Feed the Future Innovation Lab for Food Security Policy

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Africa Great Lakes Region Coffee Support Program (AGLC)

Incentivizing Farmer Investments for Sustainable Growth in Rwanda's Coffee Sector[1]

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1. Introduction

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 coffee stakeholders have shared equally in this value addition or in the 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, the volumes of coffee produced 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 (Figure 1) and by an even greater margin behind those in Latin America and other coffee-growing regions around the world.

- Since 2001, Rwanda's coffee value chain has enjoyed a "specialty coffee" renaissance, yet coffee producers have not been recognized as full partners in this exciting transformation toward high quality, world class coffee.
- Coffee producers in Rwanda receive an average of 24% below the revenues of their counterparts elsewhere in the region, resulting in neglect and disinvestment in coffee by many producers, particularly largeholder producers.
- The true cost of production in Rwanda, including household and wage labor, inputs and equipment, totals 177 RWF/Kg of cherry. It is recommended that this cost of production figure be incorporated into the formula for setting cherry floor prices.
- Largeholder coffee farmers (>1,000 trees) invest the least of all in their trees. Despite their high productive capacity, they do not invest in their coffee when prices are low. They are commercially oriented and keep an eye on profit margins. Incentivizing this group to produce coffee at a rate on par with the lowest capacity group (2.17 KG/ tree) will increase production in Rwanda by 46%.
- Now is the time for Rwanda to bring coffee back to center stage in its strategic thinking about the country's agronomic and economic future. One of Rwanda's greatest comparative advantages lies in producing coffee for the specialty market. Coffee also has powerfully protective environmental attributes and success on steep hillsides, which other priority crops do not. Actions are needed to address its vulnerabilities, starting by incentivizing farmers to invest in improved agronomic practices that will enable them to maximize their returns.

[1] Policy brief based on D. Clay et al. (2016). "Determinants of Farmer Investment in Coffee Production: Finding a Path to Sustainable Growth in Rwanda's Coffee Sector." AGLC Research Paper #1. Food Security Policy Innovation Lab.

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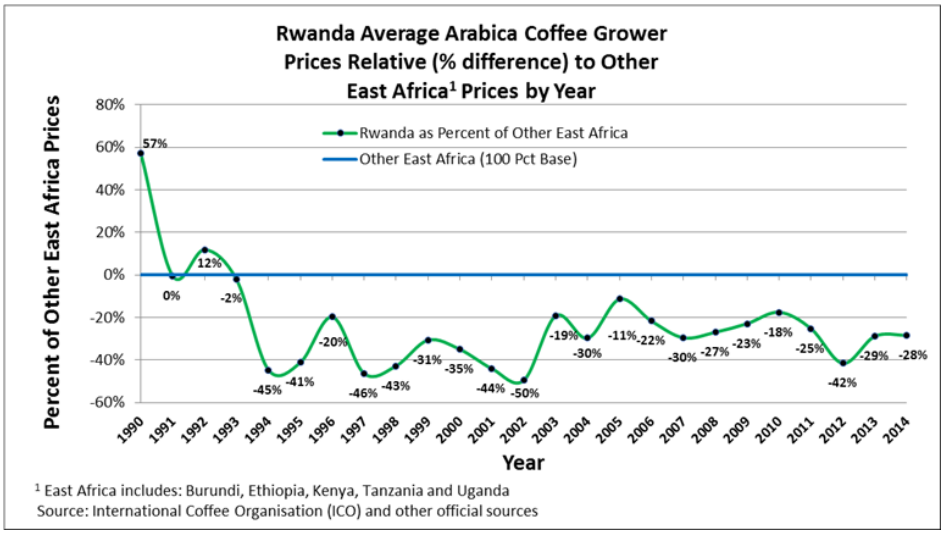
Figure 1: Rwanda Average Arabica Coffee Grower Prices Relative (% difference) to Other East Africa Price by Year



[1] East Africa includes: Burundi, Ethiopia, Kenya, Tanzania and Uganda
Source: International Coffee Organisation (ICO) and other official sources

- Premiums have an important positive effect on productivity as those receiving premiums enjoy yields 29% higher, all else equal, than those who do not. There is a need to develop/test a system for two-tier pricing of coffee cherry based on quality.

