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DETERMINANTS OF FARMER INVESTMENT IN COFFEE PRODUCTION: FINDING A PATH TO SUSTAINABLE GROWTH IN RWANDA'S COFFEE SECTOR

By

Daniel C. Clay
Aniseh S. Bro
Ruth Ann Church
Alfred Bizoza
David L. Ortega

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AUTHORS

Daniel C. Clay, Michigan State University
Aniseh S. Bro, Michigan State University
Ruth Ann Church, Michigan State University
Alfred Bizoza, Institute for Policy Analysis and Research (IPAR-Rwanda)
David L. Ortega, Michigan State University

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1. Executive Summary

Coffee production has been at the core of farm family livelihoods in Rwanda for many generations and today it serves as source of cash income for over 355,000 households across the country. Since 2001, the coffee value chain has seen a transformation in quality (fully-washed coffee) and is now well-established in specialty coffee markets around the globe. With the construction of 245 washing stations, the processing segments of the sector have prospered. Dry mills and export companies, both domestic and international, have similarly emerged during this period. While the value-added from this transformation has benefited Rwanda, those at the base, the coffee producers, have shared the least in the new prosperity. This research posits that failing to include the producers as full partners is the main reason that coffee production in Rwanda has declined and stagnated in recent decades. Sub-par compensation for their cherry, an average of 24 percent below the revenues of their counterparts elsewhere in the region, has resulted in the neglect and disinvestment in coffee by many producers, particularly largeholder producers.

Findings presented in this report show that the true cost of production in Rwanda, including household and wage labor, inputs and equipment, totals 177 RWF/Kg of cherry, a figure well above that currently used as a reference for establishing cherry floor prices in Rwanda. As a result, a large proportion of growers suffer unsustainably low margins or even net losses in coffee (over one-third in 2015). These farmers would make more by working as agricultural wage laborers on the farms of other, more productive farms.

Three predominant types of producers are identified based on their relative capacities and their incentives to invest in coffee. Understanding how these producer groups differ and perform in terms of productivity and gross margins (profits) helps us to think more clearly about steps that can be taken to improve overall sector performance. The coffee producer types are:

- *Smallholder coffee producers* (mean trees = 106) are more productive (per tree) than largeholder farmers. They lack capacity but are highly motivated to extract as much value as they can from their small holdings simply out of necessity. Their main investment is their own household labor. Despite higher productivity, their high labor investment makes coffee unprofitable for most.
- *Largeholder coffee producers* (mean trees = 2,200), by contrast, have the lowest productivity of all farmer groups. They have high capacity but do not use that capacity for coffee production. They are responsive mainly to coffee cherry prices and when prices are low, as they have been in recent years, they prefer to temporarily abandon their coffee plantations or even to uproot trees in favor of other crops.
- *Mid-range coffee producers* (mean trees = 457) are a hybrid mix of those at the extremes. They have mid-range capacity but are still stretched and out of necessity must maximize production from the resources they have. This combination of capacity and incentives enables this group to reap higher profits from their trees than any other group.

While the contributions and performance of all of Rwanda's coffee farmers are vital, and all must be recognized as full partners in Rwanda's coffee revolution, the largeholder group is where the long-term future of coffee in Rwanda lies. They are commercially oriented and have a larger scale and more capacity. They keep a close watch on profit margins and when prices are low they do not invest. Incentivizing this group alone to invest and produce coffee at a rate even

up to the modest productivity level of the lowest capacity group (2.17 KG/tree) will increase production in Rwanda by 46 percent. Bringing the mid-range producers up to the same yield level would add another 11 percent to the overall volume of coffee processed and exported from Rwanda. A change of that magnitude would place Rwanda on a path toward sustainable growth.

Findings show that end-of-year premium payments also provide an important incentive for farmers to improve productivity. Farms that receive premiums (8.3 percent, on average) have an estimated productivity that is 29.4 percent higher than those that do not receive premiums, all else equal. These findings are especially germane to our understanding of farmer incentives. It demonstrates how sensitive farmers are to even small changes in remuneration.

There are several priority steps that sector leaders can consider to help create needed incentives for producers to invest their labor, cash and eventually more land in their coffee plantations. These actions will in turn result in higher yields, better control of pests (antestia), improved quality, and higher incomes for everyone in the sector. They are summarized as follows:

1. Accelerate conversations about how cherry floor prices are established with special attention to how floor prices will motivate larger coffee producers who, even at very low levels of productivity, account for nearly half of Rwanda's coffee production.
2. Incorporate into the formula for cherry prices the actual cost of production of 177 RWF/KG to Rwanda coffee growers. The current cost of production benchmark of 80 RWF/KG cherry is badly antiquated and based on hypothetical costs to a farmer with 2,500 trees rather than the actual median of 400 trees.
3. Research and model how higher cherry prices will improve farmer investment, raise productivity, increase the volume of coffee processed and exported.
4. Similarly, there is a need to model the effects of higher investment on coffee quality, particularly the density of cherry, the share of coffee going through fully-washed channels and higher grades of coffee (and a reduction of triage grade coffee).
5. Consider how large volumes of fully-washed coffee will benefit all stakeholders in the coffee sector, and how more coffee will bring down the unit costs of processing and move closer to full capacity use of processing infrastructure.
6. Give coffee the level of national attention it deserves, and profoundly needs. Given Rwanda's comparative advantages in producing coffee for the specialty market coupled with its powerfully protective environmental attributes and success on steep hillsides, there is good reason to consider the steps needed to address its vulnerabilities, starting by motivating farmers to invest in improved agronomic practices that will help them to maximize their returns from the sector. Now is the time for Rwanda to bring coffee back to center stage in its discussions and strategic thinking about the country's agronomic and economic future.
7. Premiums are shown to have an important positive effect on productivity as those receiving premiums enjoy yields 29 percent higher, all else equal, than those who do not. There is a need to develop and test a system for two-tier pricing of coffee cherry based on quality.
8. Improve the effectiveness of fertilizer and pesticide distributions, which are far below the recommended dosage, and model the effects of cherry prices on farmer demand for inputs.
9. Rigorously assess the impact of the zoning policy on farmer incentives, investments and productivity. There may be unintended consequences of limiting competition for cherry, resulting in lower cherry prices to producers and accelerating the downward spiral of low coffee prices => low motivation => low investment => low productivity => low profits.

2. Introduction

Stakeholders throughout Rwanda's coffee value chain agree that the long-term success of the sector depends on growth in coffee production and productivity. Regrettably, as will be shown in the following section, Rwanda has seen a gradual decline and, more recently, stagnation in coffee production over the past 25 years—a source of concern for virtually all stakeholders in the coffee value chain. Indeed, NAEB in its strategy statement identifies insufficient production of coffee cherry as the primary constraint to growth in the sector (NAEB, 2016a). Seemingly, a paradox lies within: coffee productivity in Rwanda is among the lowest in the world, yet international buyers consistently rate its coffees among the very best in the world, easily on par with coffees produced elsewhere in the East Africa region. Other countries in the region, notably Ethiopia and Uganda, have experienced steady growth in their coffee sectors over the past two decades, while Rwanda has not.

Rwanda's strategic objectives are consistently in line with the expressed need to raise the productivity and quality of coffee, as well as to accelerate the shift from "ordinary" or "semi-washed" coffee to higher-value "specialty" coffee. The goal is to increase the proportion of coffee produced through the fully-washed channel to 80 percent from its current level of 55 percent.

A critical part of the solution lies in Rwandan coffee producers' capacity and incentives to invest in their coffee. Capacity, in terms of land, labor, cash/capital and knowledge (technical and entrepreneurial), are constrained for many of the country's producers. At the same time, it is well established that adequate farmer capacity will not result in the desired improvements in productivity or quality unless coupled with proper incentives to produce (Ohdiambo, et al., 2013; Integrity Reasearch, 2013; Ndayitwayeko et al., 2014). A lack of farmer motivation to invest in coffee is a serious threat to reaching Rwanda's goals of a more productive, vibrant and sustainable coffee sector.

This research report draws on recent quantitative and qualitative evidence from the AGLC project to examine patterns of farmer investment in coffee to understand the drivers of such investments—what factors enable farmers to allocate land, labor and capital to coffee production, on the one hand, and what barriers may be present that restrict their investments in the coffee sector, on the other. We start with a review of historical trends in coffee production and producer prices based on data from the International Coffee Organization, followed by an analysis of data from the AGLC Baseline Survey of producers in four important coffee-growing districts in Rwanda. We examine patterns of investment in coffee and how those investments affect farmers' productivity and gross margins (profits). We present a great deal of data and drill down on the factors that make some producer groups productive and others not so productive or profitable. Coffee producer views on the primary barriers and advantages to coffee production are presented along with an analysis of how farm households use the revenues they receive from coffee production. The report concludes by proposing a set of actions that the sector might consider and possibly rally around as it contemplates how to establish its footing and direction on a path toward sustainable growth.

3. Trends in Coffee Production, Productivity and Producer Prices in Rwanda

Overall coffee production in Rwanda is markedly lower now than it was 25 years ago (Figure 1, left side), stabilizing over the past 7-8 years in the range of 280,000 bags (16,800 MT).[1] It is notable that other selected countries in the East Africa region have increased their production during this same timeframe. Ethiopia, for one, has more than doubled its output and now stands as a model of growth for the entire region (Figure 1, right side). The question on the minds of many in coffee industry leaders in Rwanda is how to build farmer capacity and put in place the incentives that can ensure necessary farmer investment in their coffee plantations.

An important step has been the gradual transition that the Rwanda coffee sector has made since 2002 toward fully-washed specialty coffee, a process that was initiated with support from the USAID-funded PEARL project.[2] Today fully-washed specialty coffee constitutes 45% of all exported coffee from Rwanda, up from just 1% in 2002 and 21% in 2007 (NAEB 2016b). Thus, while the volume of coffee has stagnated over the past 15 years, the quality of green coffee, and the export prices derived from that quality, have risen dramatically and have placed Rwanda on the map internationally as a highly desirable coffee origin (Ndambe, 2015).

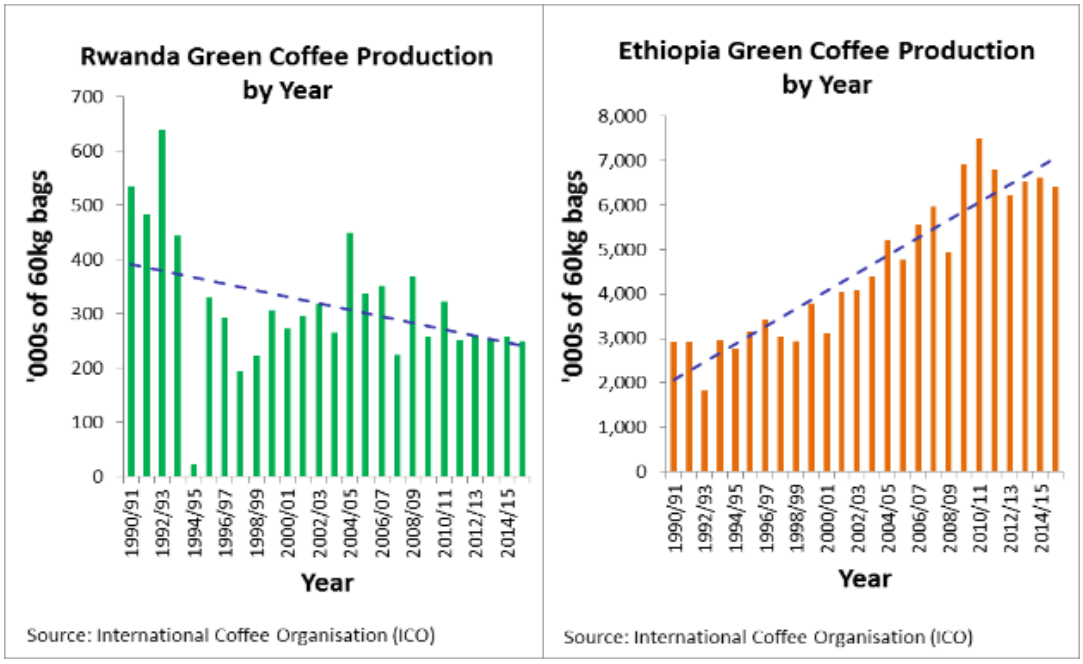

Figure 1

This transformation has enabled substantial growth in coffee processing. There are currently 245 Coffee washing stations spread across Rwanda's major coffee growing regions (NAEB 2016b), numerous dry mills, new entrants to the ranks of exporters, including major multi-national corporations, and in more recent times a remarkable growth in Rwanda's local coffee roasting

[1] International Coffee Organization (ICO) data base, supplemented by data in most recent years from the Rwanda's National Agricultural Exports Development Board (NAEB).

