DEVELOPMENT OF A DECISION SUPPORT FRAMEWORK FOR THE REHABILITATION AND SUSTAINABLE INTENSIFICATION OF COCOA PRODUCTION ON SMALL HOLDER FARMS

Nicholas Cryer, Eamon Haughey, Edmund Omane, Edward Kumah, Nimogon Guy-Abel Silue, Sarah Boyd

Mondelez UK R&D Ltd, Bournville Place, Bournville Lane, Birmingham, B30 2LU, UK.

Abstract

Sustainable high productivity cocoa farming requires the holistic combination of the best planting material with appropriate fertilizer supply, comprehensive farm management practises, and sufficient knowledge. Many farmers currently do not achieve high productivity due to limitations in their farming situation. To aid the transition of farmers from a low input – low output situation to a highly profitable, high productivity situation there is a need to provide farmers with a detailed plan with which they can effectively develop their farm. We have developed a decision support framework that integrates the key activities that farmers should take, and the impact of each activity on farm performance. This framework includes a calendar indicating the optimum time to conduct work; the amounts of resources required in terms of funding and labour, and an understanding of the impact of each activity in terms of increases to farm performance. Importantly, the level of risk, based on measurements of on-farm year-to-year variation in performance, are included. Comparing the financial implications of inputs vs. the benefits in yield and profit to the farmer allows a detailed and fully budgeted pathway to be provided for each individual farm. Here we present an overview of current tracks of research focusing on the promotion of Good Agricultural Practice. The research tracks are united in a conceptual decision support framework including a detailed economic understanding, which maps out the renovation of small holder cocoa farms.

Introduction

Status

The majority of cocoa is produced by 6 million smallholder farmers in West Africa, South East Asia, and South America (). Farm size is often small and productivity per unit area is very low. There is a huge variation in productivity between farms. Previous work identified those practices which drive yield; a holistic combination of the best planting material with appropriate fertilizer supply, comprehensive farm management practises, and sufficient farmer knowledge (Daymond *et al* 2017).

Limitations

Many farmers do not achieve high productivity due to limitations in their farming situation. To address the causes of low yield and test different service delivery models, we are working with 78 smallholder farmers in Ghana and Ivory Coast. Following a simple needs assessment, we are delivering two or three farm-specific and targeted agricultural interventions on-farm to confirm that these practices have economically significant impact.

Transformation

To aid the transition of farmers from a low input – low output situation to a highly profitable, high productivity situation we provide farmers with a detailed plan and targeted service delivery support with which they can effectively develop their farm. Drawing on extensive previous work we have created a decision support framework that integrates the key activities that farmers take, and the impact of each activity of farm performance. This framework includes a calendar indicating the optimum time to conduct work; the amounts of resources required in terms of funding and labour, and an understanding of the impact of each activity in terms of increases to farm performance. Comparing the financial implications of inputs vs the benefits in yield and profit to the farmer allows a detailed and fully budgeted pathway to be provided for each individual farm.

Methods

Farm selection and support

The targeted GAP project began in 2016 to exploit the findings of the Mapping Cocoa Productivity project (Daymond *et al* 2017) and test the hypothesis that smallholder farm productivity is often limited by a small number of factors. We chose to work on whole farms so that the recording and reporting of yield was simple for the host farmer and did not place an additional burden on their normal farming practice.

Farm area was limited to around 2 hectares to limit the cost to the project yet be sufficiently large to be a significant activity to the farmer. A survey of six metrics was used to assess the status of the farm, coupled with soil and leaf analysis. A decision support process was developed to prioritise which agronomic interventions were likely to have the largest impact on farm productivity. These could be farm management activities such as structural pruning, weeding, increasing the density of cocoa planting; plant nutrition practices such as the application of specific granular, organic, or foliar fertilisers; pest and disease control.

Location and agro-environmental situation

We chose to test the effectiveness of our service delivery strategy on farms in the Eastern region of Ghana. In this region the mean annual rainfall at the lower end of requirement to support cocoa in Ghana and with a pronounced dry season (Wood, 2001; Schroth, 2016). In the year preceding our study a prolonged and harsh dry season had effected some of the farms. Temperature is similar across the whole of the cocoa growing belt. Figure 1.