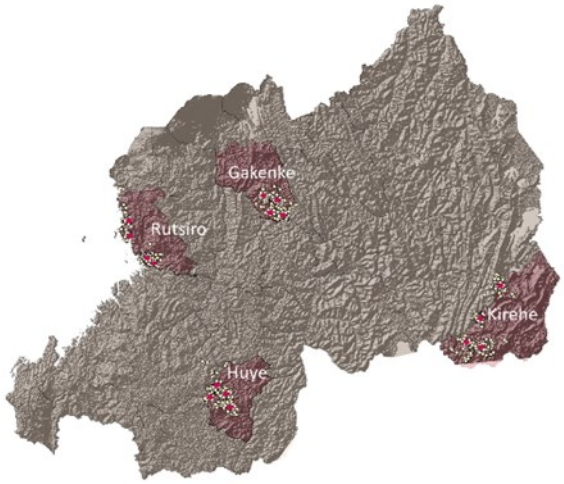
Simply put, Rwanda's producers have not been fully recognized as legitimate partners in the country's transformation toward high quality, world class coffee. Their adoption of best practices in the field, practices that produce healthy, dense, high quality cherry free of disease and defects and delivered to the washing station within hours of harvest makes them, without question, a core partner in the coffee revolution. Quality starts on the farm. But coffee farmers have not been rewarded as full partners, and until they are, their coffee productivity will remain low, particularly among largeholder farmers who produce the majority of Rwanda's coffee. Without the incentive for farmers to invest their land, labor and cash resources in coffee, the sector will not have a sustainable future. This policy brief presents data from the AGLC project to help explain how low producer compensation has resulted in a lack of farmer investment and in turn how that low investment has placed the coffee sector on a track of low productivity and stagnation.

2. 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 focused key informant interviews (KIIs) with public and private sector industry leaders, as well as focus group discussions (FGDs) with the major coffee stakeholder groups including farmers and CWS managers.

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 2). The selected districts are Rutsiro, Huye, Kirehe, and Gakenke. 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.

Figure 2: Map of Sampled Districts, Washing Stations and Households

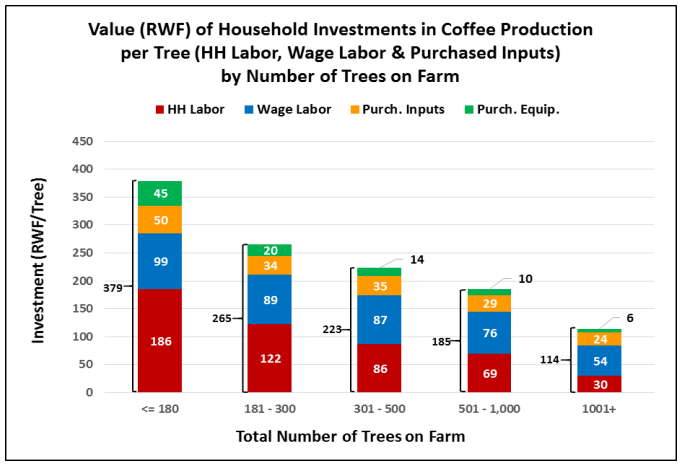


3. Findings

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.

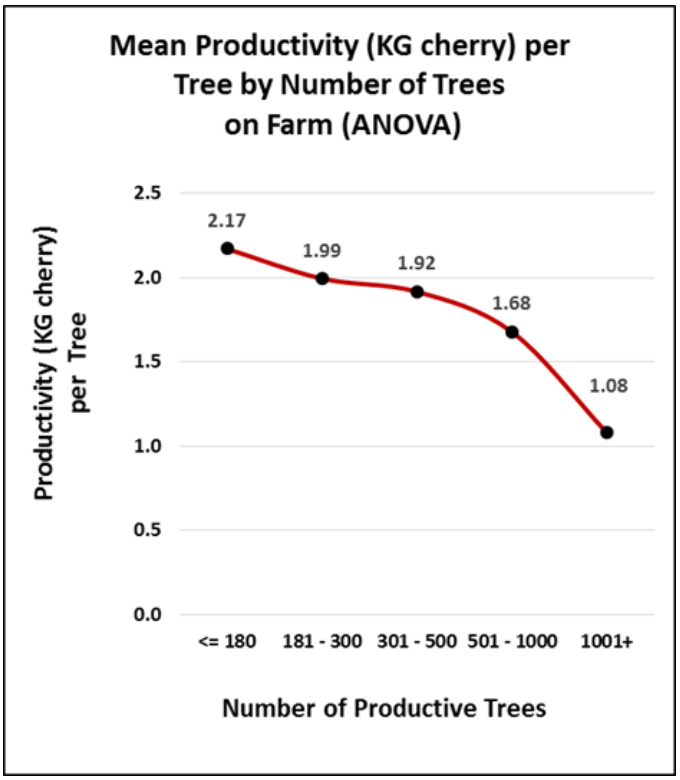
The number of trees in the coffee plantation makes a substantial difference in the amounts that farmers invest per tree. As shown in Figure 3, farmers with large scale plantations invest markedly less per tree (114 RWF/tree) than those with small plantations (379 RWF/tree), more than a three-fold difference.

