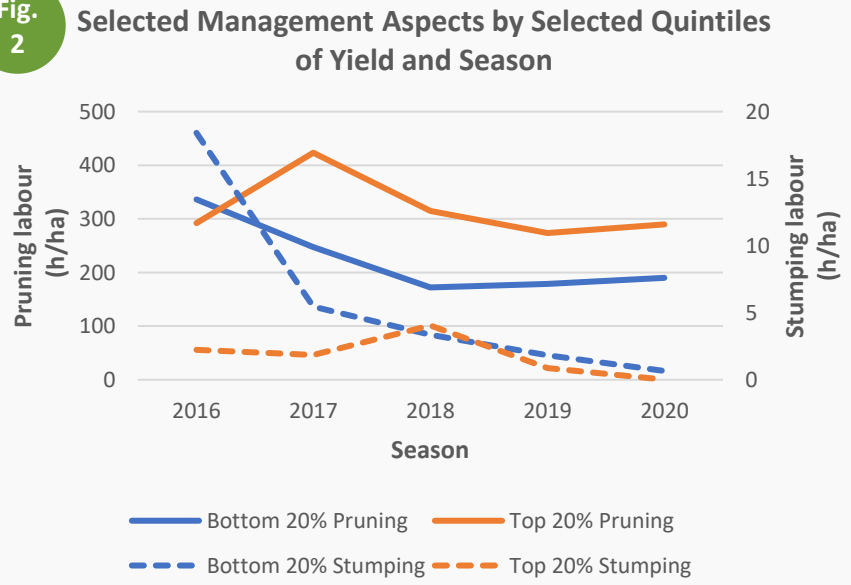
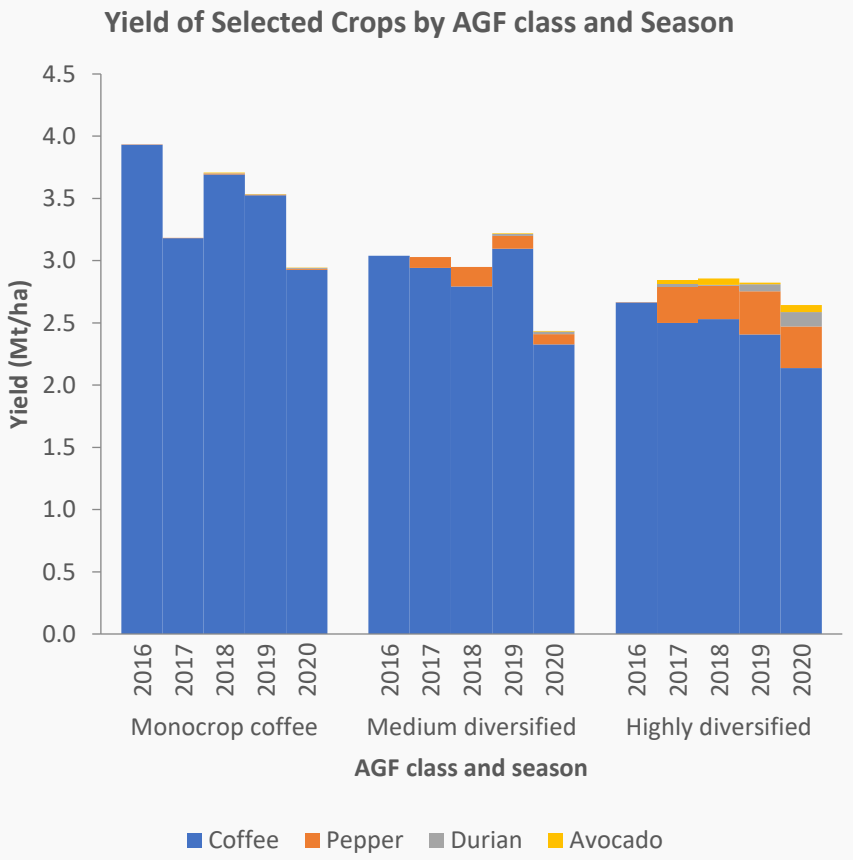


Fig. 2



Production: In Dak Lak, 5-year mean coffee yields on Highly diversified farms are significantly lower, yet profits from other crops more than outweigh this

- A central pillar of the ISLA programme is that promotion of more diversified farming creates more resilient farms, both economically and from a climate change perspective.
- In 2016, production of other crops was not properly captured, but in subsequent seasons it was.
- We see that pepper production remains the single most important non-coffee crop, but durian and avocado volumes seem to start growing especially on Highly diversified farms, albeit from a small base.
- When we combine the 5-year yield data (to maximise the number of observations) we find that in Dak Lak coffee yield levels on Highly diversified farms are significantly lower ($p<0.01$) than coffee yields on the other 2 categories. In Lam Dong this analysis does not make sense due to too few observations in the Highly diversified category.
- If we consider economic resilience through the lens of long term profit margins, we find that in Dak Lak the 5-year average profit margin on Highly diversified farms is significantly higher ($p<0.05$) than on Monocrop farms.

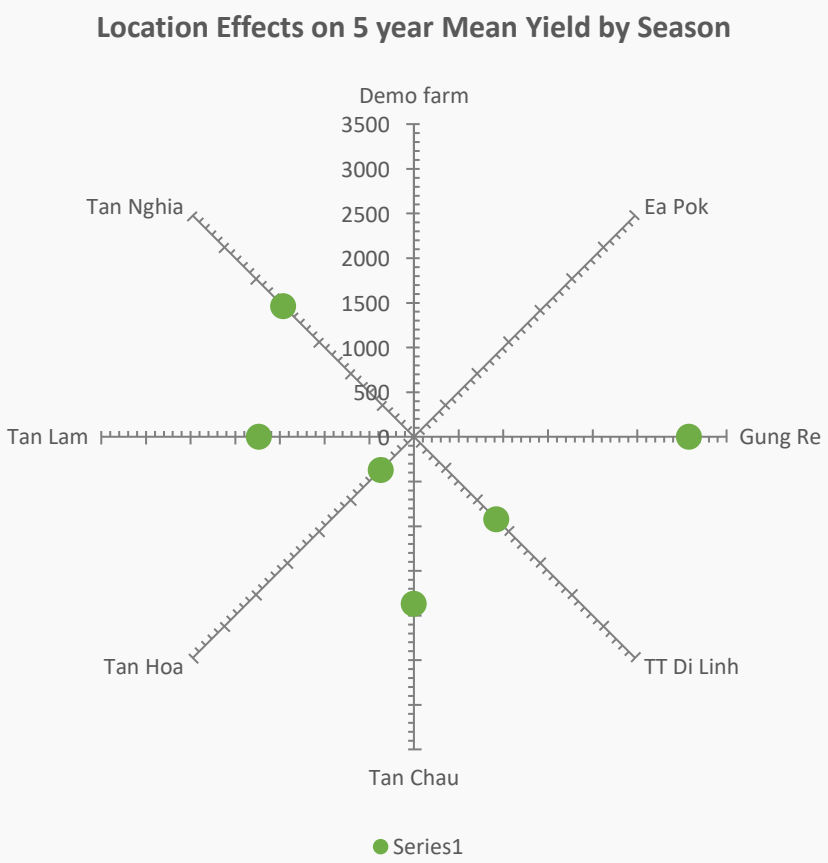


Production: We model yield and present groups of variables for location, socio-economic conditions and farm management and their effect sizes

- We constructed a linear regression model with 22 variables that we hypothesise may correlate with yield. The model was set to run at a confidence level of 95% and we used data from all 5 seasons. This maximises the number of observations and may shed more light on effects that analysing each season individually may not reveal.
- Of the variables included, one is a dummy variable for each of the 10 communes, where we take a Ea Drong, alphabetically the first commune on the dataset, as the base against which the location effects of being located in another commune is measured.
- Seven variables are related to farmers' socio-economic conditions: ethnicity, gender, age, number of years growing coffee, education level and coffee area.
- Fourteen deal with farm management aspects. These are: N, P and K applied, organic matter applied, irrigation water volume, pesticide cost, weeding equipment energy cost (a proxy for the use of brush cutters instead of herbicide), and labour for fertilising, pruning, pruning shade trees, basin maintenance, weeding, stumping and grafting.
- The following slides discuss the findings. We present the results in radar charts with dots showing if a variable had a significant effect (green for positive, reg for negative). We only show variables that show an effect.
- In addition to significance we also show the effect size, i.e. how much does yield change (measured in kg green bean per ha) with each additional unit of a variable with all else being equal.
- The model explains 41% of the observed variability in yield between farmers.
- Note that this model does not incorporate weather data. If that were included we suspect the explanatory power would increase.