[2] Partnership to Enhance Agriculture in Rwanda through Linkages (PEARL), 2001-2006.

and retail businesses, spawning an exciting new domestic coffee culture, albeit primarily an urban phenomenon to date.

While these positive, quality-based developments have added considerable value to Rwanda's coffee, one must ask how much of that value-added has made its way (trickled down) to coffee producers. Farmer compensation in Rwanda has remained largely stagnant and well below that of their counterparts in much of East Africa for the past 20 years. Figure 2 reveals that producer prices in Rwanda have lagged the rest of East Africa by an average of 24 percent during the period and that overall differential has shown little to no improvement in recent years despite Rwanda's heralded transition to higher quality, fully-washed coffee.

The implication from these observations is that nearly all of the value-added attached to higher quality coffee has accrued to those in the post-harvest stages of the value chain—comprised mainly of washing stations, dry mills and export companies. At one level, it seems logical that those segments of the value chain responsible for transforming coffee from cherry to green coffee, a detailed and highly specialized process, should be the recipients of the value that transformation adds to the final product. From another perspective, however, the producers must be recognized as partners in the quality-enhancement process, particularly to the extent that their efforts in the field through a range of best practices (weeding, pruning, mulching, etc.) result in higher quality cherry, with higher density and fewer defects, harvested at precisely the right time (fully mature and red) and delivered to the CWS within a six-hour window to avoid spoilage. Without these critical steps, Rwanda's fully washed coffees will cup below the 80 point "specialty" threshold and be classified for sale as "ordinary coffee," at best.

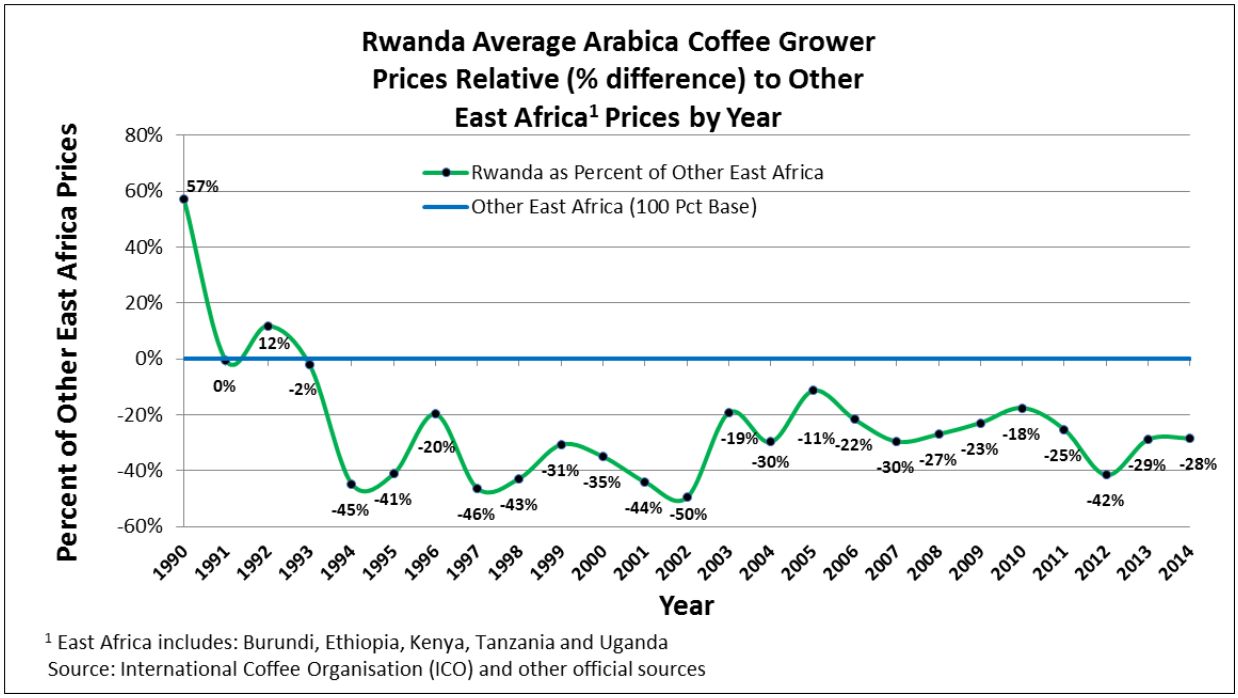

Figure 2

Thus, it is maintained here that compensating farmers for their efforts to produce a quality coffee that will fetch top prices on international specialty coffee markets is a critical step, perhaps the most critical step of all, in the long-term success of Rwanda's fully-washed, specialty coffee value chain. Demand-side incentives begin with the farmer; Rwanda's coffee renaissance is yet to embrace that concept.

Data reported by the International Coffee Organization (ICO) also show Rwanda's average productivity from 2011/12 to 2013/14 at 385 KG/Ha for Arabica green coffee, or approximately 43% below the East Africa average of 604 Kg/Ha (Figure 3). The differential in productivity is not so much a function of agro-ecological differences, such as elevation and rainfall, as Rwanda does not differ greatly from its highland African neighbors on these factors. Significant agronomic differences may be more in the coffee varieties grown in Rwanda (mainly Bourbon) compared to other countries such as Kenya, where higher-yielding varieties have been adopted at a higher rate (Gatarayiha, 2014). Rather, the primary reason for Rwanda's continued low productivity is widely believed to be due to farmer non-adoption of best practices, especially in the use of fertilizers, manure and other inputs, as well as in how coffee trees are maintained in the field through pruning, mulching, stumping, and other labor intensive practices. In point of fact, fertilizer applications in Rwanda are reported to be less than a quarter of what is recommended as industry best practice (AGLC, 2016a).

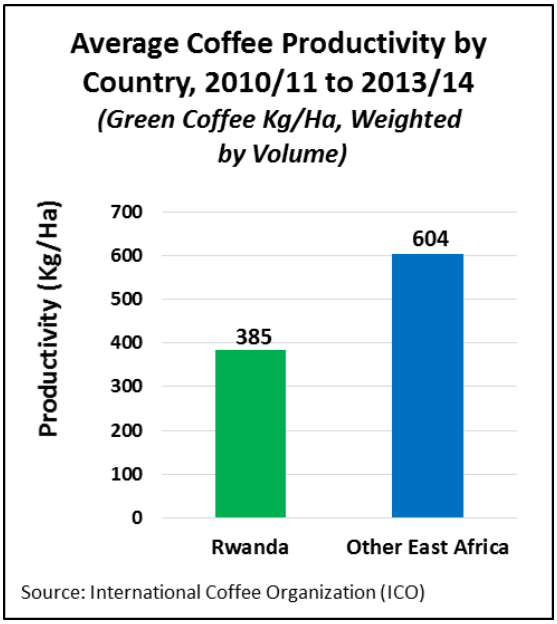

Figure 3

Low producer prices as a determinant of low productivity. These trends beg the question of whether Rwanda's low coffee producer prices and low productivity are causally related. We hypothesize that they are closely linked, with low producer prices in Rwanda being an important determinant of the country's low productivity and declining/stagnant production over time. Farmers will choose to invest in coffee (and other crops) when they have both the capacity to invest and the incentive to invest, as noted above. The main incentive to invest one's land, labor and capital in coffee is the expected financial return (cherry prices), discounted for the level of risk (of a poor harvest) that they must assume as a condition to that investment (Integrity Research, 2013). Like most crops, coffee yields are directly affected by variations in weather, pests, diseases and other natural threats, and the risk of one or more of those threats resulting in a poor harvest is substantial.

In the following sections of this paper we examine AGLC Baseline Survey data on farmer investments in coffee and how those investments are linked to both farmer capacity and potential returns. We are concerned with how farmer investments affect their productivity as well as their gross margins (profits) and how, in turn, these outcomes are conditioned by their capacity to invest in coffee.

4. Methodology

This research draws upon a broad mix of quantitative and qualitative data collection methodologies. The AGLC Baseline Survey of coffee growers is the primary source of quantitative information reported; it is supplemented by a program of Focus Group Discussions (FGDs) with coffee sector stakeholder groups.

The Baseline Survey was conducted early in 2016 on a sample of 1,024 households randomly selected from listings of 16 coffee washing stations (CWS) geographically dispersed across four major coffee-growing districts representing Rwanda's four agricultural provinces (Figure 4). The selected districts are Rutsiro (Western Province), Huye (Southern Province), Kirehe (Eastern Province), and Gakenke (Northern Province). The guiding objective of the Sector/CWS selection was to maximize geographic dispersion of the four CWSs in each district and also to ensure that the four would include two that are cooperatively owned and operated and two that are privately owned and operated. From the farmer listings at each of the CWSs, 64 farmers were randomly sampled for study, totaling 1,024 (16 CWS x 64 HH) coffee producing households in all.

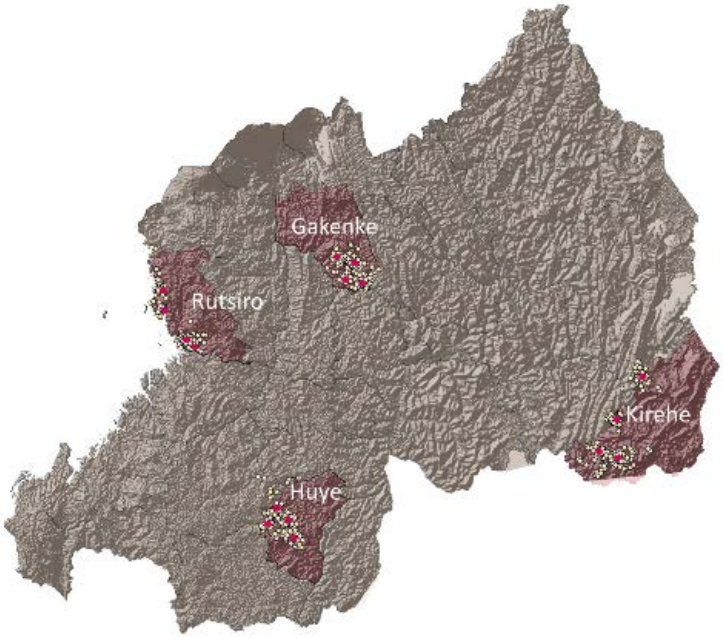

Figure 4. Map of Sampled Districts, Washing Stations and Households

The survey instruments were developed at the farm household and field levels. Sections of the questionnaire covered a diversity of topics including: coffee growing practices, antestia control practices, cost of production, coffee field size, number of trees, slope, location (GPS), cherry production, cherry sales, landholding, equipment & assets, household income, perceptions of barriers to investment in coffee and basic household demographics. The questionnaires were then translated to Kinyarwanda, programmed for Samsung 7-inch tablets using CSPro Mobile software, and pretested in the field. Experienced enumerators were hired and were trained just prior to the pretest. Immediately following the pretest a series of debriefing sessions was organized and the survey instruments were revised based on the pretest results.