Figure 3: Value (RWF) of Household Investment in Coffee Production per Tree (HH Labor, Wage Labor & Purchase Inputs) by Number of Tees on Farm



Productivity by farm size. 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 results reported in Figure 4 show that the highest level of productivity, estimated at 2.17 KG cherry/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,

Figure 4: Mean Productivity (KG cherry) per Tree by Number of Trees on Farm (ANOVA)

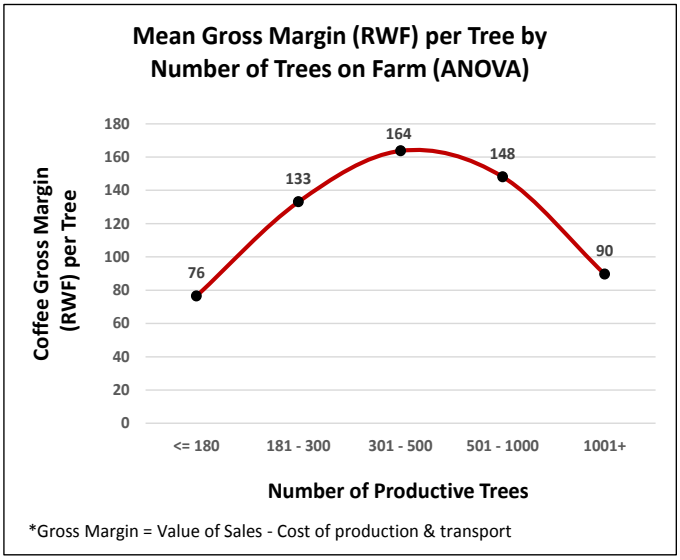


Do these investments and productivity rates translate into higher returns? While there is a clear drop in productivity associated with lower investments and more trees on the farm, it is equally important to examine how returns to farmers (gross margins) vary across these groups. Gross margins, or profits, 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 further, we find that just over 30 percent of farms in the study actually 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.

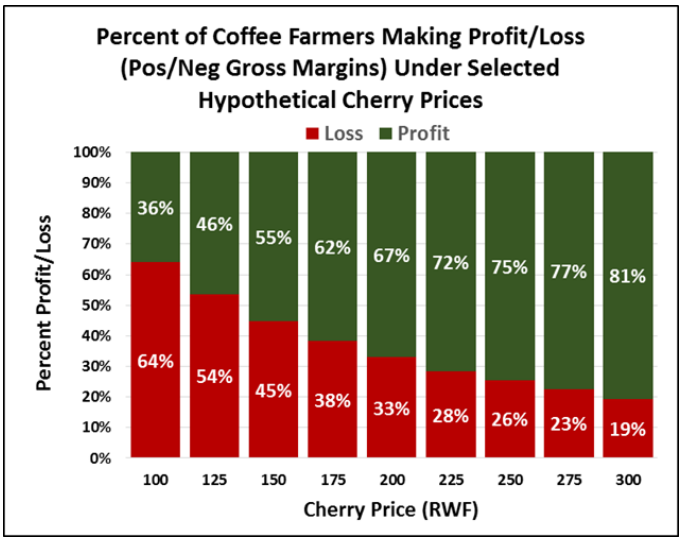
Breaking out gross margins by number of productive trees on the farm one sees that households with few trees, while far more productive than those with more trees, are indeed the least profitable farms, returning an estimated -76 RWF per tree (Figure 5). Yet those at the other end of the scale, farms 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, particularly those in the 301-500 range, make 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 5: Mean Gross Margin (RWF) per Trees on Farm (ANOVA)



Findings presented in this policy brief 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 paid to producers. As a result, a large proportion of growers suffer net losses in coffee (over one-third in 2015). These farmers would, and often do, make more working as agricultural wage laborers on the farms of other, more productive farms. Figure 6 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 4: Percent of Coffee Farmers Making Profit/Loss (Pos/Neg Gross Margins) Under Selected Hypothetical Cherry Prices



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 questions lie in the differences in the capacities and incentives to invest held by farmers at opposite ends of the farm size spectrum. 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 7: Rwanda Coffee Farmer Typology: Capacity to Invest versus Incentive to Invest (in Low Cherry Price Scenario) by Size of Plantation