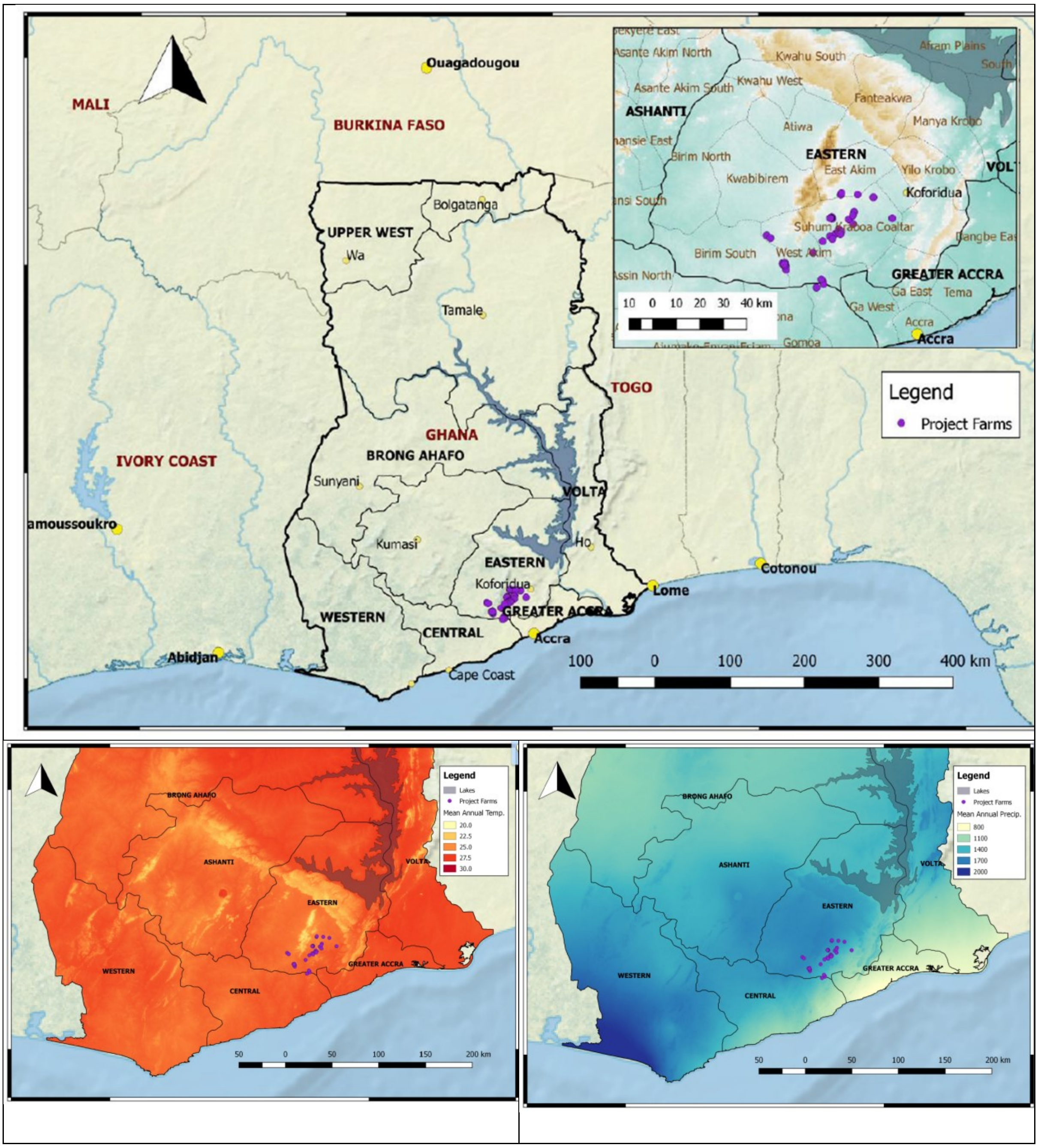

Figure 1. Project farm locations (a), mean annual temperature (b) and mean annual precipitation (c). Climate data obtained from: http://www.worldclim.org/bioclim

Assessment

Each intervention was delivered to the farm as a service and the cost and time recorded.