To supplement the quantitative survey data, an extensive series of key informant interviews was conducted with public and private sector leaders in the coffee industry, as well as focus group discussions with the major coffee stakeholder groups in Rwanda, including coffee farmers, washing station managers, coffee exporters, and others. Data from all of these sources have been integrated into a multi-component project data base and are drawn upon in our analysis of farmer incentives and capacity to invest in coffee production in Rwanda.

5. Findings and Discussion

5.1 A summary look at some of the core study variables

In the sections that follow we present a series of analyses to help understand the determinants of farmer investments in their coffee plantations. We draw on several groups of variables in these analyses including socio-demographic variables (e.g., age and gender of head of household), economic variables (e.g., household income, and land/tree ownership, and gross margins from coffee), and agronomic variables (such as production practices and elevation). Table 1 presents a summary of the descriptive parameters on some of these key determinants.

Table 1

Summary Descriptive Parameters of Selected Determinants/Covariates

	N	Min	Max	Percent	Mean	Median	S.D.
Gender of head (% female)	1024	1	2	18.5%	-	-	-
Age of head (years)	1024	22	94	-	51.1	51	14.18
Education of head (% primary complet	1024	1	10	39.1%	-	-	-
Member of coop (%)	1024	0	1	55.4%	-	-	-
CWS cooperative (%)	1024	1	2	50.0%	-	-	-
Income 2015 (not including coffee)	1023	0	4,350,000	-	318,726	180,000	452,385
Income 2015 from coffee	1021	0	2,945,000	-	200,286	125,000	256,166
Share of total income from coffee	1022	0	1		44.5	42.0	27.5
Nbr of productive coffee trees	1022	0	9,320	-	706	400	945
Total cherry production 2015 (KG)	1022	0	15,500	-	1,025	601	1,448
Total land owned (sq meters)	1024	0	80,000	-	11,986	9,449	10,673
Received premium (%)	1016	0	1	26.9%	-	-	-
Price per kg of cherry 2015	1005	100	300	-	198	200	32.49
Applied fertilizers (%)	1024	0	1	71.0%	-	-	-
Applied pesticides (%)	1024	0	1	68.8%	-	-	-
Applied manure (%)	1024	0	1	59.4%	-	-	-
Elevation of HH (m)	1024	1,310	2,179	-	1,712	1,721	165

It is important to note that the sample includes coffee growers in the four sampled districts that produce cherry for the fully-washed coffee channel in Rwanda. Similar to the broader farm population, 18.5 percent of sampled households are headed by women. We note that these women are disproportionately older and widowed. The average age of heads of households is 51 years and 39.1 percent of them have completed primary school or higher. Cooperative membership stands at 55.1 percent and 50.0 percent of households take their cherry to a cooperatively owned washing station, a reflection of the sampling frame that equally represented (50% - 50%) washing stations that were cooperatively and privately operated.

Median non-coffee income is 180,000 RWF,3 while median income from coffee is 125,000 RWF, meaning that coffee is a major part of total income of these farm households—44.5 percent on average. The mean coffee plantation is just over 700 trees (median 400 trees) and the mean cherry production from those trees is 1,025 KG (median 601 KG). Farm size (owned

[3] 1 USD = 784 RWF

land) is approximately 1.0 hectare (mean 1.2 ha, median 0.94 ha), measurably larger than the average farm size in Rwanda of 0.6 (NISR, 2016).[4]

Cash premiums are received by just over a quarter of coffee producers typically being paid by buyers for higher quality coffee. The median cherry price received by sampled farmers in 2015 was 200 RWF/KG and ranged in price from 100 to 300 RWF/KG, a variation linked mainly to cherry quality and type of buyer. We note that most households sell directly to the CWS or cooperative (91.7 percent of cherry sold) and they received a median of 200 RWF/KG for their cherry. The remaining 8.3 percent of cherry was sold to private traders and the median price received by those households was 180 RWF/KG, or approximately 10 percent less.

About two-thirds of farmers in the fully-washed channels in the four districts use recommended inputs with 71.0 percent applying fertilizers, 68.8 percent applying pesticides (both mainly from CEPAR/NAEB distributions), and 59.4 percent apply animal manure to their coffee. Sampled farm households are located in the elevation range between 1,300 and 2,200 meters above sea level, with a mean elevation of just over 1,700 meters, an elevation range that is recognized by coffee buyers for producing exceptionally high quality coffees.

5.2 Farmer investments in labor, inputs & equipment

There is wide variation in how farmers invest in their coffee plantations, both in terms of the types of investments they make and the amounts they invest. The major types of investments farmers make in the production of coffee include household labor, hired labor, purchased inputs and purchased equipment. Overall, they total 231 RWF per tree in 2015. Breaking out this figure proportionally we find that by far the largest investment made by farmers comes in the form of labor at 78.2 percent of all investments (42.0 percent as household labor and 36.2 percent as hired labor). This is followed by purchased inputs (fertilizer and pesticides) at 14.8 percent, and equipment/tools (pruning shears, sacks, etc.) at 8.1 percent of total farmer investments per coffee tree.

The number of trees in the coffee plantation makes a substantial difference in the amounts that farmers invest per tree. As shown in Figure 5, farmers with large scale plantations invest markedly less per tree (114 RWF/tree) than those with small plantations (379 RWF/tree), more than a three-fold difference. Part of this difference may be attributed to the economies of scale enjoyed by those with larger plantations. This may be particularly true for capital costs such as equipment, the costs of which can be defrayed across a larger number of coffee trees. But other investments such as household and wage labor for weeding, pruning and harvesting are not likely to see more than modest economies of scale as they are investments that are made tree by tree and are entirely manual tasks with no mechanization or other labor-saving technologies used. Similarly, purchased inputs are thought to bring only small cost savings to larger scale operations, potentially associated with purchasing inputs in larger quantities. However, because few farmers at any scale make such purchases (only 6.0 percent) and almost all in small quantities (<100 KG), we conclude that the advantages of scale in coffee production in Rwanda are minimal.

[4] Average farm size: 0.45 (West), 0.54 (North), 0.83 (East), 0.5 (South).

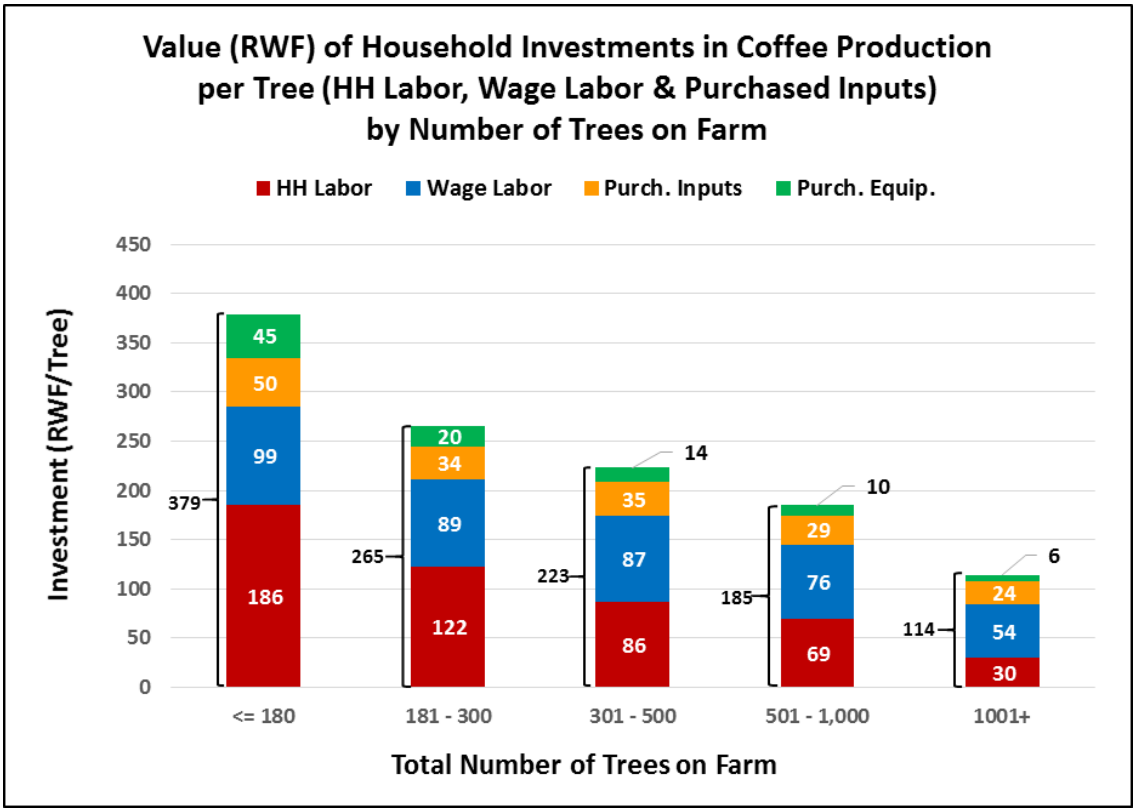

Figure 5

If not scale, what is it that accounts for the three-fold smallholder to largeholder differential in farmer investments in coffee? And why is it that by far the greatest differential of all is found in the levels of household labor they put into coffee production? The answer to these questions lie in the vast differences among these households in their capacity and incentives to invest, factors examined closely in the sections that follow.

5.3 Do these different investments result in higher productivity?

Overall, productivity in Rwanda is low compared to other coffee producing countries, as discussed in Section 3 above. Data from the AGLC Baseline Survey confirm this fact, finding that even among farmers fully or partially engaged in the fully-washed coffee channels, mean productivity measures 1.75 KG/tree and 10.9 KG/day (of labor). Expanding to include all producers in the country, many not affiliated with coffee washing stations, the estimated productivity is even lower at 1.22 KG/Tree (based on data from NAEB National Coffee Census).[5]

To test the question of whether the farmer investments presented in the previous section (labor, inputs, equipment) result in higher productivity per tree we first ran a simple bivariate correlation between the two variables and found, as expected, a strong and highly significant correlation ($r = 0.37$). Viewing that relationship across categories of farmer investment (Figure 6) we similarly observe a close and ostensibly linear association in which the lowest levels of farmer investment (<80 RWF/tree) result in the lowest productivity at 1.06 KG of cherry per

[5] Estimated from NAEB 2015 Coffee Census figures: 76,287,097 Kg cherry / 93,376,065 productive trees = 1.22 Kg/tree.

tree and, conversely, the highest investments at over 340 RWF/tree produced 2.57 KG/tree. Clearly there is a per-tree payoff to farmers who choose to more closely follow the extension recommendations encouraged by public and private sector agronomists. It is important to note, however, that when observed on a per unit of labor basis (marginal value product of labor) the reverse holds true, where greater investment leads to lower productivity per unit of labor (r = -0.45). Further analysis shows that farmers who make these higher, recommended levels of investment in their coffee are those with the fewest trees.