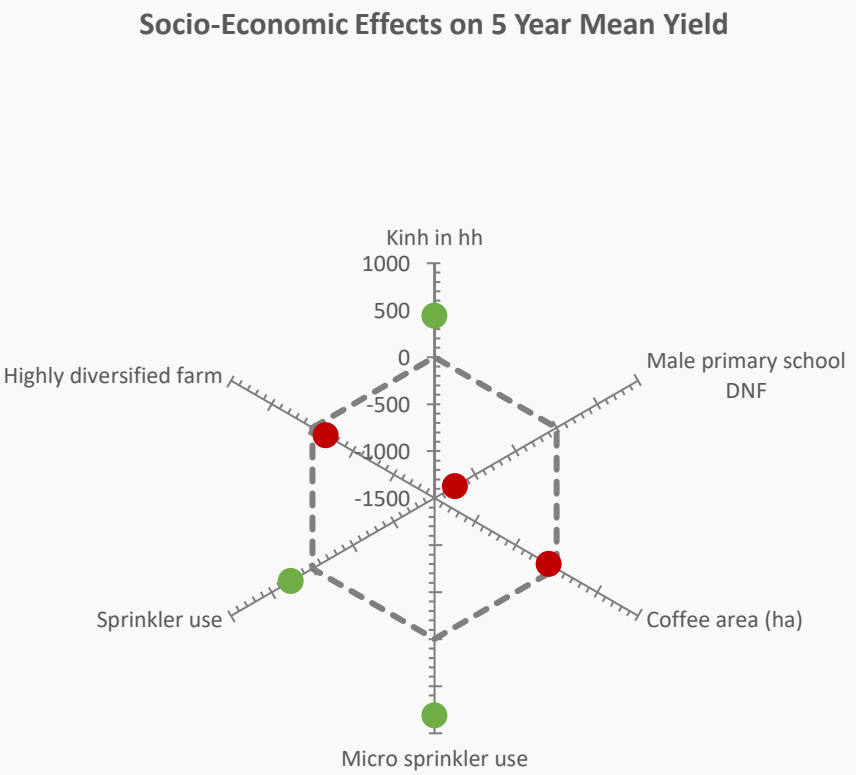
Production: Location effects are significant for all communes in Lam Dong province

- The scale on the axes in this graph (and the 2 that follow on the next pages) show the effect size on yield in kg green bean per ha if the variable plotted on that axes changes by 1 unit. Units of variables are show in the axes labels where applicable)
- Bearing in mind that Ea Drong in Dak Lak province is the base commune against which the effects of the others are measured, we find, unsurprisingly, significant effects of the communes in Lam Dong province.
- What we can also see from this figure is that long-term yield levels in Ea Pok commune (also in Dak Lak) is comparable to Ea Drong, while farmers in Tan Hoa (Dak Lak) out perform their peers in Ea Drong.
- Demo farms in Lam Dong, were established over the past 3 years and are not yet fully productive.
- Recommending Dak Lak farmers to move to Lam Dong is not very helpful. Still, the location effects matter, as they explain a part of what is happening with variations between farmers on yields.
- The next slides show socio-economic and farm management variables and how these correlate with yield *while* controlling for location effects.



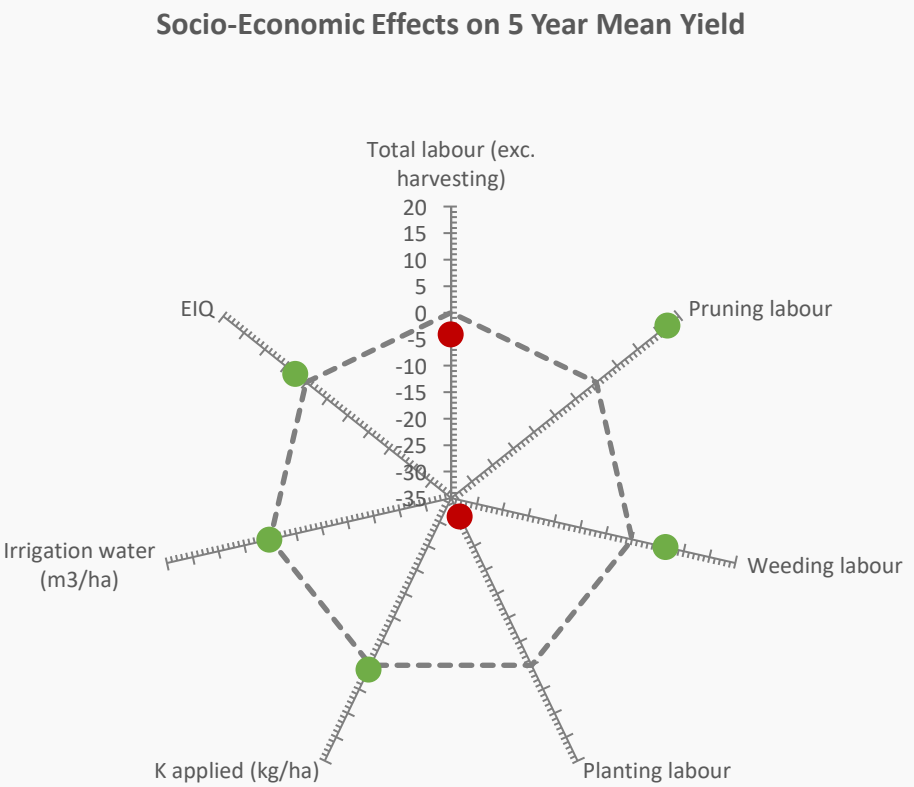
Production: Farming households with one or more members of the Kinh majority group show higher yields. Sprinkler use also has a positive effect on yield, while diversified farms perform worse than Monocrop farms

- Green dots indicate that a variable has a positive correlation with yield (all other things being equal), red dots indicate a negative effect.
- Households where one or more members belong to the Kinh group show higher 5 year mean yields, on average this amounts to +440 kg/ha/season.
- In earlier seasons we occasionally found effects of education levels, but in the 5-year long term model, only a negative effect of males in the household not having finished primary school remains. The likely under-lying driver for this is that males in ethnic minority households tend to have lower education levels, and as we saw above also lower yield levels.
- Interestingly, when we combine multiple years of yield data, we start seeing effects of alternative irrigation methods. To reiterate, we control for location effects, so this is not a difference between Dak Lak and Lam dong we are seeing. Micro sprinklers shows yields 809 kg/ha higher than those with basin irrigation, while larger overhead sprinklers have a co-efficient of 264 kg/ha.
- The effect of lower coffee yields on Highly diversified farms remains when we control for a range of other aspects. The effect becomes smaller, as some of the differences are apparently better explained by farm management, location and socio-economic aspects, yet is still significant at -168 kg/ha.



Production: Pruning and K applications continue to be the management aspects that are limiting and where farmers can make the largest improvements

- As expected, of all pre-harvest activities farmers can carry out pruning shows by far the greatest effect.
- The effect-size of K application is also significant and positive with +0.89 kg/ha with every additional kg of K applied. As we saw in the Farm Management section, the average K balance is negative, indicating that on average farmers do not apply enough K. The model on yield presented here confirms this and shows that farmers who are applying higher levels of K tend to get better yields, all other things being equal.
- A kg of Kali fertiliser cost around 6,800 VND/kg and contains 58% of K. This means an additional kg of K costs 11,724 VND, and yields a return of [0.89*32,000VND=28,480 VND/kg K applied]. This gives the average farmer more than enough margin to do such an investment and spend some time on the application
- Labour used for planting new coffee shows a negative correlation as would be expected. Not a great insight in and of itself, but this does show that the FFB is internally coherent.
- An intriguing finding is that contrary to earlier single season analyses, irrigation water use comes out as a driver for yields. While significant, the effect is not very large (0.19 kg GBE/ha per m3 of water used).
- Equally interesting is that the Environmental Impact Quotient (EIQ) comes out as a factor of relevance, indicating that higher EIQ ratings are associated with higher yields.



Results
Farm economics

Farm economics: Cost reduction was largest in Dak Lak, consequently, margin drop there was less severe than in Lam Dong, but cost savings could not off-set lower yields and coffee prices

- Figures 1 and 2 show revenue, cost and margin per farm and per ha by province for each of the five seasons.
- We see a downward trend among all farmers as a result of lower yields and lower coffee prices. Farmers have off-set this to some degree by saving on costs, particularly in Lam Dong province, but this was not enough to maintain margin levels.
- From 2016 to 2019, revenues per ha dropped by 26% in Dak Lak, costs were reduced by 34% and margins dropped by 21%.
- In Lam Dong over the same time frame revenues dropped by 42%, costs were reduced by 28% and margins were 47% lower.