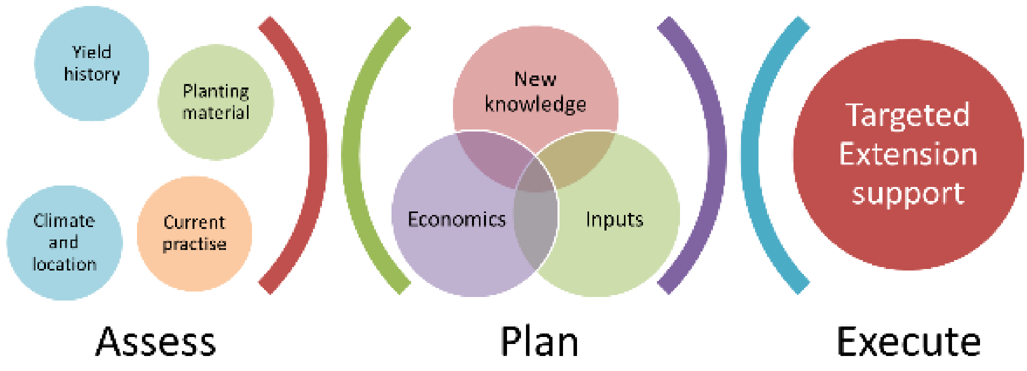

Figure 2. Decision support framework

Scheduling of interventions

Applying the correct intervention at the most effective time of year is an important component of effective farming.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
A1	Collecting essential farm information						X	X					
A2	Cocoa Swollen Shoot Virus Disease: prevention and control	X	X	X	X	X	X	X	X	X	X	X	X
A3	Black pod disease: prevention and control	X				X	X	X	X	X	X	X	X
A4	Mirids: prevention and control								X	X	X	X	X
A5	Weeding				X					X			
A6	Sanitary and structural pruning				X	X							
A7	Shade management				X						X	X	X
A8	Harvest and post-harvest practice	X	X			X	X	X			X	X	X
B1	Soil analysis and adjustment			X									
B2	Inorganic fertilizer application				X								
C1	Compost production	X	X	X	X	X	X	X	X	X	X	X	X
C2	Replanting			X	X	X	X						
C3	Formation pruning			X									

Figure 3. Calendar of on-farm operations.

Control dataset

To be able to make a judgement on if the application of agricultural interventions had an effect on the productivity of those farms, or if the change to farm productivity was a random effect we used a control dataset derived from regular monitoring of 150 farms throughout the cocoa growing region. This allowed comparison of year to year variation in farm performance and an estimation of the variation due to the treatments we applied.

Results

Baseline survey of farming practice

A scale of 0 to 4 was used to assess all farms in terms of how pruning had been done, presence of weeds in the farms, Pest damage on pods and effect of disease on yield. Out of the total number of the farms visited, 18 farmers had not done canopy pruning resulting in zero (0) score for their farms. 11 and 10 farmers had done canopy pruning in their farms, but the pruning was not done to perfection therefore, the farms were scored 1 and 2 respectively. Although no farm scored 4 which is the best score, one (1) farm scored 3 for canopy pruning (Figure 4.). Weed control was done properly in three (3) farms and were scored zero (0). Score 1 and 2 were given to 13 and 14 farms that had partial weed control respectively. Score 3 was given to 10 farms. However, none of the farms were scored 4 (chart 6). All the farms visited experienced pest infestations with 10 and 20 farms scoring 1 and 2 respectively. 9 farms experience severe mirids attack and were scored 3. None of the farms had very severe pest attack therefore no farm scored 4 (Figure 4.). Two of the visited farms did not experience black pod disease of cocoa and were scored zero (0). 15 and 20 farms were scored 1 and 2 respectively and 3 farm were score 3.

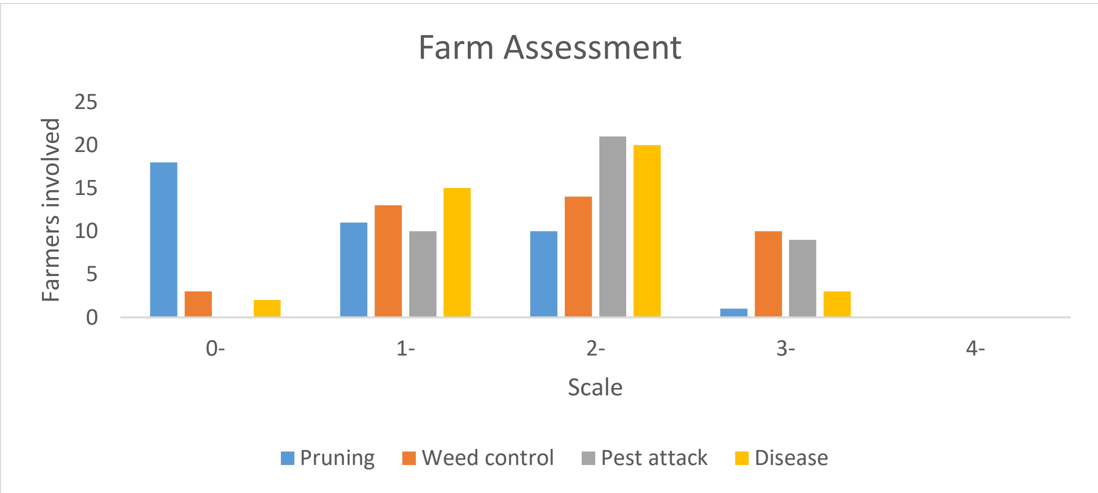

Figure 4. Baseline variation in farming practice. Subjective scoring of common farm management practices.