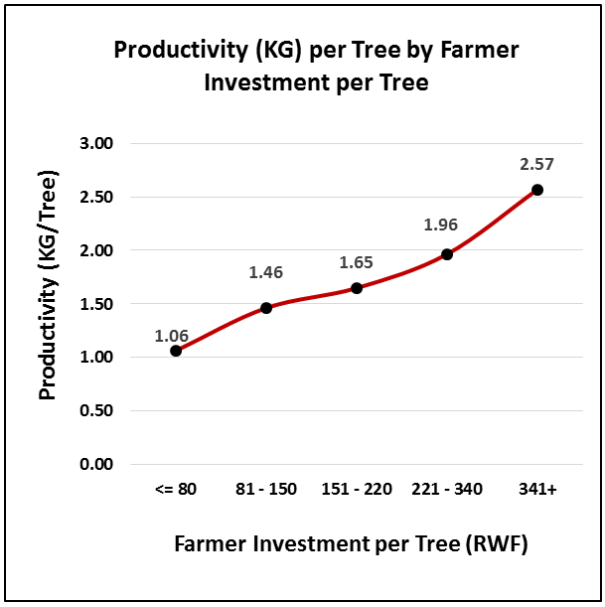

Figure 6

Breaking out productivity levels by plantation size (number of productive trees) one finds that farmers with smaller plantations are more productive per tree than are those with larger plantations. This pattern holds even after controlling for many of the factors/covariates known to affect productivity including: total household non-coffee income, land owned, age of head, education of head, active adults in household and farm elevation (m). The analysis of variance (ANOVA) model reported in Figure 7 (left side) shows that the highest level of productivity, estimated at 2.17 KG/tree, is found among farms with fewer than 180 trees; productivity declines markedly as the size of the plantation grows and hits its lowest point, estimated at 1.08 KG/tree, among those with more than 1,000 trees. We note that previous research has found a similar inverse relationship between farm size and productivity in Rwanda (Clay et al, 2014; Ansoms et al, 2009, Clay et al, 2002)

By contrast, we note the reverse effect (right side) vis-à-vis productivity per day of labor invested in coffee production (including household and wage labor). Smaller farms put much more labor into their production practices but produce only 7.4 kg of cherry per day, compared to a 17.0 kg/day return for the farmers with the largest plantations. Thus, while the smallholders invest more (mostly more labor) and produce substantially more per tree as a result, there is a clear diminishing return to that labor investment. So much so that many smallholder coffee farmers make less per day on their own farms than they would as day-laborers on their neighbors' farms.

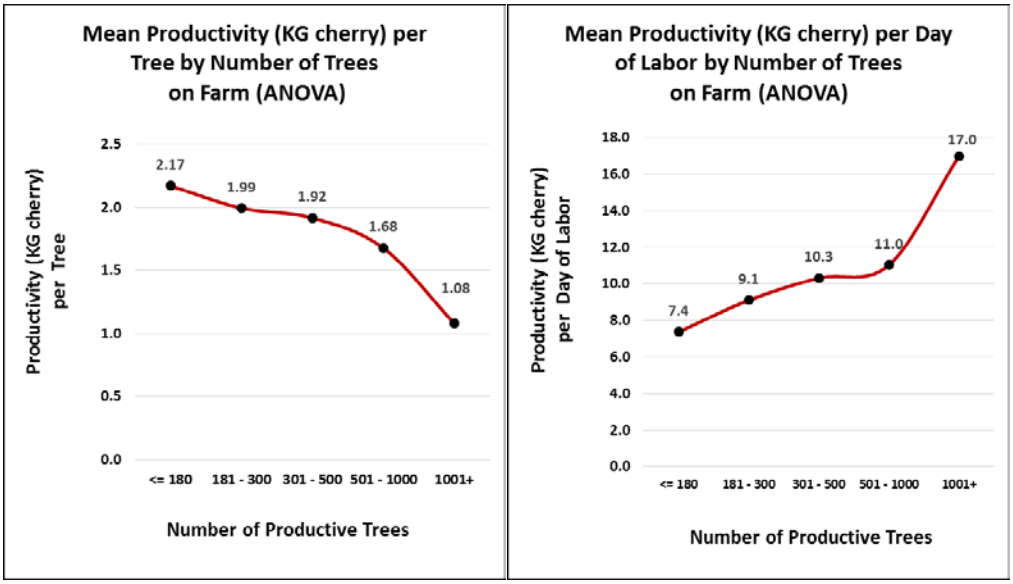

Figure 7

5.4 Do these investments and productivity rates translate into higher returns?

While there is a clear drop in productivity associated with lower investments and more trees on the farm, it is equally important to examine how returns to farmers (gross margins) vary across these groups. Gross margins, or profits, are measured at the farm level as total revenues from coffee sales, less the cost of production. On average, farmers in the sample made a profit of 91,699 RWF (median 33,198 RWF) from their coffee sales. That total farm figure translates to 121 RWF (median 87 RWF) per productive tree. Dissecting the range of values in these distributions shows that just over 30 percent of farms in the study have negative gross margins, meaning that their costs outweighed their revenues. What this means, as a practical matter, is that these households with negative profits provided their own labor (the major production cost) at an effective rate somewhere below the prevailing agricultural wage rate (700 RWF/day) paid in the four coffee-growing districts surveyed.

Breaking out gross margins by levels of farmer investment reveals that the least remunerative farms are those where farmers invest the most (Figure 8, left side), after controlling for factors and covariates in the ANOVA model.[6] This can be seen in the upper quintile of investments (341+ RWF/tree), the only group with a negative gross margin, at -13 RWF/tree. Despite the fact that these farms are the most productive (per tree) as shown earlier, they are also the least profitable of all. Conversely, those in the low investment categories are the least productive, yet the most profitable.

It is similarly revealing to observe how gross margins vary by number of productive trees on the farm. We find that households with few trees, while far more productive than those with more trees, are indeed the least profitable farms, returning an estimated 76 RWF per tree (Figure 8, right side). Yet those at the other end of the scale, farms with 1000+ trees, are almost as unprofitable at 90 RWF/tree. There is a strong curvilinear relationship between number of trees on the farm and returns per tree. Those in the middle, notably those in the 301-500 range, make

[6] Factors include gender and level of investment; covariates include number of productive coffee trees, total household non-coffee income, land owned, age of head, education of head, active adults in household, and farm elevation (m).

the most of all per tree at an estimated 164 RWF per tree, roughly double the profits of households at the two extremes, all else equal.

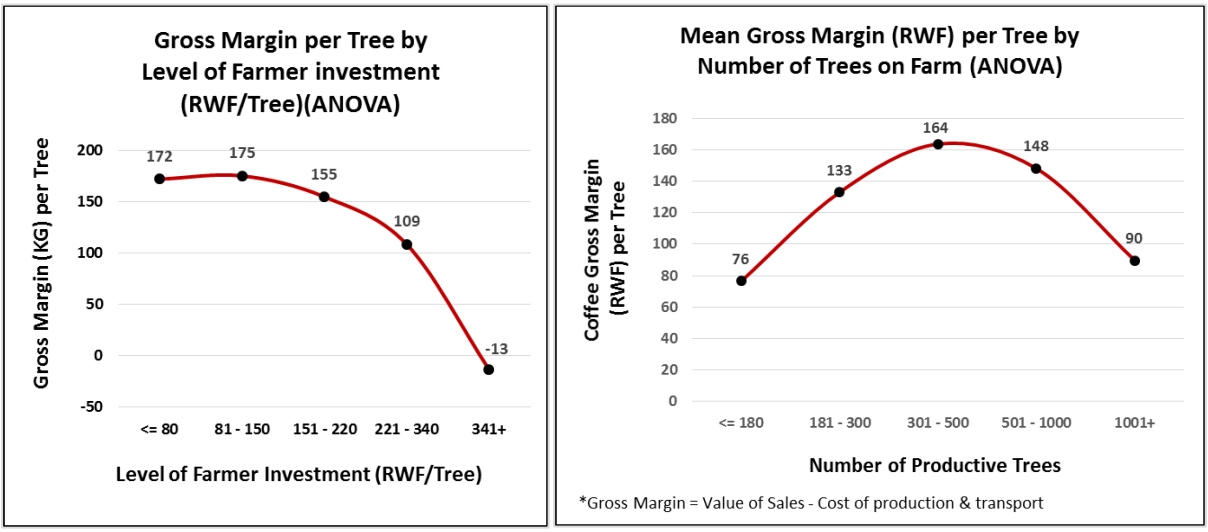

Figure 8

So in 2015, as observed above, about one in three farms had negative gross margins (lost money after subtracting out costs from revenues). One interviewed farmer put it bluntly: "It's not always that farmers don't get a profit. Sometimes the price goes up, and then the farmer makes a profit. This is what I want." Figure 9 shows how that proportion of profitable farms would change under different hypothetical cherry price scenarios. At 150 RWF/KG, for example, a full 45 percent of producers show a balance sheet in the red. At 250 RWF, the proportion drops to just 26 percent, a far more attractive level for a sector searching for sustainable solutions in the longer term.

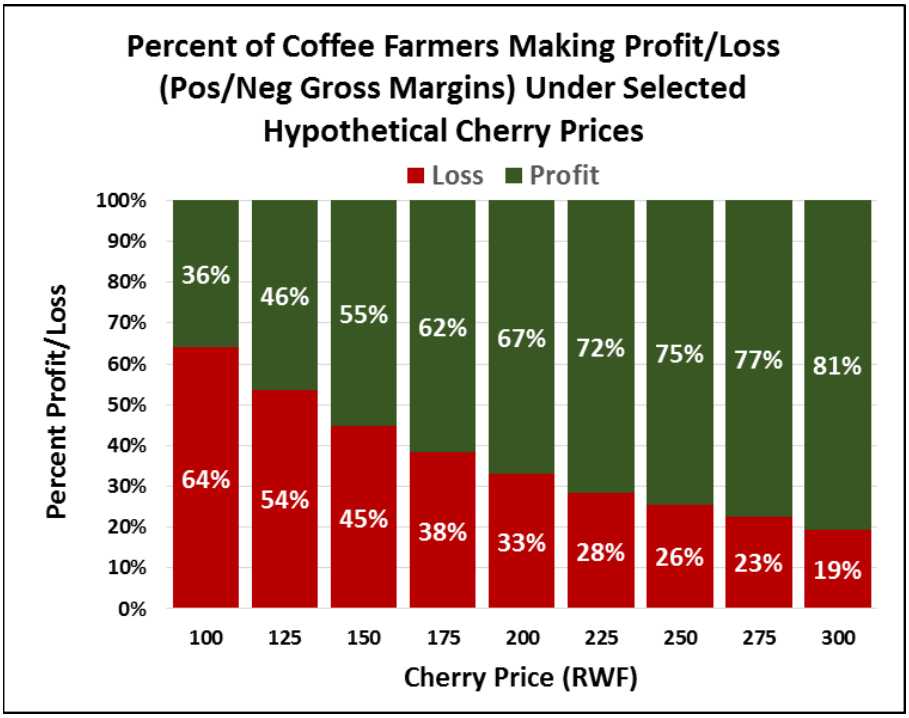

Figure 9

5.5 Solving the farmer investment, productivity, profits puzzle

What accounts for the ostensibly contradictory patterns of productivity and investment? What causes smallholders to be the most highly invested and productive farms yet the least profitable of all? At the other end of the scale, why are the largest coffee farms so poorly invested and unproductive compared to others? And finally, what are the factors that make farmers in the middle range among the most invested, productive and profitable farmers in the entire country? The answers to these puzzling questions will help us to understand why Rwanda's productivity remains so low and why production has stagnated for so many years.