Fig. 1

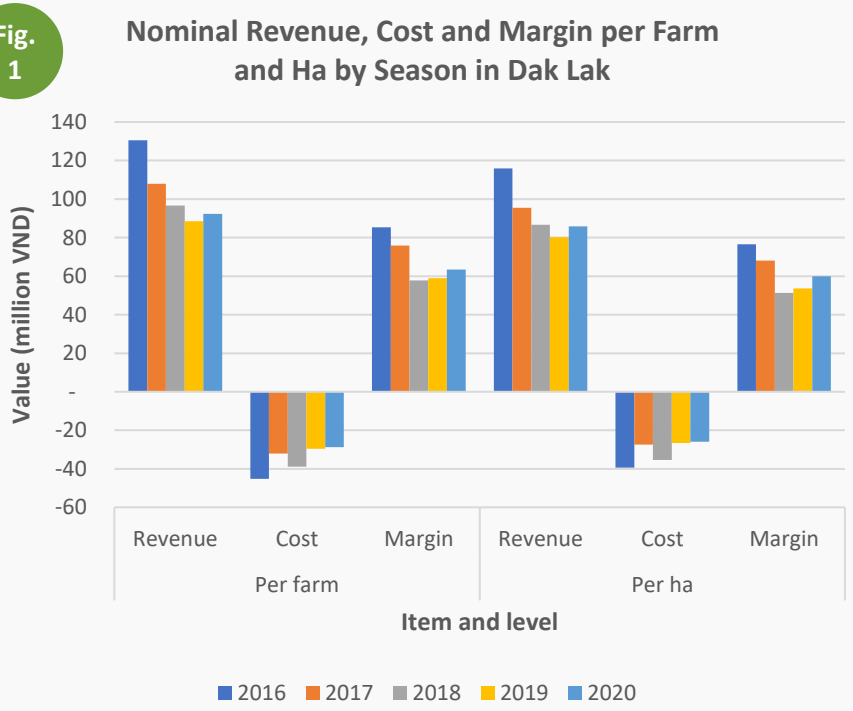
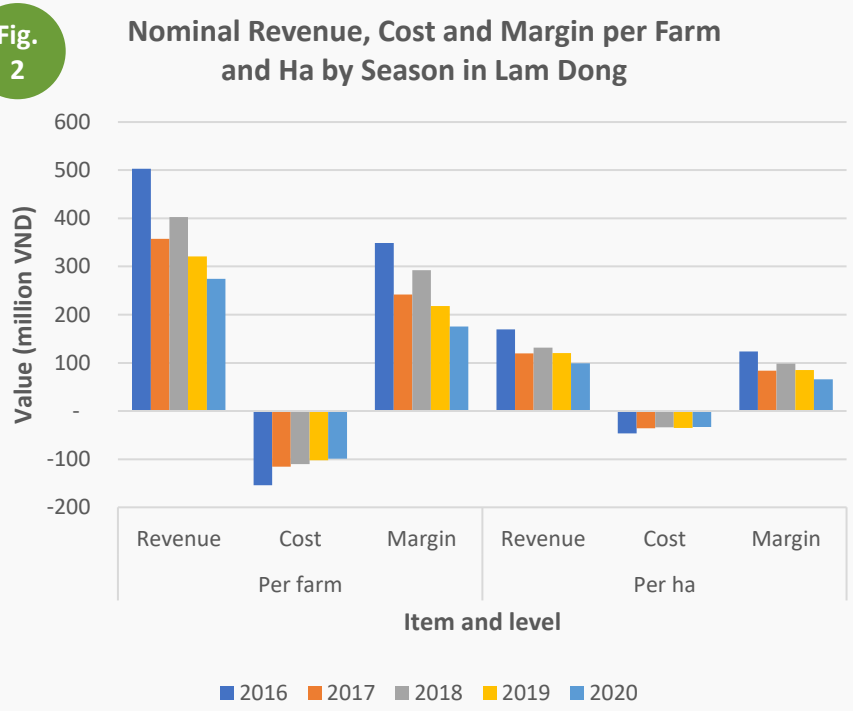


Fig. 2



Farm economics: Production cost optimisation comes predominantly from lower fertiliser investment, but we see reductions across all categories, except for energy use in Lam Dong

- We could earlier see that the excess of nitrogen application has on average been reduced and the economic effects are noticeable.
- Most of the cost savings in absolute terms in both provinces were generated by saving on fertilisers. In 2016, farmers on average spent 21.1 and 23.7 million VND/ha in Dak Lak and Lam Dong respectively. In 2020 fertiliser costs came in at 14.3 and 15.3 million VND/ha respectively.
- In Lam Dong we see the effect of greater irrigation in 2020, energy costs, which are primarily spent on fuel and electricity for irrigation pumps, has never been higher there in the 5 seasons we cover.
- While pesticide cost were never a large expenditure among FFB farmers in either province, outlays on this have disappeared in Dak Lak and are much lower than before in Lam Dong.

Fig. 1

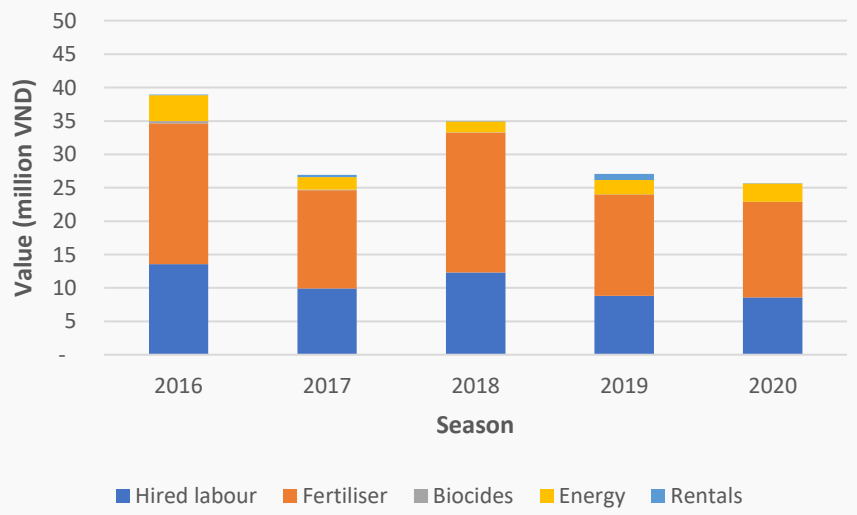
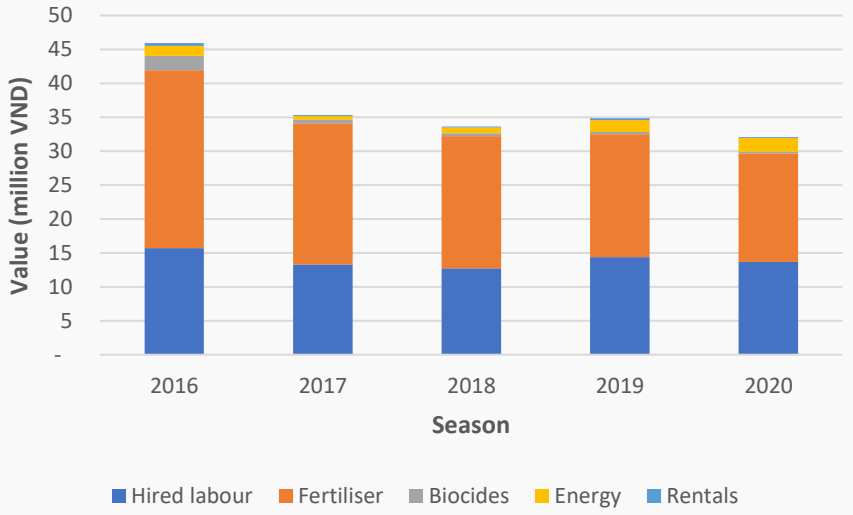


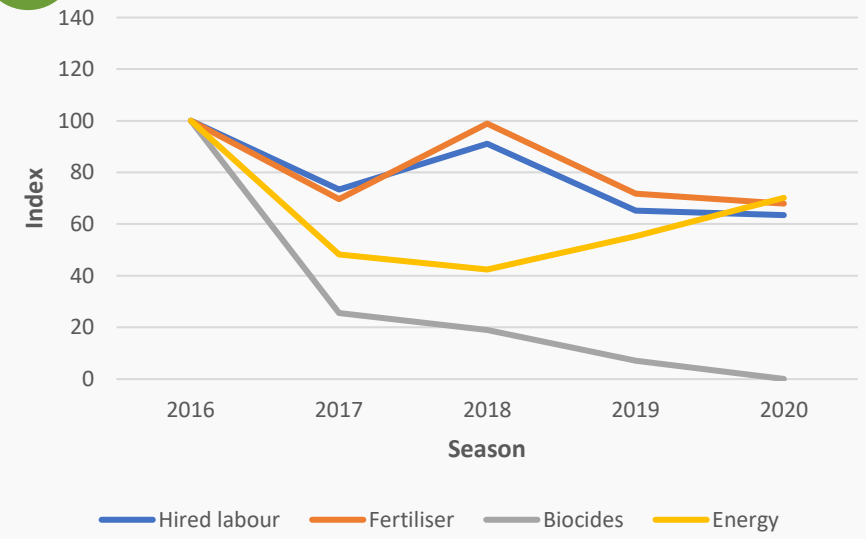
Fig. 2



Farm economics: Relative cost changes over time compared to 2016, illustrate how farm management has changed. Less reliance on pesticides and optimisation of labour and fertiliser use

- In figures 1&2 we plot index numbers for cost categories by province, where 2016 equals 100 and cost levels in subsequent seasons are compared to their 2016 level.
- The relative changes by cost category clearly show how the reliance on pesticides has reduced over time. In Dak Lak, it appears that farmers have shaved costs by roughly equal proportions across each of the other categories. Index values for hired labour, fertiliser and energy all sit between 63 and 70 compared to 2016.
- In Lam Dong the pattern looks very different. The adverse weather conditions at the start of the 2020 season result in far higher energy expenditures. Similar to Dak Lak, pesticide expenditure is down, not to zero, but still far lower than in 2016. Relative fertiliser costs have dropped to 61, but the reduction hired labour use is less strong because of higher yields than in Dak Lak.