Baseline farm performance

A large set of farms were chosen as a control group to be representative of the general Ghana cropping situation. Each farm was surveyed frequently and the number of pods on a consistent set of trees was recorded. The crop year is taken to run from 01st April until 31st March.

The average baseline productivity of farms had a range of 183 to 2409 Kg / ha, a median value of 565 Kg / ha, mean value of 662 Kg / ha with a standard deviation of 412 Kg / ha (Figure 5 D). In the following 12 months there was an increase in the spread of productivity from 195 to 4444 Kg / ha, a median value of 857, mean value of 1017 Kg / ha with a standard deviation of 870 Kg / ha (Figure 5 D). The performance of the farms can be split into three groups.

This increase of 54 % productivity can partially be explained by favourable weather, supporting a 12 % increase in production at the national level. Additionally, much of the gain in performance came from the top third of farms where productivity passed 1000 Kg / ha.

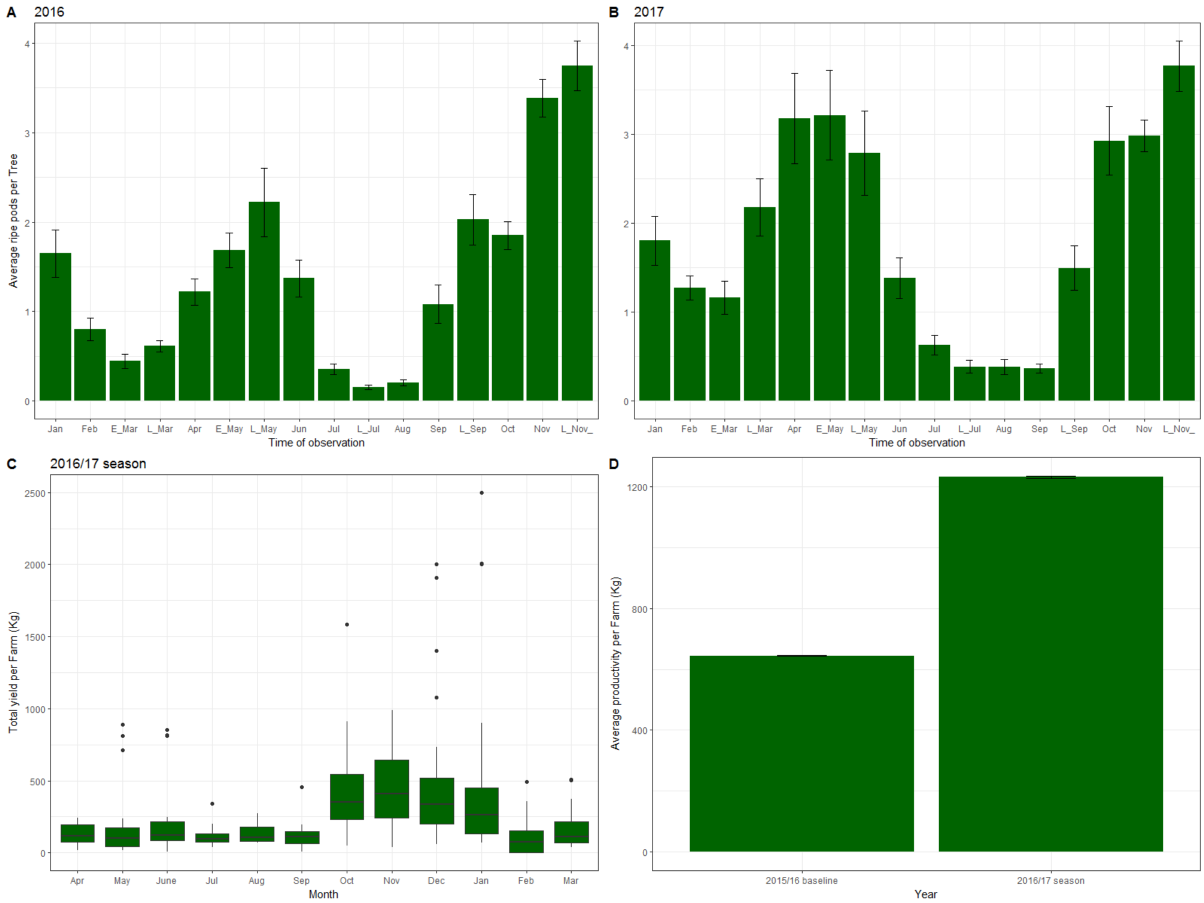

Figure 5. Farm performance observations. **A**, Average number of pods per tree observed from 150 farms across the cocoa growing region of Ghana in 2016; **B**, Average number of pods per tree observed from 150 farms across the cocoa growing region of Ghana in 2017; **C**, Monthly sales of cocoa beans from farms in the study in the 2016/17 season; **D**, Comparison of 2015/16 baseline average productivity per farm to the 2016/17 average productivity per farm.

Conclusions

Increases to farm performance

The very large increase to the performance of some farms, and the increase in median farm performance demonstrate very strongly that, with appropriate management and inputs, mature cocoa farms in Ghana can achieve yield of over 3000 Kg /ha. This is comparable with the best performing farms in South East

Asia and South America and challenges the common misconception that West African cocoa farming cannot achieve the high yield observed elsewhere.

Understanding poor farm performance

Importantly, one third of farms did not demonstrate a large increase in yield, sufficient to more than double the value of the total investment, in the first year. We believe that this was partially explained by local weather conditions (rainfall) but this is not true of all farms.

Genetics

An important factor that was not controlled in this study is the genotype of the planting material. It is possible that some of the farms which maintained poor performance did not have a high potential yield due to the limitations imposed by genetic constraints of open pollinated seed from uncertified sources.

Access to Labour

This project provided physical services to the farmer for the application of specific fertilizers and for both insecticide and fungicide spraying.

