PMI IRS COUNTRY PROGRAMS: 2015 COMPARATIVE COST ANALYSIS

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Abt Associates Inc. | 4550 Montgomery Avenue | Suite 800 North
| Bethesda, Maryland 20814 | T. 301.347.5000 | F. 301.913.9061
| www.abtassociates.com

PMI IRS COUNTRY PROGRAMS: 2015 COMPARATIVE COST ANALYSIS

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ACRONYMS

AIRS	Africa Indoor Residual Spraying
CFV	Control Flow Valve
EC	Environmental Compliance
IEC	Information, Education and Communication
IRS	Indoor Residual Spraying
IT	Information Technology
M&E	Monitoring and Evaluation
MOH	Ministry of Health
NMCP	National Malaria Control Program
OP	Organophosphate
PMI	President's Malaria Initiative
SOP	Spray Operator
STTA	Short-term Technical Assistance
USAID	United States Agency for International Development
WHO	World Health Organization

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EXECUTIVE SUMMARY

The President's Malaria Initiative (PMI) began implementing indoor residual spraying (IRS) programs in 2006, with a goal of reducing the incidence and prevalence of malaria. The Africa Indoor Residual Spraying (AIRS) Project, implemented from 2011-2014, along with its follow-on project the PMI AIRS Project, currently being implemented from 2014-2017, together constitute PMI's leading pan-African IRS initiative, which has provided program support and implementation of IRS activities since August 2011. This report presents the cost analysis of the expenses incurred during 2015 and compares these costs to IRS costs from 2012, 2013, and 2014.

The aim of the assessment is to:

1. Evaluate the overall level of IRS spending in each of the PMI AIRS countries, by program activity and by cost category;
2. Calculate and compare the unit costs of IRS in each country, including the cost per person protected, cost per structure sprayed, and cost per area sprayed (per 100 m^2);
3. Provide cost comparisons for overall annual expenditure trends within countries over the first four years of the program.

Costing data will support PMI and host countries in the decision-making process of planning and prioritizing future investments. Findings may also help to inform local governments in the planning, funding, management, or implementation of IRS programs.

Through a collaborative process with PMI, project technical, monitoring and evaluation (M&E), financial, and operational staff, the costing team:

1. *Collected project expenditures and output measures.* Financial data were collected from Abt Associates' internal financial tracking systems for the past four years. Information collected was augmented and verified through staff interviews. Program output and operational data were collected from the AIRS M&E systems.
2. *Categorized all financial expenditures according to the methodology framework.* The costing framework used in this analysis includes: (1) capital and recurrent costs, (2) technical program activities, and (3) cost categories. All capital costs are annualized for this report. All costs are reported in 2015 U.S. dollars; costs from previous years are adjusted for inflation.

Costs in 2015

Project output data, listed in Table CC1, was collected and verified by PMI AIRS M&E staff for the ten countries with PMI-funded IRS campaigns in 2015. In total, about 11 million people were protected, ranging from approximately 365,425 people in Zimbabwe to over 2.5 million people in Zambia. This corresponds to about 3 million total structures sprayed, ranging from 130,170 structures in Senegal to 704,945 structures in Ethiopia, a total of over 297 million square meters of structures sprayed, and a total of over 1.3 million sachets or bottles of insecticide used.

The average structure size varied widely across countries, ranging from 45.2 square meters (m^2) in Benin to 192.4 m^2 in Mozambique. The average people per 100 m^2 sprayed ranged from 2.3 people in Zimbabwe and Ethiopia, to 4.9 people in Zambia.

Table CC3 presents the results of the unit cost analysis. The countries have been grouped into two categories (medium and large) based on the size of the program in terms of number of structures sprayed.

The overall unweighted average cost per person protected is $6.23. The average cost per person protected by program size is $4.67 for large programs and $8.56 for medium programs. The unweighted average cost per structure sprayed across countries was $21.35. The average cost per structure sprayed for large programs is $18.15 and for medium programs is $26.15. The unweighted average cost per 100 m^2 sprayed is $26.10.

Cost Components in 2015

Country program expenditures were divided into six cost categories: insecticide, spray commodities, spray operations, full-time local labor, local administration, and U.S.-based labor and short-term technical assistance. Details on the types of expenditures included in each cost category can be found in the 2014 report (Johns 2015)[1]. The three largest cost categories were insecticide (39 percent of all costs), spray operations (28 percent of all costs), and local labor (16 percent of all costs), constituting an average of 83 percent of all costs.

Insecticide

To prevent and manage the increasing challenge of insecticide resistance, IRS programs are changing or rotating the class of insecticide used. On average, the portion of insecticide cost per 100 m^2 sprayed is $5.20 for carbamates, $7.30 for countries that used organophosphates with other classes of insecticides, and $10.75 for organophosphates. These costs reflect the insecticide used (not the insecticide purchased).