Fig. 1



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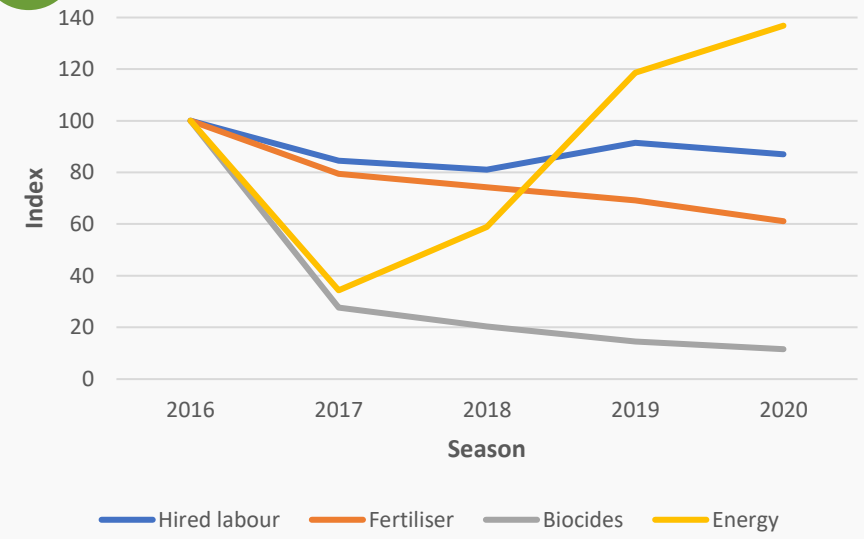


Farm economics: Labour and fertiliser expenditures occur in a couple of peaks throughout the season, while last year's coffee sales tend to be concentrated at the beginning of the new season

- We observe a number of cost peaks when we plot mean monthly expenditures per ha.
- Starting in November and moving into the following January, labour demand peaks as coffee is harvested, resulting in peaks for hired labour costs (Fig 1). This at a time when typically no, or very little coffee has been sold. One way of dealing with this potential constraint is to sell fresh cherry which is not common but appears to be increasing in more recent seasons.
- The other peak is when fertiliser is applied. There are always some farmers who apply fertiliser outside the normal period, with the exception of the month December, when fertiliser expenditures are zero (as they should be), but across the sample we observe 2 distinct peaks: one in the period May to July and one in September.
- At the end of the season, which generally is still prior to the bulk of the coffee sales of the coffee harvested that season, we find that on average 30 million VND/ha has been spent (Fig 2). Given that revenue streams are more lumpy, i.e. coming in over relatively short periods of time at the start of the new season, judicious cash management is critical to retain sufficient investment capacity later on in the year.

Fig. 1

Monthly Expenditures for Fertiliser, Labour and Energy in 2020

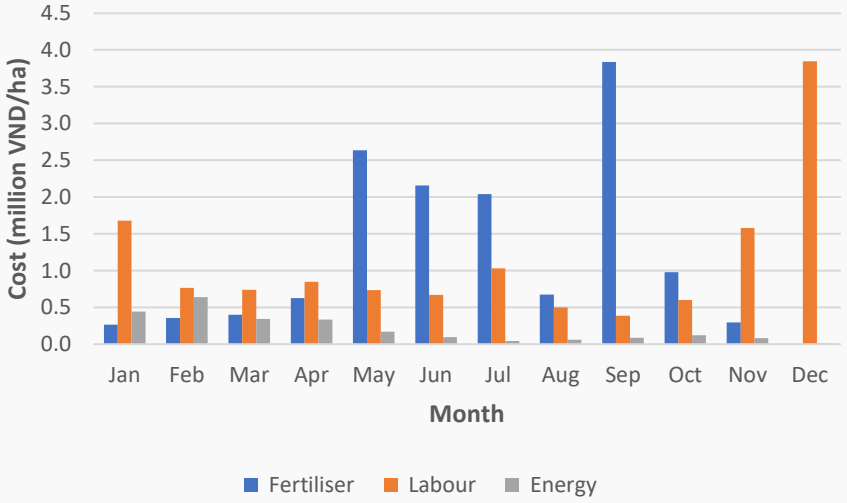
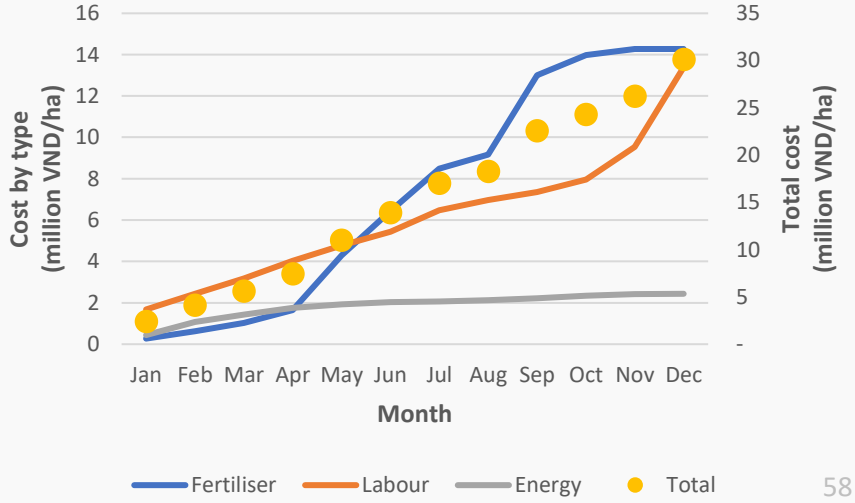


Fig. 2

Cumulative Monthly Expenditures for Fertiliser, Labour and Energy and Total in 2020



Farm economics: Medium and highly diversified farms in Dak Lak deliver better margins for farmers compared to monocrop farms

- When we plot margins by Agro-forestry class for Dak Lak, we find that in 3 out of 5 years margins on medium and highly diversified farms are higher than on monocrop farms. Within a single season, these differences do not tend to be significant, but the 5 year average margin on highly diversified farms is significantly higher than on monocrop farms ($p<0.05$). We did not conduct this analysis for Lam Dong, where the share of farms in the highly diversified category is too small.
- We also find that margin over time are more stable on Highly diversified farms (Fig 2), this underpins the logic of diversifying for greater income stability and economic resilience.

Fig. 1

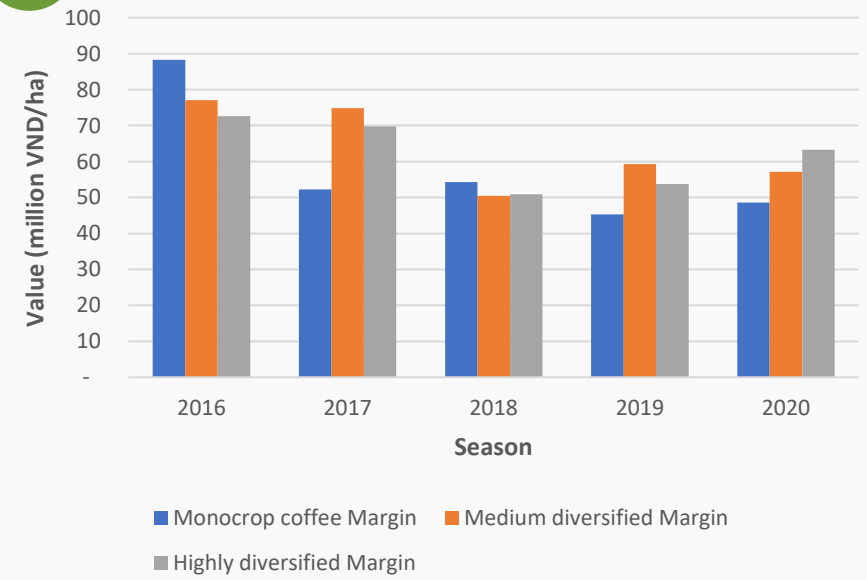
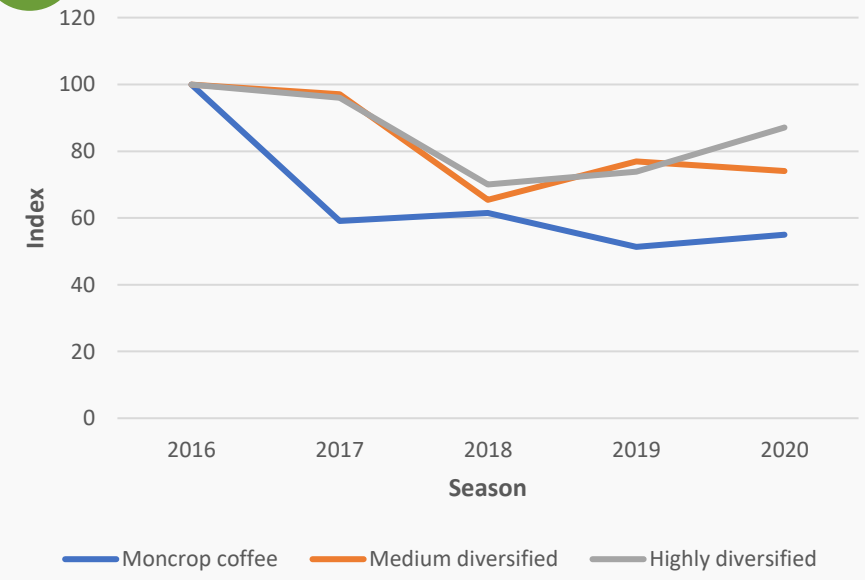


Fig. 2



Farm economics: As a result of other crop income and cost reductions, the Benefit-Cost Ratio (BCR) has recovered in Dak Lak but gradually declines in Lam Dong

- The BCR is calculated by dividing the profit margin by the total cost. The resulting value shows how much was earned on every VND invested.
- We assume that a BCR of 2 is the point below which returns may become unattractive to farmers.
- In Dak Lak (Fig 1) we saw 70% of farmers earning less than 2 VND for every 1 VND invested in 2018, when costs per ha jumped from the previous season. With sub-sequent cost-savings and a growing production of non-coffee crops, ratios are more favourable now and better than they were in 2016..
- In Lam Dong, where farms are larger and yields are higher, the need to optimise may have been less pressing, but we are now seeing gradual worsening of BCR values there (Fig 3) to the point where 45% are below a BCR of 2 (Fig 2).