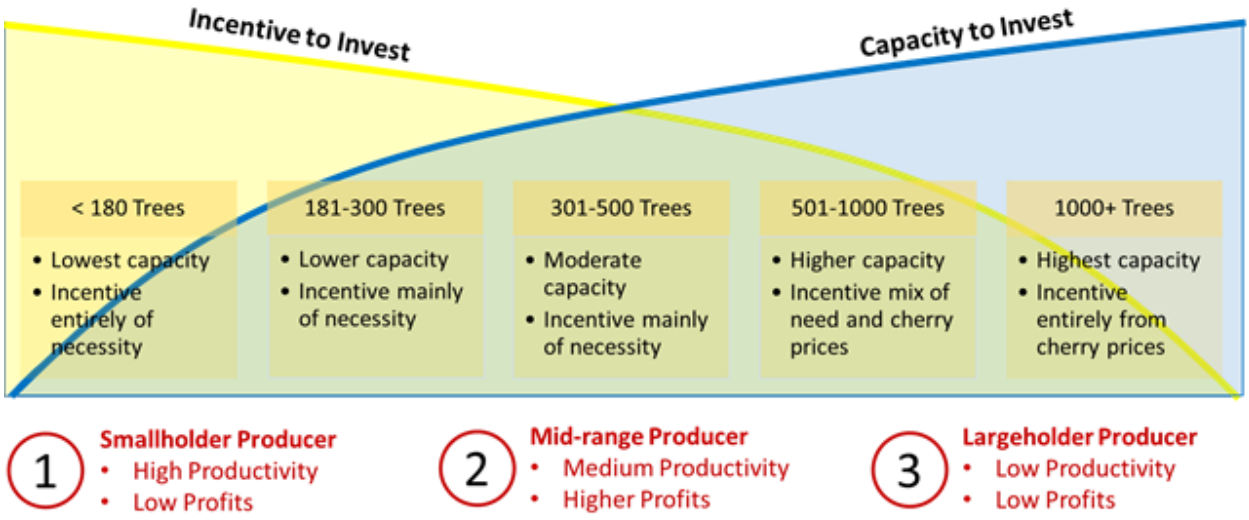


Figure 7 helps to visually capture how these producer types compare and perform in their levels of productive capacity on the one hand and their incentives to invest on the other.

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; some even 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 economically 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.

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. Figure 8 demonstrates 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 all, at 1.53 KG/tree. This is a group of 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 8: Productivity (Kg/Tree) and Number of Trees by Level of Coffee Investment Capacity (Composite Index)

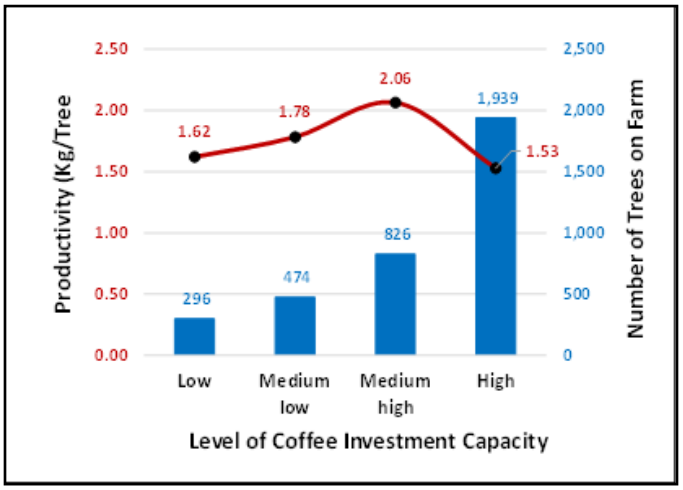
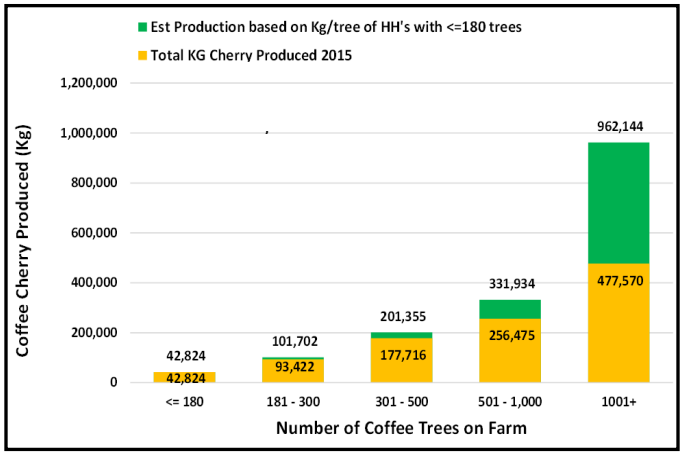


Figure 9: What if all coffee farmers attained the productivity of those with the fewest trees (<=180 trees)?