Spray Operations

Spray operations include costs associated with temporary labor of spray operators (SOPs), ground transportation, warehousing costs, etc. Four (Ethiopia, Mozambique, Rwanda, and Zimbabwe) of the five countries that sprayed the most area per day also had the lowest spray operations costs per 100 m^2 sprayed. However, among countries that sprayed a similar amount of area per day, there is wide variation in the spray operations costs per 100 m^2 sprayed. Spray operations thus varied as a proportion of the total cost per 100 m^2 sprayed from 17 percent of costs in Zimbabwe to 33 percent of costs in Rwanda and Zambia.

Full-Time Local Labor

Local labor includes the country site office full-time staff members. The local labor portion of the unit costs per 100 m^2 sprayed ranged from $1.22 in Rwanda to $10.32 in Senegal, with an average of $5.07. The unit cost of local labor per area sprayed tends to be lower for larger programs and higher for smaller programs.

Year-on-Year Comparison

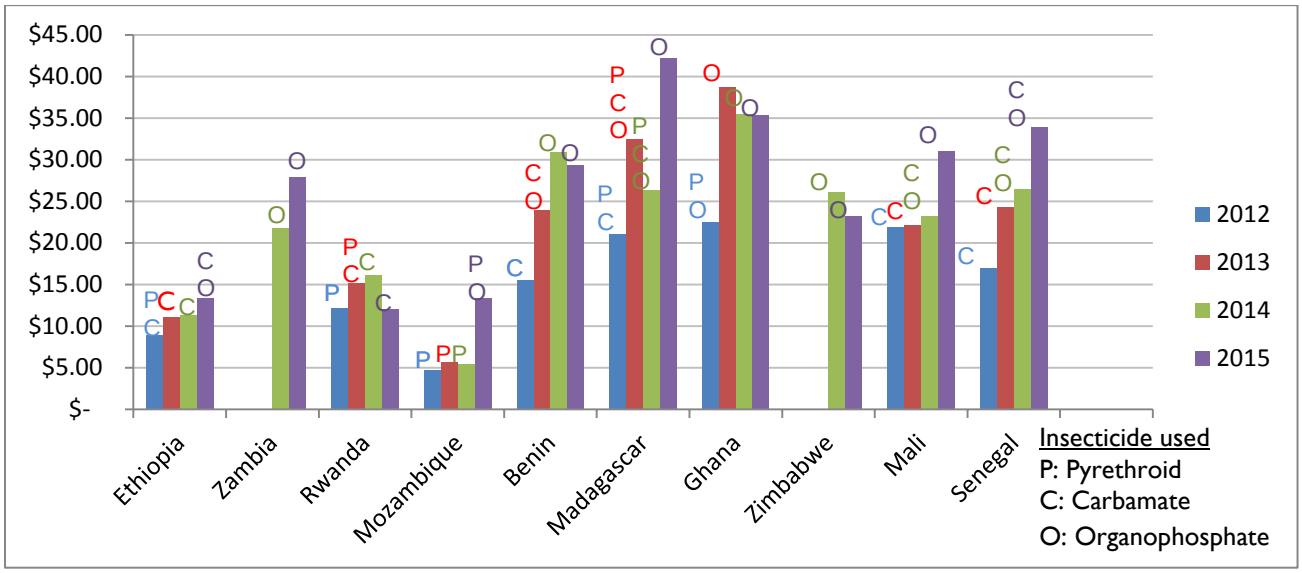
Four countries increased the number of structures sprayed in 2015 from 2014: Ethiopia (6 percent), Rwanda (16 percent), Zambia (27 percent), and Zimbabwe (10 percent), while Benin (-1 percent),

[1] Available at http://www.pmi.gov/docs/default-source/default-document-library/implementing-partner-reports/africa-indoor-residual-spraying-project-pmi-irs-country-programs-2014-comparative-cost-analysis.pdf?sfvrsn=4.

Madagascar (-10 percent), Mali (-41 percent), Mozambique (-24 percent), and Senegal (-36 percent) all sprayed fewer structures. Ghana sprayed almost the same number of structures in 2015 as in 2014.

Figure ES1 shows the unit costs for the countries included in this analysis for the years 2012 through 2015, as well as the type of insecticide used. It shows that cost per area sprayed in 2015 is generally lower or about the same as in 2014 for Benin, Ghana, Rwanda, and Zimbabwe. Cost per 100 m^2 sprayed increased in Ethiopia and Mozambique in association with the introduction of organophosphate insecticides for some of the areas sprayed. Additionally, Mali and Madagascar switched to using organophosphate insecticides for all areas. The non-insecticide portion of the cost per 100 m^2 sprayed was less in 2015 than it was in 2014 in Benin, Ethiopia, Ghana, Rwanda, and Zimbabwe. In Mali, Madagascar, Mozambique, and Senegal, the non-insecticide portion of the cost per 100 m^2 increased, while overall the countries sprayed less area. In Zambia, more area was sprayed, while the non-insecticide portion of the cost per 100 m^2 increased due to higher spray operation costs (as a result of door-to-door mobilization), the move to a larger office and the hiring of 21 new staff.