One of the factors that proved difficult to achieve was optimum weed control on each farm. Weeding is an important task to reduce competition with the economic crop but is also essential to allow easy access across the farm; facilitating pruning, sanitary harvest, and the application of insecticide and fungicide. The task was mainly done by manual weeding with a cutlass and is limited by the farmer’s access to labour and the time at which labour is available. The common practice in farming communities is that weeding, and many other tasks, are performed as a community activity. Therefore labour is only available when the community are willing and able to work on this task. The balance with other competing interests means that community labour is often not available at times other than the usual time that this activity is done in that community; this timing of availability varies from community to community and from farm to farm. To free the farmer from the restriction of collective labour availability there is a need to introduce mechanisation wherever it is economically beneficial to do so.

We are developing strategies to limit the investment into farms in the first year to allow non-responsive farms to withdraw. This is an essential step to limit the exposure of the farmer and other stakeholders to financial risk.

Scale-up

To transform cocoa growing and extension services we will collaborate to coordinate activity across multiple stakeholder sectors to align activities more closely with the needs of the farmer. This will deliver a small number of farm-specific recommendations that are known to give a significant increase in productivity. The platform required to engage the full range of enabling institutions is yet to be built. A schematic of the range of the stakeholders we seek to engage is shown by Figure 6.

Reference

Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis, 2005. Very high resolution interpolated climate surfaces for global land areas. *International Journal of Climatology 25: 1965-1978*.

E. Lichtfouse (ed.), Sustainable Agriculture Reviews, Sustainable Agriculture Reviews 19, DOI 10.1007/978-3-319-26777-7_4 Chapter 4 Cacao Nutrition and Fertilization. Didier Snoeck , Louis Koko , Joël Joffre , Philippe Bastide , and Patrick Jagoret.

A.J. Daymond, K. Acheampong, A. Prawoto, S. Abdoellah, G. Addo, P. Adu-Yeboah, A. Arthur, N.C. Cryer, Y. N. Dankwa, F. Lahive, S. Konlan, A. Susilo, C.J. Turnbull and P. Hadley. 2018. Mapping Cocoa Productivity in Ghana, Indonesia and Côte d'Ivoire. In: Proceedings of the International Symposium on Cocoa Research (ISCR), Lima, Peru, 13-17 November 2017. In press.

G. Schroth, P. Läderach, A. I. Martinez-Valle, C. Bunn, L. Jassogne (2016). Vulnerability to climate change of cocoa in West Africa: Patterns, opportunities and limits to adaptation. Science of The Total Environment, Volume 556,Pages 231-241.