Fig. 1 Farmers' Numeric Rank by Benefit-Cost Ratio and Season in Dak Lak

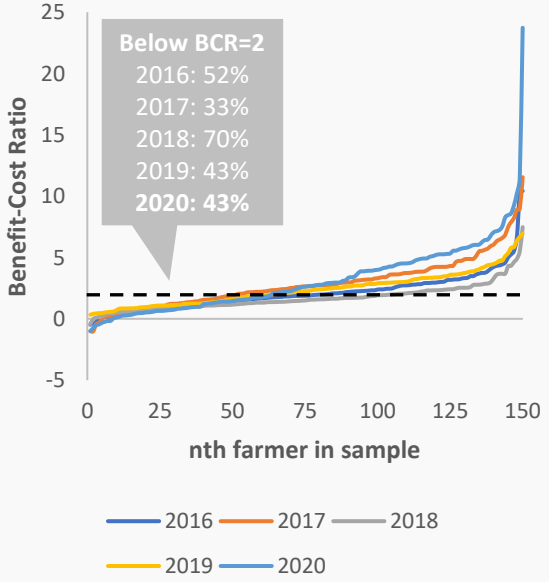


Fig. 2 Farmers' Numeric Rank by Benefit-Cost Ratio and Season in Lam Dong

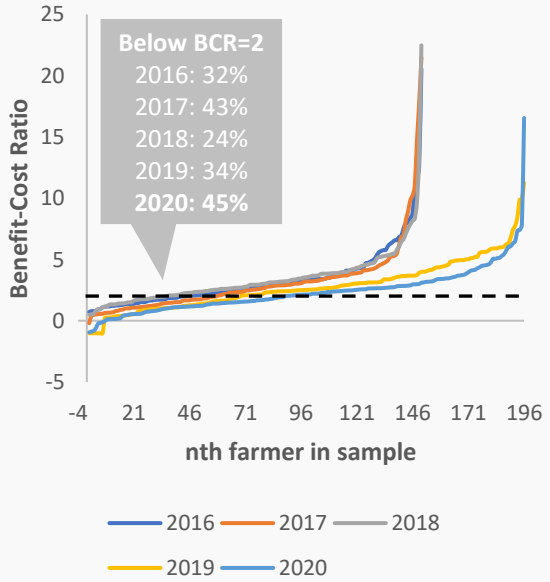
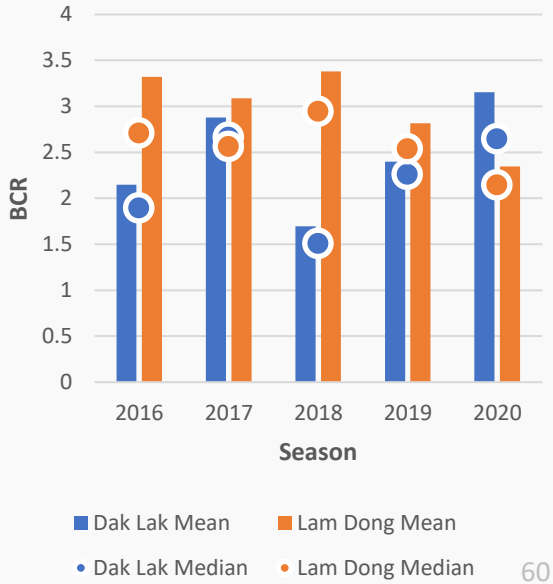


Fig. 3 Mean and Median BCR by Season and Province



Farm economics: The average rate of return on assets is down from 10.9% to 6.9%. Farmers with poor returns (<8%) used to produce just 14% of the total supply but this is now 54%

- The Return on Assets (RoA) is calculated by dividing the profit margin (revenue minus total cost) by the total value of production assets.
- We have valued land at a fixed market value of 900 million VND/ha and added that to the production assets data from the FFB. This gives farmers an average asset value of 1.93 billion VND, of which 2.1% is in the form of machinery and equipment.
- The mean and median RoA shows a steady decline over time (Fig 1).
- We further assume a minimum Return on Assets of 8% for coffee to remain economically attractive to farmers. In 2016, 31% of farmers were below this threshold in 2016, whereas in 2018 this share increased to just over 60% (Fig 2).
- Consequently, a growing share of production comes from farms where returns are less favourable. In 2016, just 14% of supply came from farms with a RoA of less than 8%, in 2020 this figure is 54%.

Fig. 1

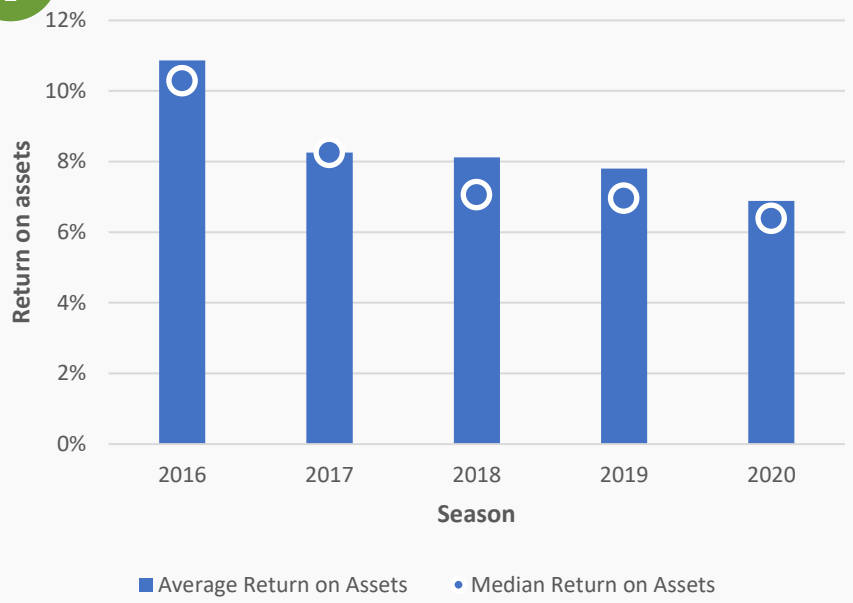
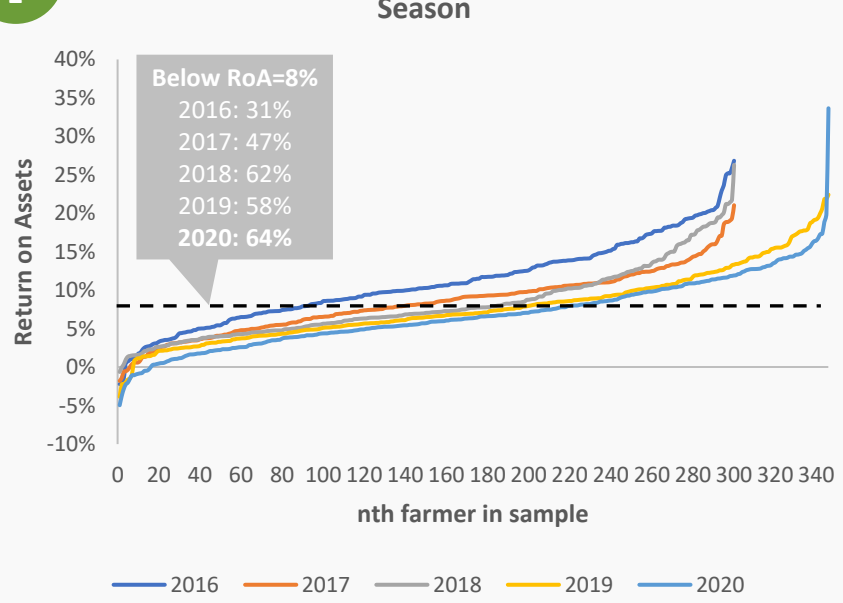
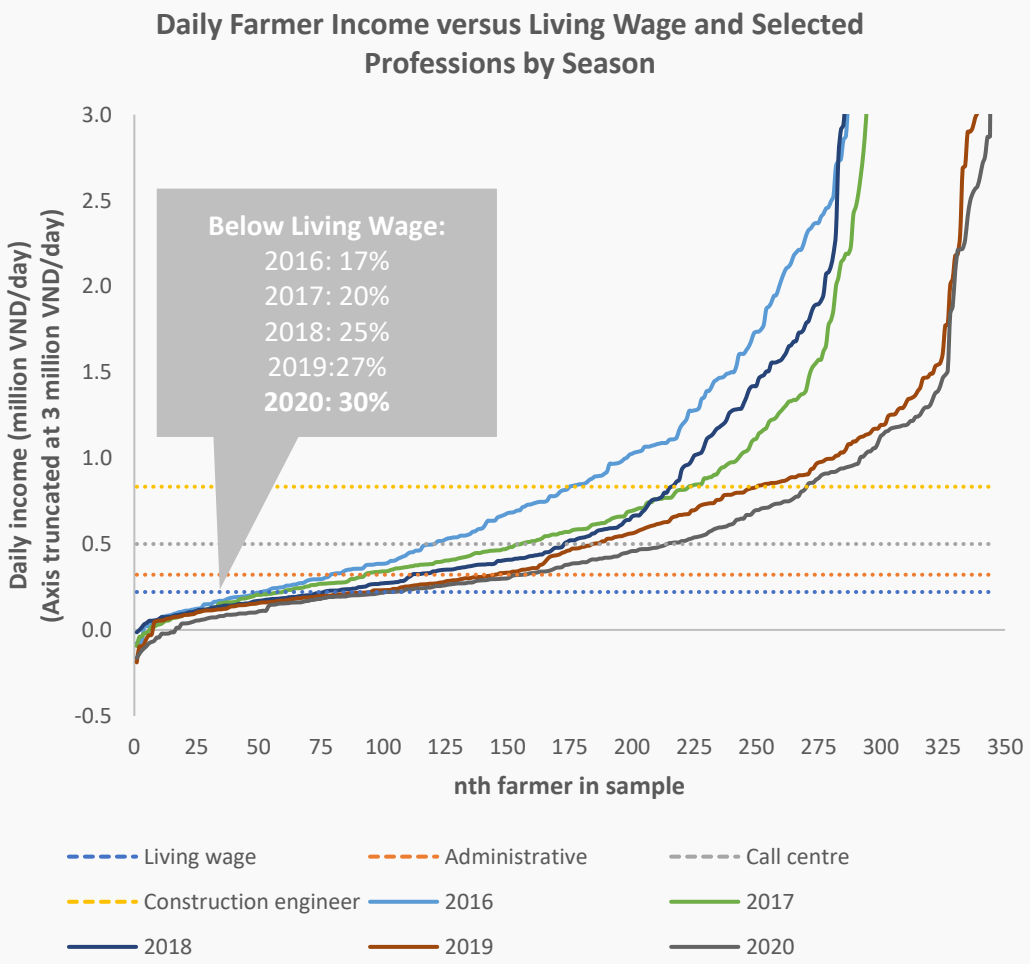