FIGURE ES1: COST PER 100M² SPRAYED 2012 THROUGH 2015



Country Chapters

This report includes a more detailed and specific chapter for each IRS country program covered in this analysis. The country chapters each include a background section with relevant country context, M&E data, total program costs, and unit costs per person protected, per structure sprayed, and per area sprayed. These chapters also include a more detailed analysis of unit costs between 2014 and 2015.

CONCLUSIONS

Limitations

Limitations in available data influence the results. In-kind contributions by host governments may be provided (e.g., supervision or information, education, and communication material), but this is generally unknown and varies by government and spray campaign; therefore, they have not been included in this report.

Comparing unit costs across countries poses limitations in conclusive results as well. It is important to note that variations between countries, unrelated to the IRS program structure or implementation, can account for differences in cost. Country differences include geography and breadth of spray coverage areas, average size of structures, and number of peak malaria transmission seasons. In addition, differences in country input prices may cause variations in unit costs that are not attributable to program efficiency.

As in past reports, we use the area sprayed as the unit for comparing costs across countries. This unit allows for a standardized metric to compare the relative efficiency of country programs that is not influenced by differences in the size of structures or the number of people per structure across countries. However, the true area sprayed is not measured routinely in PMI AIRS country programs. Rather, we estimate the area sprayed based on the amount of insecticide used. Thus, there still remains the possibility for differences in the efficiency of insecticide use between countries (due to differing spray equipment, etc.) that affect the comparisons. Further, the efficacy of use may change over time; for example, there may be higher efficiency in terms of flow rate when spray pumps are equipped with a control flow valve (CFV), such as those that come standard on Goizper pumps. Thus, some degree of inaccuracy in the comparisons is possible, and should be kept in mind when reading the results.

Program Scale

Broadly speaking, we find, similar to previous years, that unit costs for large programs are lower than for small programs (although larger programs tend to cost more in total). Using the most standardized comparison unit cost available, there is no 'one-price-fits-all' for IRS across countries. Large-sized programs averaged a cost per 100 m^2 sprayed of $23.00, and medium programs averaged $30.87.

Insecticide

Insecticide makes up the second largest cost category across the IRS programs when looking at the cost per 100 m^2 sprayed; it is the largest cost category when assessing total expenditures. The insecticide portion of the cost per area sprayed constitutes an average of 35 percent of the total unit cost across country programs. Costs of insecticides in this report reflect the cost of insecticides used, unless otherwise noted.

INTRODUCTION

1.1 BACKGROUND

The President's Malaria Initiative (PMI) aims to reduce the incidence and prevalence of malaria. PMI has provided IRS program support to Ministries of Health (MOHs) and National Malaria Control Programs (NMCPs) in sub-Saharan Africa since 2006. In April 2015, PMI's 2015-2020 strategy was released with specific objectives to: 1) reduce malaria mortality by one-third from 2015 levels in PMI-supported countries, achieving a greater than 80 percent reduction from PMI's original 2000 baseline levels, 2) reduce malaria morbidity in PMI-supported countries by 40 percent from 2015 levels, and 3) assist at least five PMI-supported countries to meet the WHO criteria for national or sub-national pre-elimination. The Africa Indoor Residual Spraying (AIRS) Project, implemented from 2011-2014, along with its follow-on project the PMI AIRS Project, currently being implemented from 2014-2017, together constitute PMI's leading pan-African IRS initiative.

In 2015, the PMI AIRS Project provided 10 PMI-supported countries with full IRS operations and logistics support (Benin, Ethiopia, Ghana, Madagascar, Mali, Mozambique, Rwanda, Senegal, Zambia, and Zimbabwe).

The PMI AIRS Project implements all aspects of the IRS process, including:

- Planning and forecasting IRS programming with government, community leaders, and other key stakeholders;
- Procuring insecticides and spray equipment/materials;
- Managing the supply chain of all IRS equipment and materials;
- Working with local leaders and organizations to ensure community awareness and knowledge of IRS campaign objectives, benefits, and timelines; and working with communities to provide further buy-in and further sensitization regarding malaria control for neighboring communities;
- Implementing IRS campaigns in targeted areas;
- Ensuring environmental compliance (EC) of IRS campaigns, and materials used in the campaigns;
- Monitoring and evaluating all program activities; and
- Completing entomological surveillance, and testing insecticide effectiveness.