We believe that the key lies in the differences in the capacities and incentives to invest held by farmers at opposite ends of the farm size spectrum. As discussed in Section 3, high performance in agriculture requires that producers have both the capacity and the incentive to invest. Farmers must hold the resources and abilities to invest in their coffee trees and they must also be motivated to do so. One without the other will not have a positive result.

Results from the AGLC baseline survey enable us to characterize three types of coffee producing households based on their differences in capacities, incentives, productivity and profits. We refer to them as smallholders, largeholders and those in the middle range. Figure 10 helps to visually capture how these producer types compare and perform in their levels of productive capacity on the one hand and their incentives to invest on the other. We describe and discuss the unique characteristics of each in the following subsections.

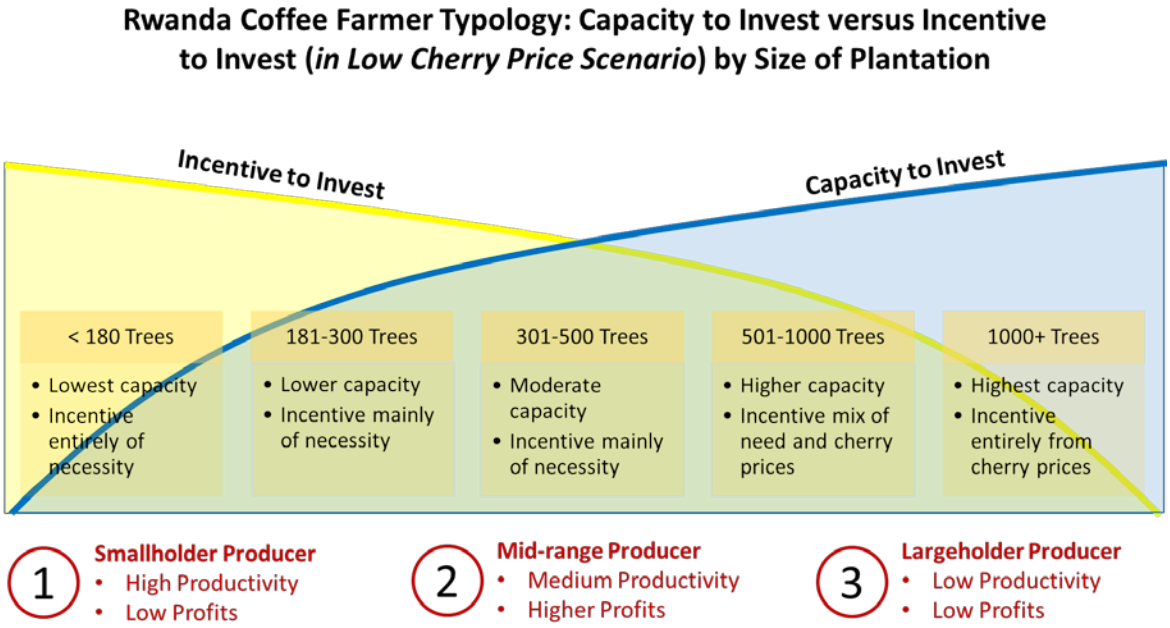

Figure 10

Smallholder coffee farmers. Starting with the smallholder farmers, those with relatively few coffee trees (avg. trees = 106), we find that their capacity to invest in their coffee trees tends to be severely limited. Table 2 presents a profile of producers by number of trees on the farm. The data show that households with few trees have significantly less household labor, less land, and fewer livestock. Their non-coffee incomes are lower and substantially more likely to be based on agricultural labor on the farms of others. They are less likely to hire laborers to help with their coffee. Only a third of farmers with 180 trees or less are members of a coffee cooperative, an

institution known to be beneficial to farmers in Rwanda as a promoter of good agricultural practices and source of premium payments for quality coffee (AGLC, 2016b). Having more trees on the farm translates into higher cooperative membership. Table 2 also shows that households with few trees are also significantly more likely to be female, widowed, with lower levels of formal education, and in the 71+ age group. Household heads with 180 trees or less are disproportionally over 70 years of age or under 30.

While these smallholder coffee farmers have exceptionally low productive capacity and few advantages, they are nonetheless more productive than those with larger coffee plantations, as shown in previous sections. Their higher productivity comes in spite of their low capacity. What they do have is significantly greater motivation to produce, a motivation borne of necessity. With little land, few trees, little labor or sources of outside income, these households have to squeeze out every bit of value they can from their meager resources. They invest their own labor because that is all they have to invest. Their coffee production is highly labor intensive and many, as we have found, draw less income working in their own coffee fields than they do working on their neighbors' farms. And this is the reason that their per-tree profits are abysmally low. They are caught in a squeeze; unable to uproot trees and start over they simply make the best of what they have. In the words of one Rutsiro farmer: "If you don't work, you don't get anything. You have to get your hands out of your pockets. And, if you uproot coffee plants you can go to prison… I continue to manage the coffee because tomorrow someone will pay more." We also know that for many of these low-resource farmers, coffee is their main source of cash income. It is a source of income that they cannot do without. As another Rutsiro farmer confided, "We used the coffee money to buy food. It only helped for 1½ - 2 months this year because the price was so low." Their main constraint is capacity, not motivation.

Table 2

Indicators of HH Capacity to Invest in Coffee
by Number of Trees on the Farm

Number of Trees	Active adults in HH	Total land owned	Livestock owned (TLU)	Non-coffee Income 2015	% Inc from ag labor	Hired labor (FRW)	% HHH member of Coop	N
<= 180	2.6	7,477	0.84	208,913	12.7%	12,941	33.0%	194
181 - 300	2.7	8,685	1.00	227,887	8.5%	21,100	54.0%	200
301 - 500	3.0	11,426	1.09	295,439	4.6%	34,466	51.7%	234
501 - 1,000	3.1	12,661	1.32	357,747	2.8%	54,529	62.2%	209
1001+	3.6	20,141	1.62	516,390	1.1%	102,909	77.0%	187
Total	3.0	11,986	1.17	318,726	5.9%	44,314	55.4%	1,024
Sig.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	

Number of trees	% HHH female	% HHH no educ	% HHH sec+ educ	% HHH single (never mar)	% HHH widow/ widower	% HHH aged <= 30	% HHH aged 71+	N
<= 180	24.2%	31.4%	1.5%	7.2%	21.6%	7.2%	12.9%	194
181 - 300	24.0%	31.0%	1.5%	2.0%	22.0%	6.5%	11.5%	200
301 - 500	17.5%	26.5%	2.6%	2.1%	14.1%	6.4%	6.4%	234
501 - 1,000	11.0%	28.2%	2.9%	1.9%	10.0%	3.8%	7.7%	209
1001+	16.0%	25.7%	6.4%	2.1%	12.8%	4.8%	4.3%	187
Total	18.5%	28.5%	2.9%	3.0%	16.0%	5.8%	8.5%	1,024
Sig.	0.002	0.619	0.028	0.006	0.002	0.577	0.012	

Largeholder coffee farmers. Turning now to the other extreme, the largeholder coffee farmers with over 1,000 trees, this is a group that has an average of 2,200 trees and holds all of the advantages that, as just described, the smallholder coffee farmer does not. They are privileged to have more land, more labor, more livestock, and more cash income from non-farm sources (Table 2). They are more highly educated, neither very old nor very young, they are married, and they are far more likely to be cooperative members. In short, they have the highest productive capacity of any farmer group in the AGLC baseline survey.

While this group of largeholder coffee farmers has exceptional capacity, they also have far and away the lowest productivity of all (1.08 KG/tree). What these households lack is the incentive to be more productive. Because they have other options—more land, other sources of income—and often these options are more remunerative than coffee, many choose to disinvest in coffee, either temporarily or permanently. The smallholder is "pushed" (out of necessity) to invest and to produce more; the largeholder, by contrast, must be "pulled" into investment in coffee. There must be an attraction, and that attraction comes mainly in the form of higher and more stable cherry prices.

Largeholder coffee farmers have a strong business orientation and they have the capacity to produce significant quantities of coffee if they choose, but at current cherry prices most largeholders take an "austerity approach," investing only enough to keep their coffee plantations minimally maintained and minimally productive. Most of the labor they use to maintain and harvest their coffee comes as external wage labor. They see the cash go through their hands at the end of the day and they know they are losing money at current coffee prices. So they hold back on their investments. The same goes for inputs such as fertilizers and manure. They have the cash but many do not see coffee as a profitable investment at current prices. At current prices coffee is a losing proposition. As an example, Mr. Habimana (name changed), a Rutsiro coffee farmer with 7,500 trees, reduced from 10,000 trees in 2012 says that with the prices in 2016 remaining the same

Largeholder Coffee Farmers Respond to Coffee Cherry Prices

Mr. HABIMANA (name changed) has been growing coffee for 34 years. He grew up in the Rutsiro area and remembers watching neighbors planting coffee. They received good things with the money they earned from it. HABIMANA planted his first 90 seedlings, received from the government, when he was 15 years old. He planned to get into coffee as a business—as an income earner. Later he bought a plot of land and planted more seedlings as he could.

He continued increasing his investments in coffee until 2012, when he decided to uproot 2,500 of his 10,000 trees. Coffee prices were low that year and the labor requirements continued to be high; there was even some inflation in wage rates. He hires most the labor from outside and his wife is the one who goes to the coffee fields daily. She supervises the workers and he goes once a week to see how she is doing.

With the prices in 2016 remaining the same as last year, around 170 RWF/Kg cherry, he says he will probably again reduce the number of coffee trees he farms. With the price at 170 he can't cover the cost of labor. He plans to replace the coffee with banana trees. The one hectare that he uprooted in 2012 was also replaced with banana. But he planted those banana trees with large spacing so that he could plant coffee in between the banana trees in the future if coffee prices went back up. He needs at least 250 RWF/Kg cherry to cover the labor cost and make some profit.

When asked about the biggest challenges to being a coffee farmer in the past three years, HABIMANA said, "…just the low price… the expenditure is not covered by the income." When asked if he sees this problem changing in the future, he said he doesn't know what will happen, but if the price stays low, he will no longer stay in coffee. He thinks he could grow his livestock business and still make enough money to keep his family's income the same.

He says the sentiment is the same for other coffee farmers, especially for those who farm large numbers of trees. There are some coffee growers who are already reducing the number of trees, although some do this indirectly, as they are afraid the government will punish them for removing coffee. He gave an example of a friend who planted 20,000 coffee trees and then got out of coffee because the price dropped. But this friend still has his coffee trees. He has just stopped caring for them. He's worried about consequences from the government. So, like others, he leaves the trees but does not invest in them.

as last year (around 170 RWF/Kg cherry) he will probably again reduce the number of coffee trees he has. With the price at 170 he can't cover the cost of labor. He plans to replace the coffee with banana trees. He says he needs at least 250 RWF/Kg cherry to cover the labor cost and make some profit (see full story in text box).

Mid-range coffee farmers. Coffee producers in the middle range, those with as few as 181 and as many as 1,000 trees, are a hybrid group. They have greater productive capacity than those at the very low end, with mid-sized land holdings and coffee plantations (Table 2) averaging 557 productive trees on 0.20 hectares. They are of mixed ages with moderate levels of household labor and non-farm income. In nearly all ways they are farmers with enough capacity to free themselves from the day-to-day survival mentality and level of poverty seen in the true smallholder group (≤ 180 trees). But the mid-level producer is by no means resource rich. They must still invest their own land, labor and cash to the fullest degree to maintain a livelihood that keeps them a step ahead of poverty. They do not enjoy the freedoms of the largeholder group (> 1,000 trees) to simply shift focus to other crops and areas of their farms or non-farm enterprises. They do not have the option to ignore or even abandon their trees as the largeholder group can when cherry prices drop below a profitable level. They still rely on much household labor and accept that returns to their labor will be subpar. We suspect that as cherry prices decline so does their use of hired labor, a phenomenon that likely occurs among all producer groups, large and small alike.