Fig. 2



Farm economics: A growing share of farmers earns less than the Living Wage, but on average coffee remains an attractive proposition compared other non-farming options

- In the absence of a living wage or living income study for the Central Highlands, we have used the Ho Chi Minh City living wage level as a benchmark.
- For workers in Ho Chi Minh City the living wage level is set at 221,542 VND/day[9].
- The living wage is based on a standard working week day. To calculate the farmers' daily income we have divided their profit margin by 220 working days per year. This results in an average daily income of 576,500 VND in 2020. The median farmer's income in that season is 377,636 VND/day, roughly similar to the living wage level.
- Back in 2016, 83% of farmers earned more than the living wage benchmark. For the most recent season, this share dropped to 70%.
- Compared to other professions, growing coffee and on diversified farms a number of other crops, still works out well compared to a number of other job categories. It is any case unlikely that farmers who tend to be older, would shift to a new career this late in life. But, the attractiveness of coffee compared to other options does matter for the next generation of coffee farmers.



Results
Environmental performance

Environmental performance: The environmental impact quotient per ha has dropped significantly from 17.5 to 2.2, indicating strongly reduced use of the most hazardous pesticides

- The EIQ is a compound index value that aims to give an index figure for the toxicity of a pestcide. The FFB software calculates EIQ values using the Cornell University's EIQ database and the volumes and active ingredients of the pesticides used by farmers.
- The EIQ does have a number of methodological drawbacks, but as a general indication of how toxic loading develops over time, it serves our purpose here.
- The average EIQ for all farmers, including those that do not spray, is 2.2 per ha a strong reduction from 2016 when it came at 17.5.
- In the absence of benchmark EIQ data for coffee production we decided back in 2016 to set a target of achieving an average EIQ per ha of 29[1]. This value represented the median EIQ value of all the original 900 FFB farmers in the ISLA programme in that year. Our recommendation was to target farmers with high EIQ values and offer them non- or lower toxic alternatives.
- This appears to have worked, EIQ values are now extremely low and while some use of Highly Hazardous Pesticides continues to take place, this is confined to a very small minority of farmers.

Fig. 1

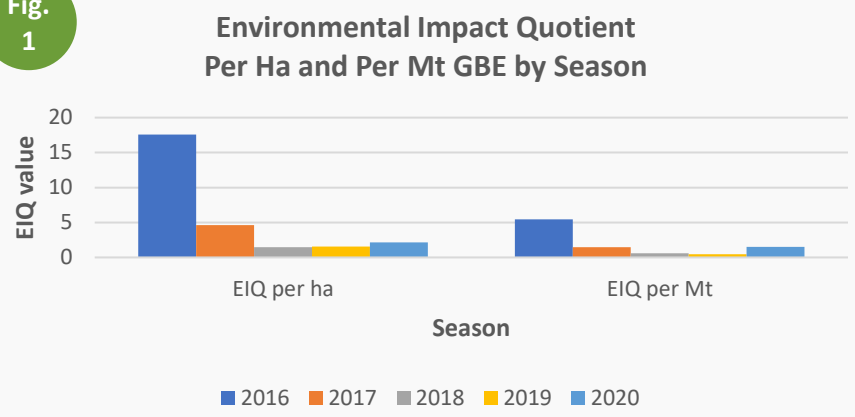
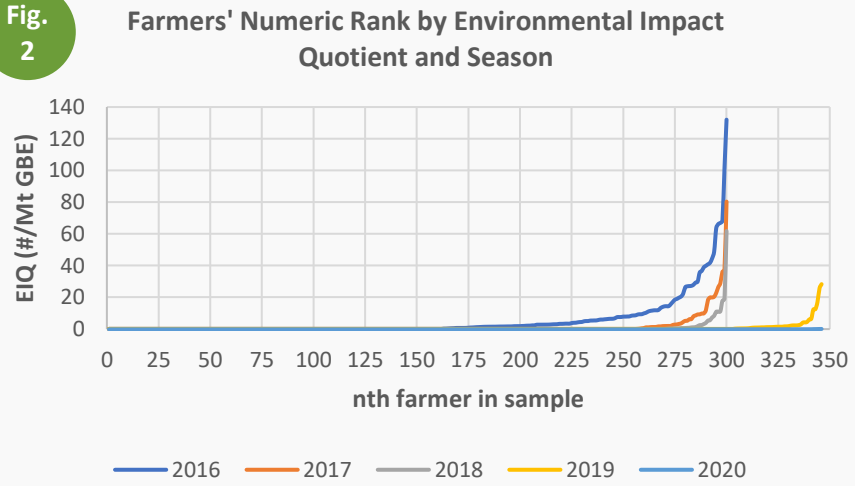


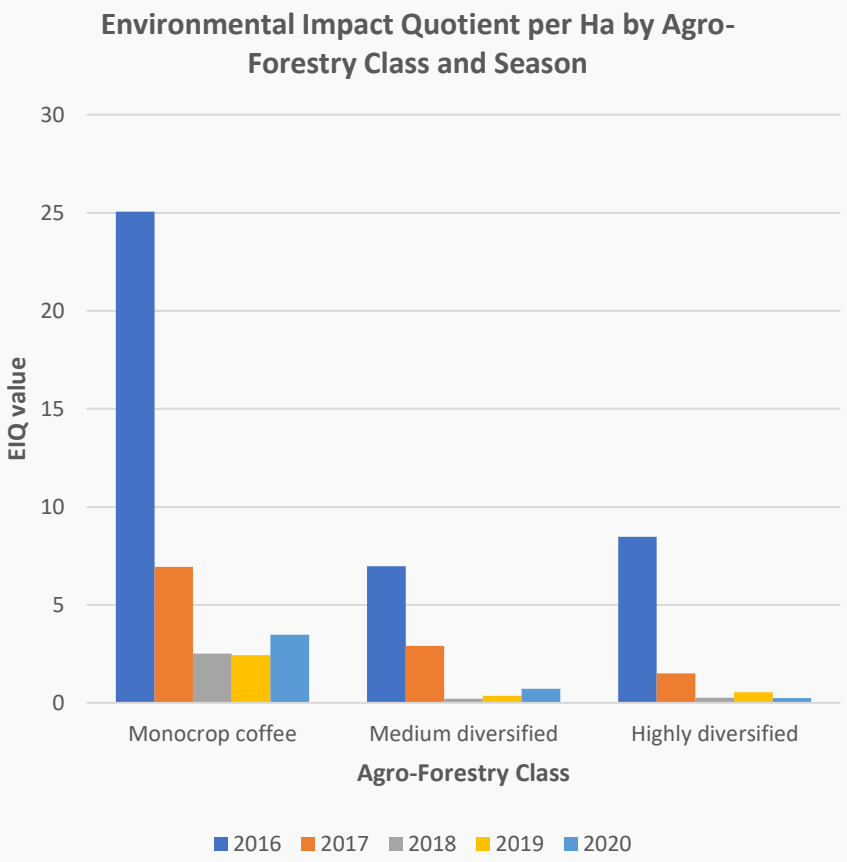
Fig. 2



[1] This median was including the farmers of LDC and Simexco who subsequently ceased FFB operations

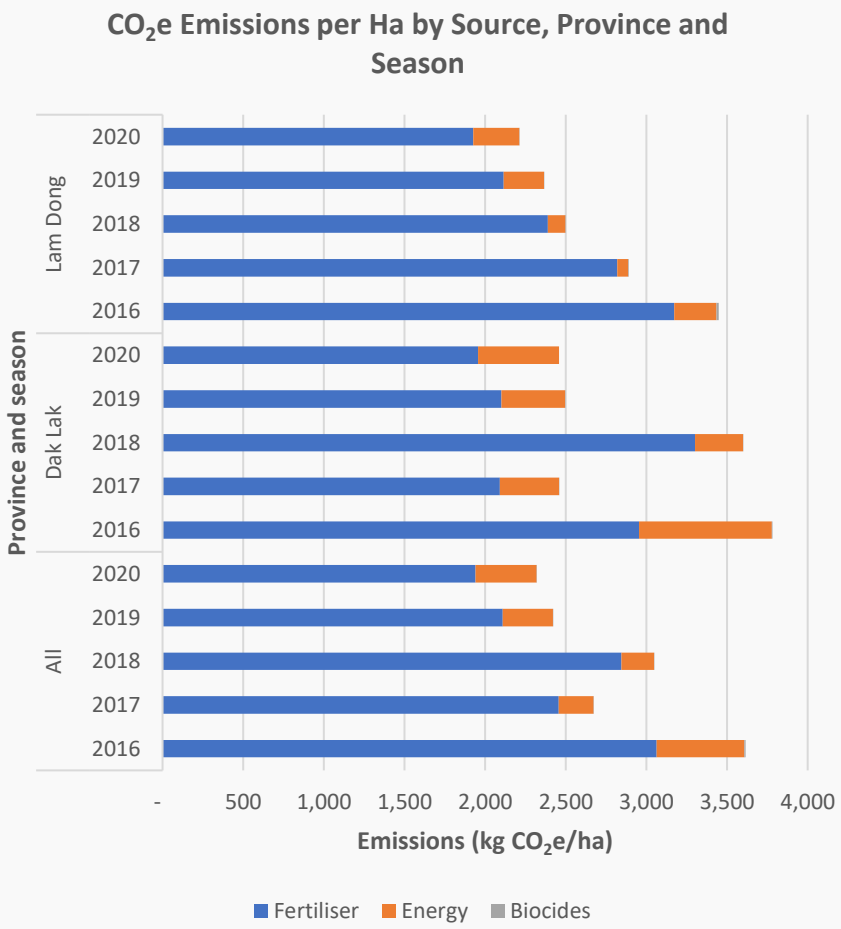
Environmental performance: Reductions in toxic loading are seen across all types of agro-forestry classes, but monocrop farms continue to see significantly higher EIQ rates