How the largeholder goes, so goes the coffee sector. 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, it is evident that 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 massive 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.

Consequently, the long-term future of the Rwanda coffee sector lies squarely with the largeholder producer group. They are commercially oriented and have a larger scale and far more capacity. They keep a close watch on profit margins and when prices are low they do not invest. 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 9. Colored in gold is the total KG of cherry actually produced in 2015; colored in green is the estimated additional KGs of coffee that would be produced in applying the smallholder productivity rate to all groups.

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.

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. 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. Results show that premiums provide an important incentive for farmers to improve productivity. We find that after controlling for gender and a set of covariates thought to influence or otherwise distort the effects of premium distributions, farms that received premiums have an estimated productivity of 2.07 KG/tree compared to 1.64 KG/tree for those not receiving a bonus. This translates into a 29.4 percent boost in productivity for the group receiving premiums

This finding demonstrates how sensitive coffee 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 percent bump, is significant.

4. Policy Considerations

Building on the findings and analysis presented in this policy brief we can identify a set of steps that the government of Rwanda and other leaders in 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. Incorporate into the formula for setting cherry floor prices the real cost of production of 177 RWF/KG cherry 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 that 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, achieving a better gender balance in these areas 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.

2. *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 may 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's infrastructure is well prepared to process a significantly higher volume of cherry (46.4 percent) without any further investment in washing station brick and mortar.

3. *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 the lack of policy attention 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 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. Moreover, 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.

4. *Premiums are shown to have an important positive effect on productivity.* Coffee farmers 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 29 percent of 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 the 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 (LMCP), 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 U.S. 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.

References

Ansoms, A., Verdoot, A., & Van Ranst, E. (2009). *The Inverse Relationship between Farm Size and Productivity in Rural Rwanda.* Antwerp: Institute of Development Policy and Management.

Clay, Daniel C., Aniseh S. Bro, Ruth Ann Church, Alfred Bizoza, David Ortega. (2016) Determinants of Farmer Investment in Coffee Production: Finding a Path to Sustainable Growth in Rwanda's Coffee Sector. Feed the Future Africa Great Lakes Region Coffee Support Program (AGLC) Research Paper #1. Food Security Policy Innovation Lab. Michigan State University.

Clay, Daniel C., J. Turetsinze and Nathan J. Clay (2014). Baseline Report on the Rwanda Horticulture Organisations Survey (RHOS). Rwanda National Agriculture Export Development Board (NAEB).

Clay, Daniel C., Valerie Kelly, Edson Mpyisi, and Thomas Reardon. (2002) "Input Use and Conservation Investments among Farm Households in Rwanda: Patterns and Determinants." In C.B. Barrett, F. Place, and A.A. Aboud, (eds), Natural Resource Management in African Agriculture: Understanding and Improving Current Practices.

Clay, Daniel C. and Lawrence A. Lewis. (1990). "Land Use, Soil Loss and Sustainable Agriculture in Rwanda." *Human Ecology*, 18 (2), pp. 147-161.

Lewis, Lawrence A., Clay, Daniel C., and Dejaegher, Yvan. (1988). "Soil Loss, Agriculture and Conservation in Rwanda: Toward Sound Strategies for Soil Management." *Journal of Soil and Water Conservation*, Sept-Oct, 1988.

NAEB (2016a). Coffee Strategy. From Rwanda National Agricultural Export Development Board (NAEB) website July 2016, http://www.naeb.gov.rw/index.php?id=49.

NAEB (2016b) National Coffee Census 2015. National Agricultural Export Development Board (NAEB).

Kathiresan, Arumugam. (2011). Strategies for Sustainable Crop Intensification in Rwanda: Shifting focus from producing enough to producing surplus. Ministry of Agriculture and Animal Resources (MINAGRI), Rwanda.

Ovalle-Rivera O, Läderach P, Bunn C, Obersteiner M, Schroth G. (2015). Projected Shifts in *Coffea Arabica* Suitability among Major Global Producing Regions Due to Climate Change. *PLoS ONE* 10 (4): 124-155. Link: http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0124155

Rahn E, Läderach P, Baca M, Cressy C, Schroth G, Malin D, Van Rikxoort H, Shriver J. (2013). Climate change adaptation, mitigation and livelihood benefits in coffee production: where are the synergies? *Mitigation and Adaptation Strategies for Global Change* 19 (8) 1119-1137. Link: http://link.springer.com/article/10.1007%2Fs11027-013-9467-x.

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