What makes producers of the middle range so unique is that they have some productive capacity to invest in coffee (like the largeholder), but they also are highly motivated to maximize their returns from what modest resources they do have (like the smallholder). This combination of capacities and incentives to invest places them above all others in terms of their per-tree profit margins. As reported above from (Figure 8), this group generates a positive cash flow of 133–164 RWF/tree, substantially outperforming those at the upper and lower extremes.

The main lesson from this group lies in our recognition that if farmers have both capacity and motivation they will invest in coffee and that they can be at least moderately profitable under certain circumstances. But make no mistake, the main motivational driver for this group tends to be, as it is for the smallholder, borne of necessity; they are pushed to be more productive, not attracted to it as a remunerative investment. Their advantage is that they have the capacity to translate that motivation into a more profitable operation than can those at the lower end of the spectrum.

A focused look at investment capacity. To underscore the importance of the relationship between capacity and productivity alluded to in the above typology, we have computed a "farm investment capacity index" that combines into a summated scale seven key farm capacity indicators including: gender, age, education and civil status of the head of household plus land ownership, number of coffee trees, and non-coffee income. Each of the seven indicators is coded as 1 for high value and 0 for a low value, except for number of trees which was assigned three values (0, 1, 2) with 2 being the largest category of trees. These values are aggregated into an ordinal scale of farm investment capacity with the following four categories: "Low," "Medium low," "Medium high," and "High." It is a simple index that we believe effectively separates households that are relatively advantaged from those that are less advantaged in terms of their capacity to invest in coffee. Indeed, the individual items in the scale show a high degree of inter-correlation. For example households with many coffee trees also tend to have more land, more non-coffee income, and more highly educated.

Next we compared productivity and number of trees across the four categories of investment capacity. The results are presented in Figure 11. They demonstrate that productivity steadily increases with level of household capacity (red axis) up until the fourth, "high" group. This group is expected to show the highest productivity as a reflection of their greater capacity to invest in their plantations, but instead their productivity drops off radically; they stand out as the least productive group of them all, at 1.53 KG/tree. This is a group farms with unusually large plantations (nearly 2,000 trees) on average (blue axis). What is occurring is that in spite of their high-capacity, these large-plantation farms have the lowest incentives to invest in their trees, a pattern that mirrors the conclusions from our presentation and discussion of the three-way typology of coffee producers in Rwanda. These farms could easily produce more given their high capacity but because they find coffee unprofitable at current cherry prices, they do not.

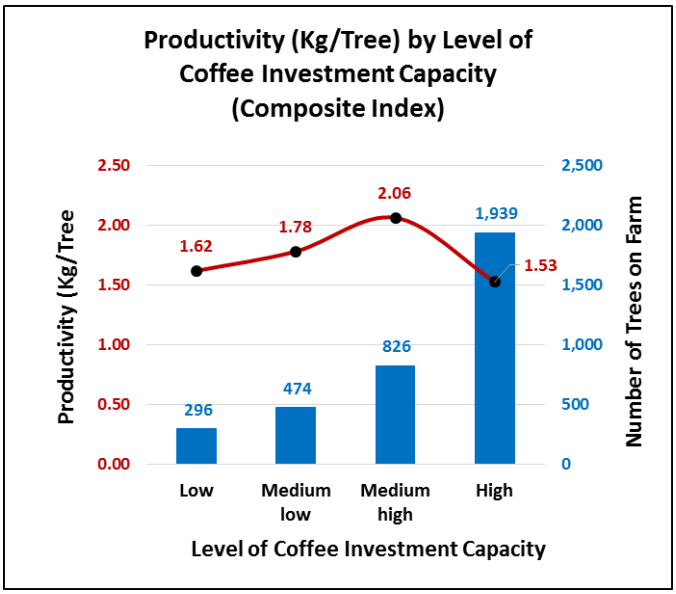

Figure 11

5.6 How the largeholder goes, so goes the coffee sector

The typology of coffee producers is useful for understanding the characteristics and motivations of three important groups of producers in Rwanda, but this is not to say that they are all of equal weight or importance to the future of the coffee sector. Certainly all households are worthy of attention and support from other stakeholders in the value chain; a sustainable approach must also be an equitable approach. Yet, not all groups have an equal impact on the success of the sector. The fact is that the largeholder producers have a disproportionate effect on sector performance simply by virtue of the number of coffee trees they farm. While farms of 1,000+ trees account for just 18.4 percent of all coffee farmers in our sample, they farm 56.4 percent of all the trees. By contrast, the smallholders comprise an equivalent share of coffee households (18.9 percent) yet they farm only 2.8 percent of the trees—a 20-fold difference.

The sheer number of trees farmed by the largeholder group assures that the direction of the coffee sector will, in large measure, be determined by the management decisions they make. Effectively their choices outweigh the smallholder group by a factor of 20 to 1, as noted above. As a case in point, we find that the decision to not invest in their coffee has a dramatic effect on the overall volume of coffee that flows through the value chain in Rwanda. Figure 12 shows the proportion of coffee trees farmed (blue bars) and contribution to total cherry production (red

bars) by number of coffee trees on the farm. The largeholder group cultivates 56.6% of the trees, yet they account for only 45.6 percent of the total 2015 cherry harvest. The small and mid-range farmers, by contract, invest more in their coffee trees and as a result account for disproportionately more of the country's coffee harvest. This is especially true for the mid-range groups who have sufficient capacity and incentive to raise their productivity.

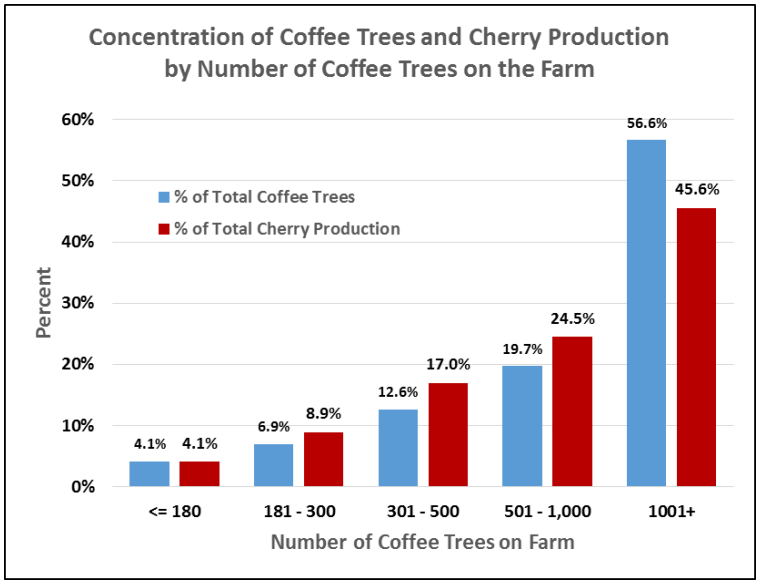

Figure 12

The inconvenient truth is that a one percent increase in productivity among farmers in this group would raise total production in the country by the same amount as a 20 percent increase among the smallholder group. To further demonstrate the point, if Rwanda were to succeed in raising productivity across all five plantation size groups to the modest level already attained by the smallholder group (2.17 KG/tree) the outcome would be as depicted in Figure 13. In gold is the total KG of cherry produced in 2015; in green is the estimated additional KGs of coffee produced in applying the smallholder productivity rate.

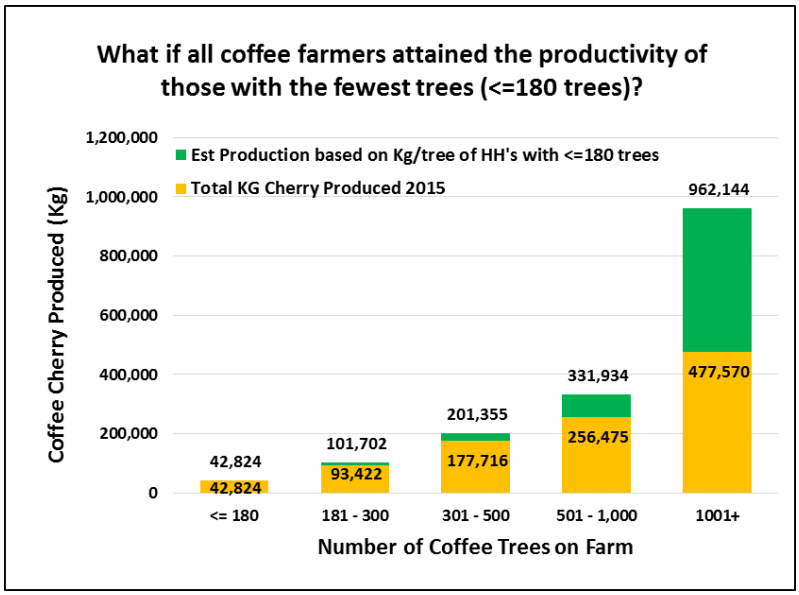

Figure 13

In short, the overall increase in coffee production in this scenario would be 57 percent. At the national level that would elevate the 2015 production of 22,131 MT to 33,450 MT, and the great bulk of this increase (82 percent) would come from the largeholder producers. These are the farms with the highest capacity (but lowest incentive), so increasing production would not be a difficult challenge for them. They already know what to do; they just need a good reason to do it.

5.7 Incentivizing farmers to invest in their coffee plantations

The challenge of raising farmer investment in coffee production is not new in Rwanda (Mujawamariya et al, 2013; Clay et al, 2002). For many years the vicious cycle of low incentives, low investment and low production has brought decades of sub-par producer prices and stagnant coffee exports. So when asked why they do not invest more in their coffee trees, it is not surprising to learn that the majority of farmers cite low cherry prices (71 percent) and unstable cherry prices (46 percent) as the main barriers to their investment (Figure 14). Many also point to a lack of inputs distribution (35 percent) and high cost of inputs (19 percent) as barriers, reinforcing the finding (AGLC, 2016c) that farmers have grown accustomed to receiving subsidized fertilizer and pesticide distributions (though in insufficient amounts) and rarely consider outright cash expenditures for inputs.

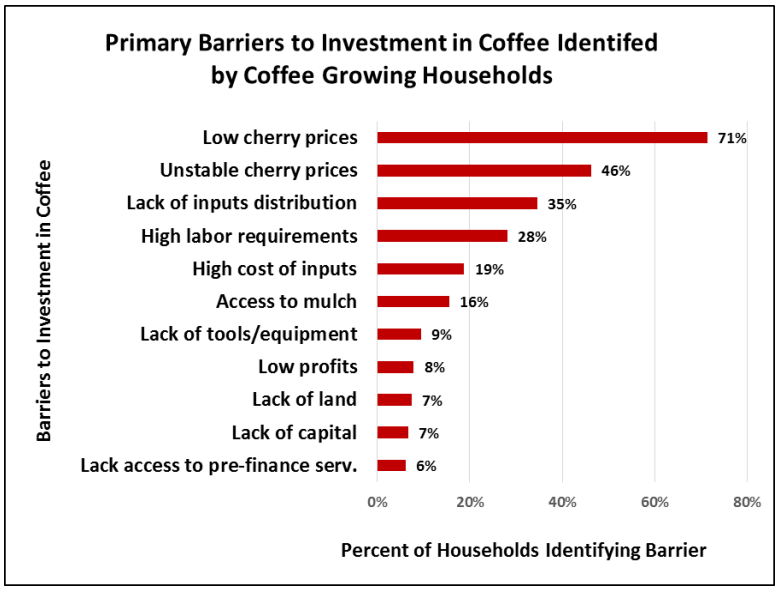

Figure 14

It is also instructive to find that the high labor requirements in coffee production are identified by 28 percent of coffee farmers as an obstacle to their investment in coffee. Not only is coffee a labor-intensive crop, when following best agricultural practices for pruning, mulching, weeding, etc., but we know that over a third of all coffee producers (35.6 percent) hire most of the labor they put into these tasks. This is particularly true of those with larger plantations for whom household labor is rarely sufficient to meet their needs even at low investment levels. Interviews with some largeholder coffee producers drew explicit comments about the high cost of labor (especially since 2012 when they say higher wage rates were imposed) and their preference for minimizing cash expenditures until higher cherry prices warrant the greater outlays for labor.