- The reduction of the EIQ over time is observed across all three Agro-forestry classes. The graph appears to indicate a steady downward trend, but for each Agro-forestry only the reduction in EIQ from 2016 to 2017 is statistically significant ($p<0.01$). After 2017, we see lower average EIQ values, but none of these are significant.
- This is important, because it indicates that a reduction in useage of the more toxic pesticides can be realised in a short time frame of a single season, provided of course what we see here is a programme effect.
- Another important finding is that monocrop farms use more pesticides and consequently show significantly higher EIQ values in each of the five seasons. This does not hold in each season, location, i.e. province, explains higher EIQ ratings in 2016 and 2017 as farmers in Lam Dong tend to use more pesticides. Beyond those seasons, location no longer helps explain the variability in EIQ but agro-forestry class does with highly diversified farms displaying significantl lower EIQ values.
- In the absence of a control group we can not be completely certain that what we observe here is an effect of the ISLA programme, but in the absence of wide-spread sector-level indications of significantly lower pestcide use over the past 5 seasons, we think it likely that the programme has contributed to this development among the FFB farmers.



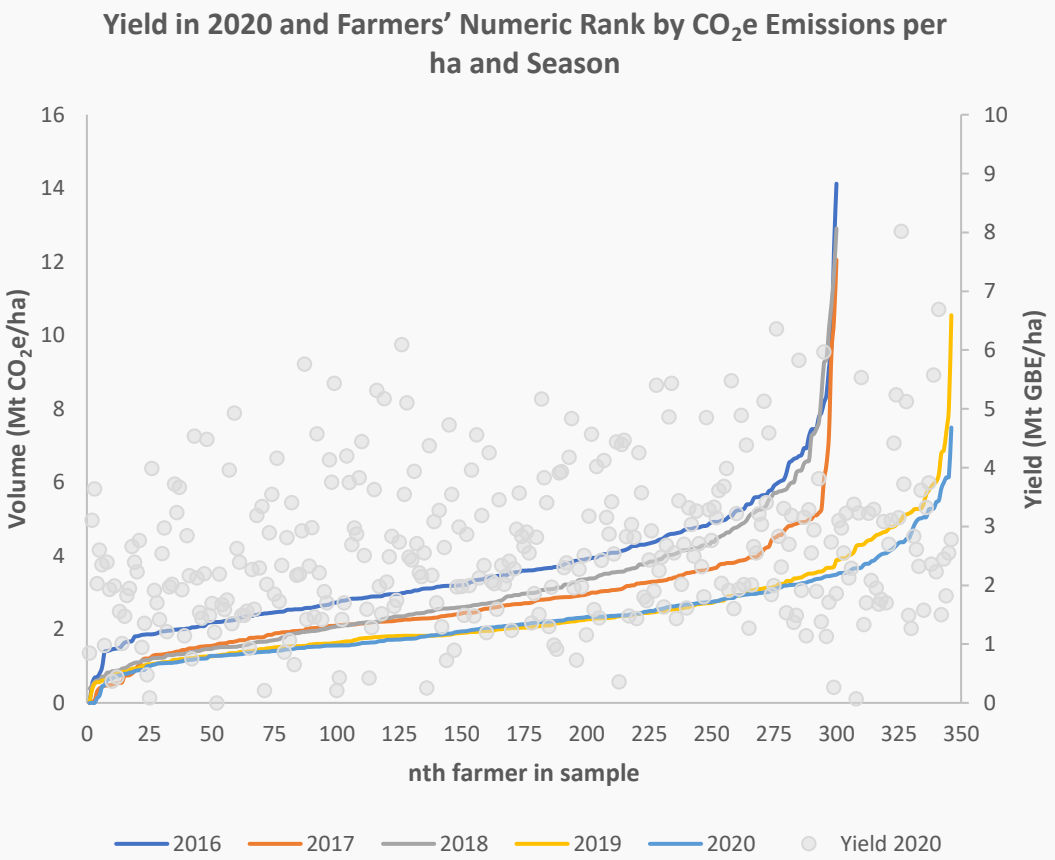
Environmental performance: The role of fertiliser management is critical to controlling emissions from coffee production

- The farms in the FFB sample have all been established more than 20 years ago. In line with the Product Category Rules for green coffee[8], emissions associated with taking land into cultivation are no longer included if the farm was taken into production more than 20 years ago.
- This means that emissions associated with fertiliser application are by far the most important source, making up between 82% and 95% of all emissions, depending on the season.
- In line with the reduction in fertiliser we observed in earlier section, we see a concomitant reduction in fertiliser related emissions, indicating the importance of judicious fertiliser management if emissions are to be controlled.
- Energy use related emissions originate predominantly from irrigation activities. We find that in years where more water is used, e.g. 2016 and 2020, energy emissions rise.



Environmental performance: We find no relation whatsoever between emissions and yields, indicating that high(er) emissions are not a prerequisite for optimal yields

- In this graph we plot the emissions per ha sorted from small to large by the rank of farms in the sample. We do this for 5 season and we include for each farmer his or her yield level in 2020.
- With this we can explore if higher emissions rates are required to obtain higher yield levels. As the graph shows there is no correlation, yield levels are all over the place in relation to emission levels.
- For readability purposes we do not show the yield levels from 2016 to 2019, but the pattern and lack of correlation, is very similar to what we find in 2020.
- We have communicated this message in earlier reports and while we can not be sure of that is what has contributed to optimisation, we do see a gradual decline in extreme emission outliers at the right hand side of the graph. In 2916 emissions per ha peaked at just over 14,000 kg/ha while in 2020 the maximum observed is just over 7,400 kg/ha.



Environmental performance: Coffee can be a mitigating factor in climate change, removing more carbon from the air through biomass growth than it emits in production. Fertiliser management and diversification are key factors

- Once we factor in the rate of carbon sequestration on each farm, i.e. the rate at which CO_2 is removed from the air as a result of biomass growth, we can calculate the carbon footprint (i.e. emissions minus sequestration) and we find that coffee can be produced in a climate neutral manner, but the balance between being a source or sink of carbon is a precarious one.
- In the most recent season, on average the farms in the sample acted as carbon sinks, but in 2 out of the 5 seasons emissions outweighed the rate of carbon sequestration (Fig 1).
- Monocrop farms can be carbon sinks, on such farms, the reduction in fertiliser use is the most critical factor that decides whether a farm is a carbon source or sink. On highly diversified farms in particular the rate of sequestration is somewhat higher, helping to offset emissions from inputs to a greater degree (Fig 2).

Fig. 1

CO_2e Emissions, Sequestration and Footprint by Season

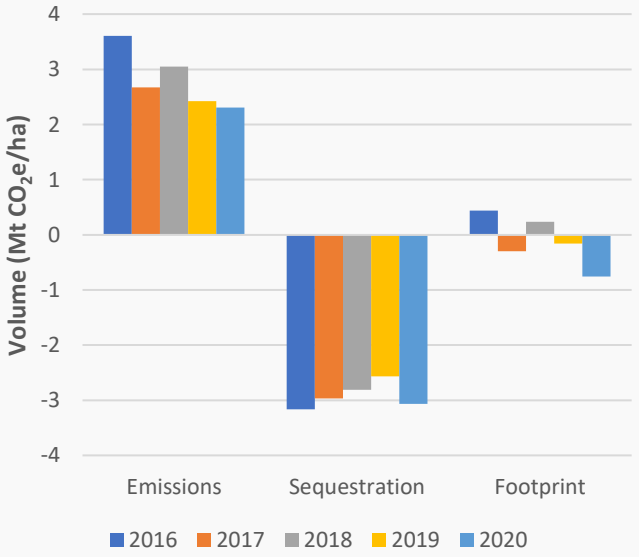
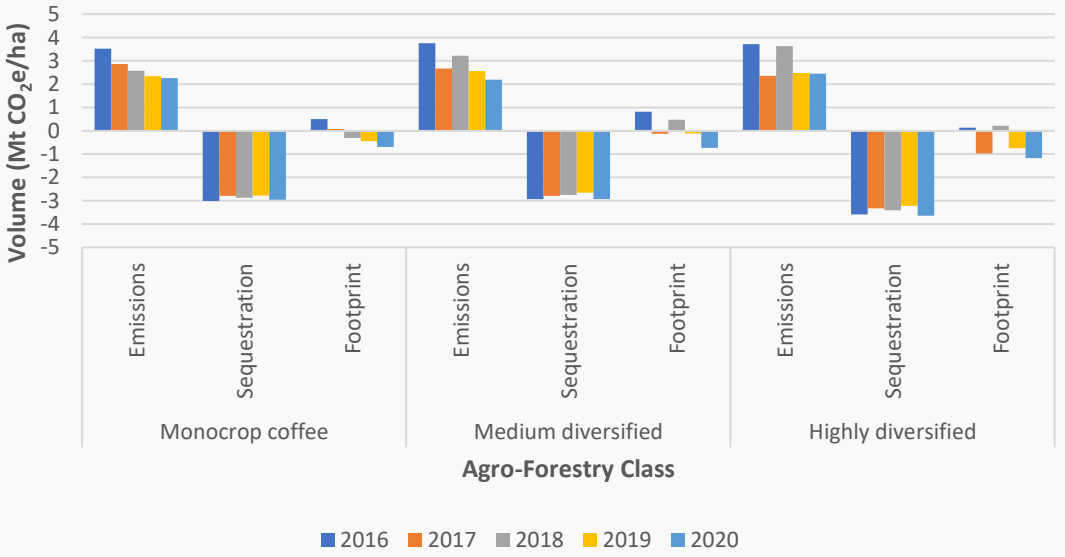


Fig. 2

CO_2e Emissions, Sequestration and Footprint by Agro-Forestry Class and Season



Environmental performance: Similar to the finding on yield, we observe that margins are not related to footprint levels. This indicates that farms that act as carbon sinks are not more or less profitable than those that do not

- In this graph we plot the carbon footprint values per ha sorted from small to large by the rank of farms in the sample. We do this for 5 season and we include for each farmer his or her profit margin level in 2020.
- With this we can explore if and how footprint values relate to profit margins. The distribution of margin values in 2020 shows no correlation with footprint values (Fig 1), and the same applies to earlier seasons (not shown in Fig 1 to aid readability).
- Further analysis leads us to conclude that there is no significant difference ($p<0.05$) in profit margins between farms that are carbon sources and sinks (Fig 2).

Fig. 1

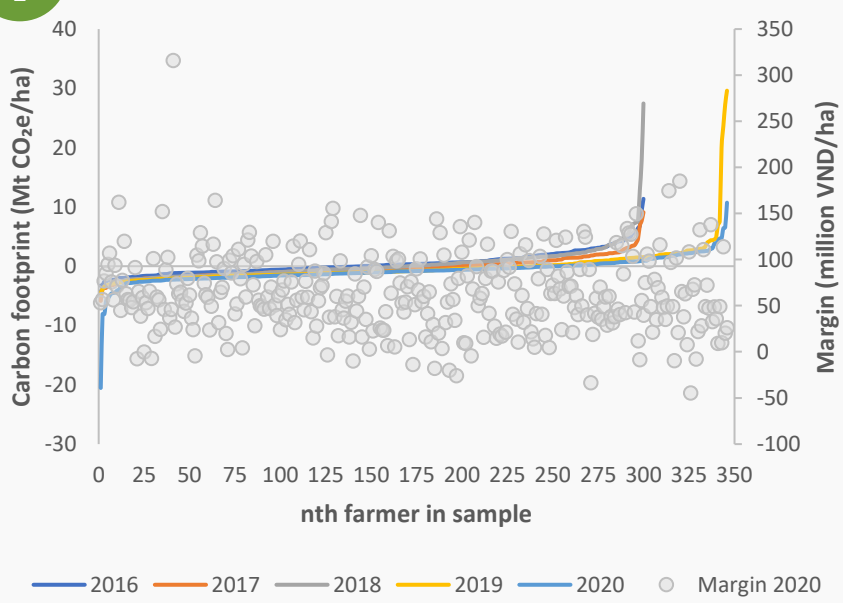
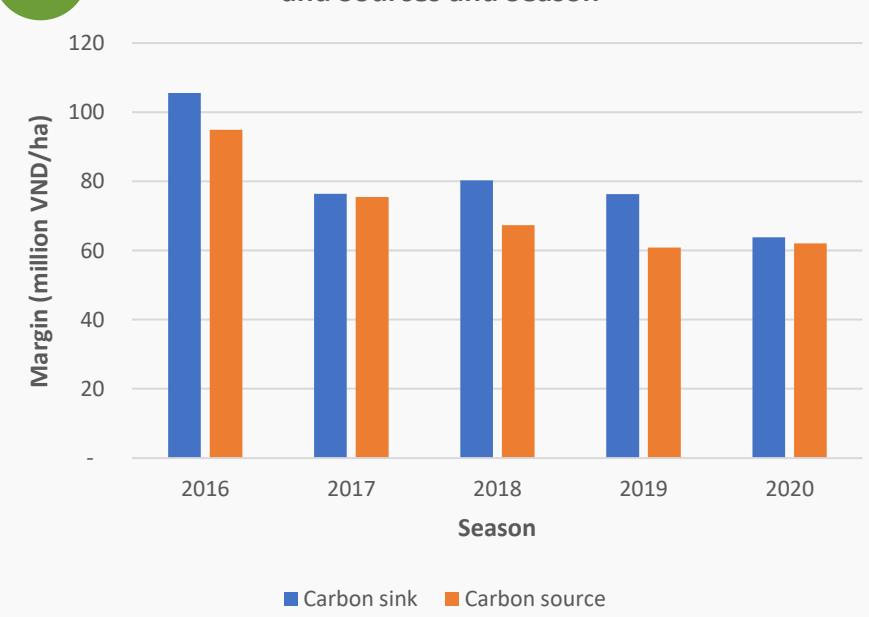


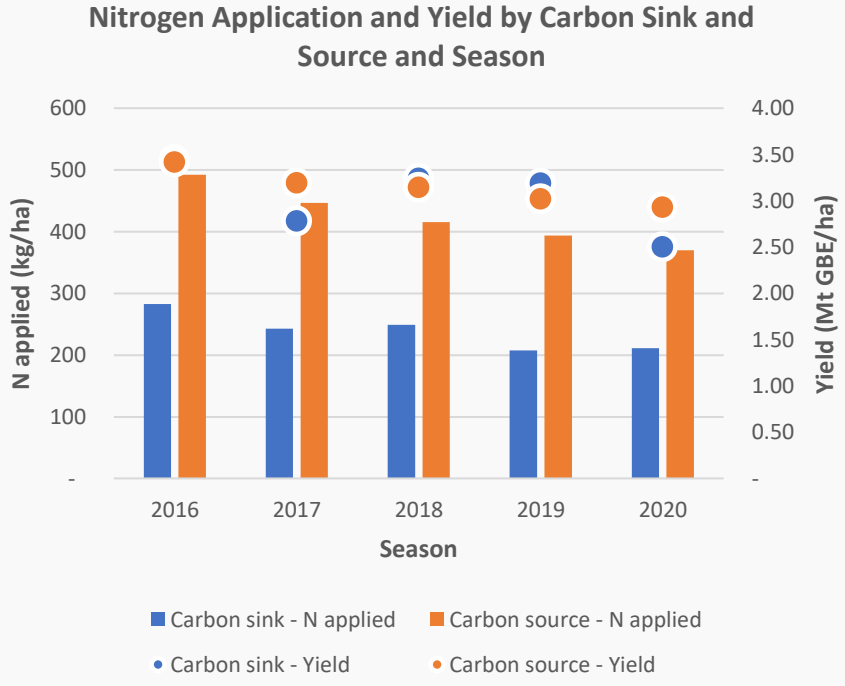
Fig. 2



Environmental performance: As a result of optimised nutrient management of nitrogen in particular, a growing share of farms are now acting as carbon sinks

- The share of farms that acts as carbon sinks has increased from 48% in 2016 to 74% in 2020 (Table).
- Much of this improvement is the result of optimised nutrient management and in particular that of nitrogen. We find that N applications in kg/ha are consistently and significantly ($p<0.01$) lower on farms that are carbon sinks in each of the 5 seasons, while yield levels as we could earlier observe, are not noticeably affected.
- Also on farms in the carbon source category, N applications have gone down from just under 500 kg/ha in 2016 to 370 kg/ha in 2020, a significant reduction ($p<0.05$), yet still a factor 1.75 higher than the 211 kg/ha we find in 2020 on farms that are carbon sinks.
- When comparing yield levels between farms that are carbon sources and sinks we find no significant differences ($p<0.01$) in any of the seasons.
- This indicates that the lower nitrogen application regime we find on farms that are carbon sinks are probably not detrimental to yield levels. Of course, local conditions may drive specific farms to apply more fertiliser, for example to compensate for lower soil fertility, but on average our conclusion appears to hold.

Share of farmers	Season				
	2016	2017	2018	2019	2020
Carbon sink	48%	64%	57%	68%	74%
Carbon source	52%	36%	43%	32%	26%



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About Agri-Logic

Agri-Logic – management, consultancy and research - operates where agricultural production, development, international trade and consumer markets intersect. We combine a thorough understanding of farm level reality and commodity trade with scientific research skills and a track record in sustainability strategy design and implementation, to help clients deal with sustainability challenges and market requirements.

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References

[1] https://www.ilo.org/wcmsp5/groups/public/---asia/---ro-bangkok/---ilo-hanoi/documents/publication/wcms_626102.pdf
[2] https://www.reuters.com/article/coffee-colombia/labor-shortage-to-limit-colombian-coffee-crops-as-beans-go-unpicked-idUSL2N0XA28020150603
[3] http://www.ico.org/documents/cy2014-15/icc-114-5-r1e-overview-coffee-sector-africa.pdf
[4] https://ec.europa.eu/agriculture/sites/agriculture/files/rural-area-economics/briefs/pdf/015_en.pdf
[5] https://www.statista.com/statistics/444749/inflation-rate-in-vietnam/
[6] https://gcp-connect.org/content/4633/farmer-field-book-analysis
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