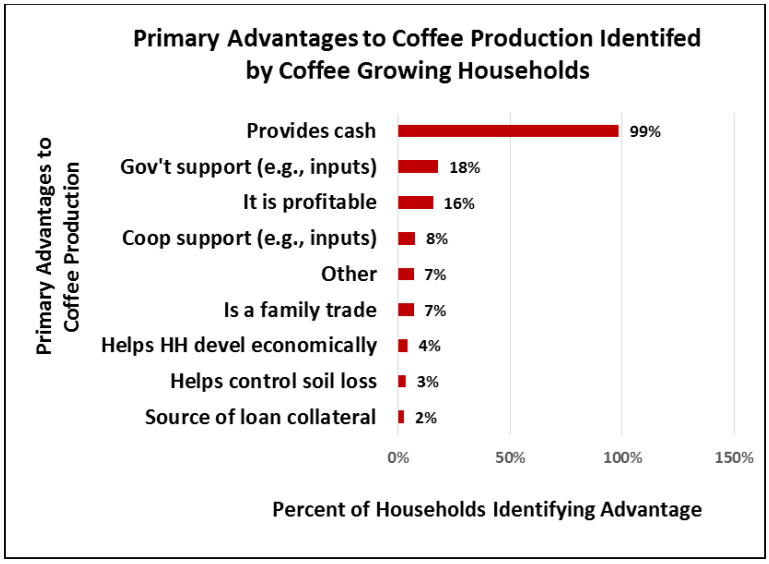

Figure 15

In spite of these barriers, 99 percent of surveyed farmers reported that coffee is advantageous to them because it is a source of cash (Figure 15). While many crops, even traditional subsistence crops such as sweet potatoes, are also an important source of cash, few can provide cash in larger sums the way coffee does. It is, after all, the country's top cash crop and by and large is not consumed domestically. When asked about how they spend their coffee revenues, farmers often identify larger single costs (Figure 16) such as health services (51 percent), school fees (33 percent) or livestock (27 percent). But this pattern of expenditures is by no means universal, especially when broken out by overall income levels. Low income households, for example, often use their coffee revenues for basic expenses such as food and clothing. Wealthier households, by contrast, tend to use their coffee revenues on larger, one-time items such as school fees, other assets and to a lesser degree on small business investments and savings.

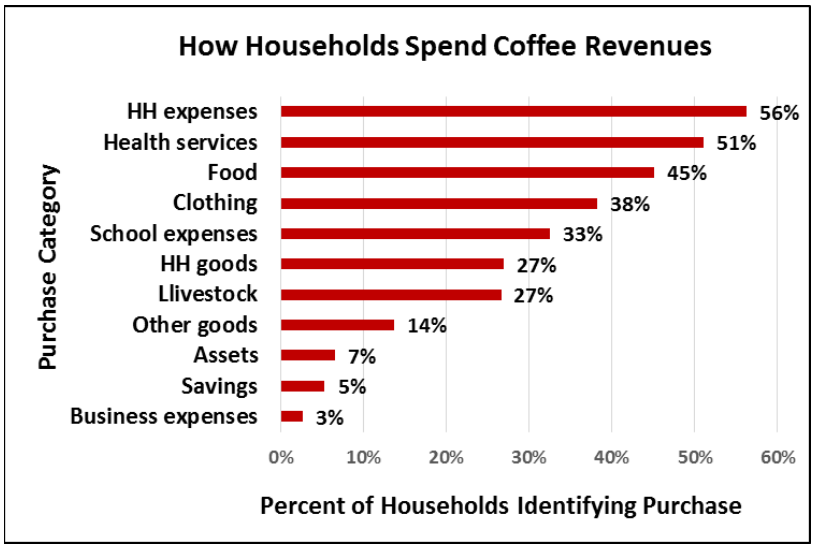

Figure 16

Returning to Figure 15 on the advantages to coffee production, we also find that only 16 percent of producers claim to grow coffee because they find it profitable. This response, together with the finding that low and unstable prices are seen as a deterrent to farmer investment in coffee,

are further explored through a set of contingent valuation questions in which we asked households whether cherry prices were high enough for them to invest more of their cash, labor and land in coffee, and if not, at what price they would make these investments. The results from these conditional questions are reported in Table 3. Two important conclusions can be underscored. The first is that only one in six farmers (approximately 14-18 percent) agrees that cherry prices are high enough for them to allocate more cash for inputs, labor or land to the production of coffee.

The second important finding is that there is considerable consensus that the level at which they would again be interested in investing their resources into coffee production, versus other crops or opportunities, is 300 RWF per KG of cherry. This is the median price at with farmers indicate coffee would be an attractive investment for them. Some farmers indicated even higher cherry prices and thus the mean value ranges from 345 to 373 RWF.

Table 3

Household Opinions on Cherry Prices and Their Motivation to Invest More Cash, Labor and Land in Their Coffee Plantations

		Are cherry prices high enough to invest more… ?			If no, how high would cherry prices have to go (FRW) to invest more… ?	
Investment type	Yes/No	N	%		Mean RWF	Median RWF
Prices are high enough to purchase more inputs?	No	839	81.9	→	345	300
	Yes	185	18.1			
	Total	1,024	100.0			
Prices are high enough to allocate more labor to coffee?	No	864	84.4	→	349	300
	Yes	160	15.6			
	Total	1,024	100.0			
Price high enough to allocate more land to coffee?	No	884	86.3	→	373	300
	Yes	140	13.7			
	Total	1,024	100.0			

At the current 2016 cherry price of 150 RWF, it seems almost certain that stakeholder aspirations for breaking the cycle of low productivity and stagnant revenues will again not be realized. The incentives are simply not there for the vast majority of the country's coffee producers, particularly among the largeholder producers for whom price is the primary incentive to invest in coffee.

Premium payments: an added incentive for higher coffee production

Another piece of the incentive puzzle is the payment of premiums, an additional amount that often comes at the end of the season after coffee is cupped and sold. The premiums are paid mainly by the coffee buyers, as a reward for higher quality in coffee produced. In some cases, due to vertically integration, the buyers paying premiums may be companies that also process and export the coffee. Normally premiums are distributed through the CWS or farmer

cooperative and their amounts are proportional to the volume of cherry they deliver to the washing station.

In 2015 only 29 percent of sampled coffee farmers received premiums for their coffee and of these, two-thirds were members of a coffee producer cooperative; one-third were nonmembers. Not surprisingly, one of the most important advantages of cooperative membership as cited by farmers (48 percent) is the fact that they provide premiums to members. The premiums are an important incentive for improving coffee quality and for strengthening farmer allegiance to the cooperative or CWS.

Premiums also provide an important incentive for farmers to improve productivity. Table 4 presents the results of an analysis of variance model that assesses the impact of premiums on farmer productivity (KG/tree), controlling for gender and a set of covariates thought to influence or otherwise distort the effects of premium distributions, as noted. We find that farms that received premiums have an estimated productivity of 2.11 KG/tree compared to 1.63 KG/tree for those not receiving a bonus. This translates into a 29.4 percent improvement in productivity as a consequence of the premium payment.

Table 4

ANOVA: Estimated Productivity (KG/Tree) by Premium Received, Adjusted for Gender and Covariates*

			Predicted Mean Productivity (KG/Tree)			
Productivity measure	Premium Received	N	Unadjusted	Adjusted for Factors (Gender of HHH)	Adjusted for Factors and Covariates*	Sig.
Productivity (KG cherry) per tree	No	722	1.64	1.63	1.63	0.000
	Yes	269	2.09	2.10	2.11	

*Covariates: Nbr of trees on farm, Total HH non-coffee income, Total land owned, Age of HHH, Educ. of HHH, Active adults in HH, Elevation

This finding is especially germane to our understanding of farmer incentives. It demonstrates how sensitive farmers are to relatively small changes in remuneration. The average premium received by farmers in 2015 was 16.4 RWF/Kg. This amounts to a modest 8.3 percent bonus payment to the 200 RWF median price they received over the course of the harvest season. Yet the impact this payment has on their productivity, a 29.4 percent bump, is significant.

What makes the premiums especially effective as a motivator is that they are not just a one-off payment. They are often paid with some regularity, normally at year's end. When farmers know ahead that their performance will be rewarded with a premium, they do what they can to avail themselves of that advantage. We posit that the stability or recurrence of such a bonus payments is critical to their impact. Several potential options for expanding premium payment schemes in Rwanda are considered in the next section in the context of our policy recommendations.

6. Conclusions and Policy Implications

Coffee production has been at the core of farm family livelihoods in Rwanda for many generations. Today it remains a primary source of cash income for over 355,000 households across the country (NAEB 2016b). Since 2001, the coffee value chain has enjoyed a renaissance

and has emerged as the darling of specialty coffee markets and consumers around the globe. The processing side of the sector has thrived with the construction of 245 privately and cooperatively funded washing stations in every coffee growing region of the country. Dry mills and export companies, both domestic and international, have likewise opened for business. There has been tremendous value added in the industry's transformation.

But not all have shared equally in this value addition or in sector's post-genocide revival. Producers have been largely excluded from the benefits of the transformation. And that is one reason why, despite all the excitement and media attention, coffee production in Rwanda has declined and stagnated over the past decades. The heart and soul of the industry, its producers, have been left behind. For decades they have received sub-par compensation for their cherry, an average of 24 percent below the revenues of their counterparts elsewhere in the region and by an even greater margin behind those in Latin America and other coffee-growing regions around the world. Simply put, Rwanda's producers have not been fully recognized as legitimate partners in the country's transformation toward high quality, world class coffee. Their adoption of best practices in the field, practices that produce healthy, dense, high quality cherry free of disease and defects and delivered to the washing station within hours of harvest makes them, without question, a core partner in the coffee revolution. But the producers are not rewarded as partners, and that failure has become an existential threat to the sector's future.

Findings presented in this report show that the true cost of production in Rwanda, including household and wage labor, inputs and equipment, totals 177 RWF/Kg of cherry, well above antiquated figures often used to determine what are thought to be fair cherry prices. As a result a large proportion of growers suffer net losses in coffee (over one-third in 2015). These farmers would make more working as agricultural wage laborers on the farms of other, more productive farms.

Three predominant types of producers are identified based on their relative capacities and their incentives to invest in coffee. Understanding how these producer groups differ and perform in terms of productivity and gross margins (profits) helps us to think more clearly about steps that can be taken to improve overall sector performance. The coffee producer types are:

- *Smallholder coffee producers* are more productive (per tree) than largeholder farmers. They lack capacity but are highly motivated to extract as much value as they can from their small holdings simply out of necessity. Their main investment is their own household labor. Despite higher productivity, their high labor investment makes coffee unprofitable for most.
- *Largeholder coffee producers*, by contrast, have the lowest productivity of all farmer groups. They have high capacity but do not use that capacity for coffee production. They are responsive mainly to coffee cherry prices and when prices are low, as they have been in recent years, they prefer to temporarily abandon their coffee plantations or even to uproot trees in favor of other crops.
- *Mid-range coffee producers* are a hybrid mix of those at the extremes. They have mid-range capacity and average approximately 400 coffee trees, but these farms are still stretched and out of necessity must maximize production from the resources they have. This combination of capacity and incentives enables this group to reap higher profits from their trees than any other group.

While the contributions and performance of all of Rwanda's coffee farmers are vital, and all must be recognized as full partners in Rwanda's coffee revolution, the largeholder group is

where the long-term future of coffee in Rwanda lies. They are commercially oriented and have a larger scale and more capacity. They keep a close watch on profit margins and when prices are low they do not invest. Incentivizing this group alone to invest and produce coffee even at the modest productivity rate of the lowest capacity group (2.17 KG/tree) will increase production in Rwanda by a full 46 percent. Bringing the mid-range producers up to the same yield level would add another 11 percent to the overall volume of coffee processed and exported from Rwanda. A change of that magnitude would place Rwanda on a path toward sustainable growth.

Policy and research implications

Building on the findings and analysis presented in this report we can identify a set of steps that the government of Rwanda and other leaders of the coffee sector might consider to help create needed incentives for producers to invest their labor, cash and eventually more land in their coffee plantations. These investments will, in turn, result in higher productivity, better control of antestia/PTD and higher incomes all along the value chain.

1. Accelerate conversations about how cherry floor prices are established, with special attention to how they will motivate larger coffee producers who, even at very low levels of productivity, account for nearly half of Rwanda's coffee production.
2. Incorporate into the formula for setting cherry floor prices the real cost of production of 177 RWF/KG to Rwanda coffee growers. The current CoP figure of 80 RWF/KG cherry is badly antiquated and based on hypothetical costs to a farmer with 2,500 trees rather than the actual median of 400 trees. Consider conducting a regular survey, possibly on a 3-year cycle, to ensure accurate cost of production figures will be available and used in establishing floor prices. This regular survey will also enable NAEB to track how CoP changes over time and whether producers are becoming more efficient in their use of resources, adopting better practices, purchasing more inputs, improving productivity, profiting from coffee and so on. Tracking these important changes will continue to inform policy/planning in the sector and will provide critical benchmarks to assessing whether the sector is on a path to sustainable growth.
3. Research and model how higher cherry prices will improve farmer investments in coffee, raise productivity, and increase the volume of coffee processed and exported. These estimates will help in setting realistic growth targets and in meeting those targets.
4. Similarly, there is a need to model the effects of higher investment on coffee *quality*, particularly the density of cherry, the share of coffee going through fully-washed channels and higher grades of coffee (and a reduction of triage grade coffee). It is also expected that higher farmer investment in best practices and the application of improved inputs will lower the incidence of PTD. Research results from the Rwanda agricultural Board (RAB) have demonstrated this effect (Bigirimana 2016), and research results from the AGLC experimental fields are also expected to corroborate these findings on a broader scale, across all of the major coffee-growing regions in Rwanda.
5. Consider how larger volumes of fully-washed coffee will benefit all stakeholders in the coffee sector, and how more coffee will bring down the unit costs of processing and move closer to full capacity use of processing infrastructure. Increased efficiencies will also come with operating at full capacity in washing stations and dry mills. Currently

Rwanda's 245 coffee washing stations are operating well below (at 53.6 percent) their estimated capacity of 104,600 MT/year as reported by NAEB (2016b). This is based on the assumption that 60 percent (NAEB estimate) of Rwanda's 93,376 MT of cherry documented in the 2015 Coffee Census was processed through the fully-washed channel. We conclude that Rwanda is well prepared to process a significantly higher volume of cherry (46.4 percent) without any further investment in washing station infrastructure. The challenge lies more in how to increase the volume of cherry produced.

6. Give coffee the level of national attention it deserves, and profoundly needs. Coffee has been allocated second-tier status in terms of GOR priority investments in agriculture. In 2007 Rwanda launched the Crop Intensification Program (CIP), an ambitious and high cost initiative designed to raise the productivity and profitability of six high priority crops: maize, wheat, rice, Irish potato, bean and cassava. Subsidized inputs, promotion of new varieties and engagement of farmers in the intensification process are key components of the program. These actions have been coupled with massive engineering investments to drain valley marshlands and to construct bench terraces on hillsides. Though costly, the program has succeeded in dramatically improving crop yields, reportedly by as much as six-fold for maize and wheat (Kathiresan, 2011).

   The unavoidable question, in light of recent findings of exceptionally low coffee productivity and profitability, asks: Why has coffee not received similar attention and support to crops in the CIP? Coffee is Rwanda's most important source of cash revenues for farmers, revenues that can go a long way toward improving food security and living standards in the country. Moreover, as discussed below, coffee holds phenomenal potential in terms of long-term economic and environmental sustainability.

   Perhaps it is because coffee is a cash crop and thus is seen as independently robust and well-financed. While this may be true on one level, on another coffee has been shown (in this report) to be highly vulnerable, subject to the vagaries of international coffee markets and to a level of intense international competition and quality standards that few domestically produced and consumed commodities must meet. Raising coffee productivity has the potential to reduce these vulnerabilities and to enable 355,000 coffee farmers and their families to receive higher incomes, improve nutrition, pay school fees, and create tens of thousands of new employment opportunities.

   On top of these obvious direct benefits, it is most important to recognize how important coffee is to Rwanda's long-term economic growth and sustainability. High quality coffee has a very high ceiling. There is a growing worldwide demand for specialty coffees and the potential returns to exporting countries are notable. Rwanda's agroecology is ideally suited to meeting market demand for quality coffees, one of the few crops in the world (similar to tea) that actually improves in quality in a high elevation and mountainous environment. Rwanda's climate and terrain make the country's producers more competitive in specialty coffee world markets, not less. By contrast, traditional field crops become less competitive in such a hillside environment, especially when the high costs of terracing and valley drainage are factored in.

   Perhaps the most compelling argument of all in favor of supporting greater coffee production and productivity is the established fact that coffee is one of Rwanda's most

successful crops at combating soil loss (Lewis, et al, 1988; Clay & Lewis 1990). It is a perennial crop that does not require churning/exposing the soil (as annual crops do several times a year). Coffee also has good leaf canopy and root structure, both effective attributes in controlling erosion. Perhaps most important of all, coffee is a crop that is nearly universally mulched in Rwanda. Mulch protects the soil from erosion and helps to retain water. In short, where coffee is planted, there is generally no need for the costly construction and maintenance of bench terraces or other engineering approaches to erosion control.

Given Rwanda's comparative advantages in producing coffee for the specialty market coupled with its powerfully protective environmental attributes and success on steep hillsides, there is good reason to consider the steps needed to address its vulnerabilities, starting by motivating farmers to invest in improved agronomic practices that will help them to maximize their returns from the sector. Now is the time for Rwanda to bring coffee back to center stage in its discussions and strategic thinking about the country's agronomic and economic future. The specter of climate change and what it means for Rwanda's environmentally fragile mountain ecosystem gives us ample reason to accelerate the pace. Moreover, recent research has shown that Ethiopia, Kenya, Rwanda, and Burundi are all expected to remain highly suitable for Arabica coffee production under predicted climate change scenarios (Ovalle-Rivera et al., 2015), and that coffee also has the potential for climate change mitigation and positive carbon accounting (Rahn et al., 2013), adding further to the case for increased investment in coffee.

In light of these important needs and advantages, it is highly recommended that consideration soon be given to marshalling for coffee the same scale of support and political will that has been mustered for targeted CIP crops. A first step would involve a careful assessment of coffee's potential in Rwanda, an assessment that incorporates the crops positive environmental externalities and seriously considers coffee's prospects for economic and ecological sustainability in the long term.

7. Premiums are shown to have an important positive effect on productivity as those receiving premiums enjoy yields 29.4 percent higher, all else equal, than those who do not. While premiums have a significant motivational impact, incentivizing farmers to produce more and higher quality coffee, currently only 1 in 4 coffee producers receives a premium. Higher quality coffee will likely lead to more premiums from buyers. The challenge lies in is how to jump-start the virtuous circle of high quality coffee cherry, generating higher prices from green coffee buyers, which in turn enable more premiums to be paid to farmers. There are policy options that warrant consideration for how to initiate and incentivize delivery of high quality, mature, ripe cherry.

   One option is to implement a two-tiered system at the point of sale of the cherry. Mahembe, a private washing station in Nyamasheke district, pays 50 RWF more per KG if the "chief of quality" at the washing station designates the delivery as "ripe cherry." If the farmer's harvest is classified as "mixed," he/she is paid the NAEB floor price. An indicator that Mahembe's efforts have paid off can be seen in their coffee's exceptionally high score of 90.13 in the 2015 Cup of Excellence competition and its selection as a

featured coffee at the Starbucks Reserve Roastery & Tasting room in Seattle, WA, retailing at $40 per half pound (226g).

A second policy option is to implement much higher standards for all cherry deliveries, accompanied by a premium price for cherry meeting the standard. As is the case today, washing stations would pay "one-price-for-all," but they would enforce a high standard with no exceptions, and be willing to turn away farmers who do not meet the standard. We are not aware of CWSs in Rwanda employing this approach at present. However, two washing stations run by the same owner in Burundi, Long Miles Coffee Project, have tested this form of incentivized quality control over the past two seasons, turning away farmers arriving with low quality cherry. In the first season they lost 400 producer households that had delivered to them the previous year; but they also added to their roster 600 new producers who showed up with the desired high-quality cherry and were eager to receive the higher price LMCP was paying. The owner reports that this year they had 1,000 new farmers delivering to their stations and that feedback from their customers, specialty roasters in the US and Europe, was positive.

It is recommended that coffee stakeholders in Rwanda learn from these promising experimental efforts and consider promoting or even piloting a premium payment scheme that can be broadly adopted by all washing stations willing to participate. The potential impact on coffee quality and quantity could be significant, particularly if it can attract interest from largeholder producers.

8. The effectiveness of fertilizer and pesticide distributions is critical to the discussion. We know that amounts distributed presently are far below the recommended dosage and this has serious negative implications for productivity and quality (PTD). AGLC has addressed this question in a separate research report (AGLC, 2016c), however we posit here that attractive cherry prices will raise the demand for fertilizers and pesticides, particularly among the largeholders who have capacity and cash resources to purchase inputs.

9. This research also has implications for the coffee zoning policy, implemented in 2015-16. While one rationale for the zoning policy is that it will benefit farmers by eliminating the middleman (independent traders), some fear that there will be the unintended consequence of limiting competition for cherry, resulting in lower cherry prices to producers. This is a potentially devastating scenario for the coffee sector as it could risk accelerating the downward spiral of: low coffee prices => low motivation => low investment => low productivity => low profits.

   Even if zoning does not result in significant loss in price competitiveness for the producer, the policy may still be *perceived* by producers as "controlling" and unfavorable to them and to the cooperatives they belong to (sometimes in a different zone from where farmers live). There is a risk that the zoning policy will thereby alienate certain groups of farmers and have a demotivating effect on them, at a time when the sector needs to find more and better ways to motivate farmers. A prudent approach to such sensitivities may be to find ways to assuage these perceptions through measures that will be clearly beneficial to farmers, incentivize greater participation and promote good will among them.

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