PMI also seeks to ensure sustainability of IRS and other malaria control approaches. It therefore expects the PMI AIRS Project to empower country governments, the private sector, and communities by developing local knowledge and technical capacity needed to lead future IRS efforts. To this end, the project works closely with MOHs and NMCPs, health centers, and community leaders to encourage and enable their involvement in malaria control planning and implementation. In some countries, the project partners with local organizations that complete entomological surveillance and information, education, and communication (IEC) activities.

PMI requested the Project to provide annual comparative cost analyses on the total and unit costs of the IRS country programs. This report builds upon the 2012, 2013, and 2014 findings by reporting on 2015 costs and comparing them with those of the previous three years.

1.2 OBJECTIVE

This report presents and compares the findings of a cost analysis of the expenses that were incurred during the last four years of IRS program implementation in ten PMI countries, using a methodology that can be repeated on an annual basis. The purpose of the assessment is to evaluate the unit costs and the overall level of spending, by program activity and by cost category, in each of these countries.

The analysis separates capital expenditure items (used throughout full project implementation), and recurrent expenditure items (for each year of program implementation). The analysis also includes the cost of items inherited from previous IRS programs, as provided in each country's disposition inventory, as well as the cost of insecticides provided by local governments (where possible) in order to reflect the full cost of program implementation. These categories are defined in detail in the 2014 report (Johns 2015)[2].

Conducted annually over the course of the project, the analyses will provide cost comparisons for overall annual expenditure trends within and across countries. Costing data findings will also support PMI and host countries in the decision-making process of planning and prioritizing future investments within a country. Findings may also help local governments decide whether they would like to expand funding or management of IRS programs, and eventually to conduct full IRS activities themselves.

1.3 TARGET AUDIENCE

The results and findings of the cost analysis will be used by PMI and host countries to make informed decisions about how and at what funding level to invest in IRS in the future. The findings will also be used by Project staff for program management, and may be shared with PMI's government partners and other key stakeholders to inform them of specific costs of implementing an IRS program in their respective countries. PMI also intends to share findings broadly with global partners and post the analysis on its publicly available website.

[2] Available at http://www.pmi.gov/docs/default-source/default-document-library/implementing-partner-reports/africa-indoor-residual-spraying-project-pmi-irs-country-programs-2014-comparative-cost-analysis.pdf?sfvrsn=4.

2. APPROACH

The methodology used for the analyses presented in this report is generally the same as used for the reports from 2012, 2013, and 2014 (Abbott 2013, Abbott 2014, Johns 2015), with the exception of how insecticide costs are treated. In this report, all insecticide costs reflect the cost of the insecticide used, rather than the expenditures for insecticide procurement (as was done in the past). Insecticide costs are estimated based on the unit cost of insecticides procured, with the unit costs incurred in procurement then applied to the amount of insecticide used.

In keeping with the methodology used in the 2014 report, the useful life of capital items reflects a six-year timeframe for implementation. Items with an expected useful life of less than six years (boots, overalls, and other personal protective equipment) were not changed. Further, in the year-to-year comparisons, we did not apply inflation to insecticide costs. Insecticides are internationally available goods; when assessing the price of insecticides across the past four years, price changes do not appear to be correlated with the inflation rates in individual countries. We do adjust all other cost inputs for inflation, as described below and done in previous years' reports.

For a detailed description of the methodology and assumptions used, as well as limitations, please refer to the 2014 report (Johns 2015)[3].

This comparative costing analysis covers 2012, 2013, 2014, and 2015 of IRS implementation. However, the dates of each program year (the period of program implementation) vary by country. The specific program dates for each country program can be found in the respective country chapter.

[3] Available at http://www.pmi.gov/docs/default-source/default-document-library/implementing-partner-reports/africa-indoor-residual-spraying-project-pmi-irs-country-programs-2014-comparative-cost-analysis.pdf?sfvrsn=4.

3. Cross-Country Results

3.1 Background

Output Measures

Table CC1 presents the coverage provided by the PMI AIRS project's spray campaigns in each country. The area sprayed (number of 100 m^2 sprayed) was calculated by multiplying the total number of sachets/bottles of insecticide used by 250 m^2, the estimate of coverage provided by each sachet/bottle, and dividing by 100 m^2 in order to develop a more usable unit of measure. Note that in Ethiopia and Rwanda, total number of sachets was multiplied by 200 m^2 because the programs use an 8L spray tank (and smaller (100g) sachets), which holds less insecticide than in other countries, and thus covers less surface area. The average size of a structure in each country was calculated by the total area sprayed divided by the number of structures sprayed. The number of people per area sprayed was calculated by dividing the total population protected by the area sprayed in terms of 100 m^2, and ranged from 2.3 in Ethiopia and Zimbabwe to 4.9 in Zambia. Note that one sachet of pyrethroid or carbamate is equivalent to one bottle of organophosphate.

TABLE CC1: PMI AIRS PROJECT SPRAY COVERAGE IN 2015, BY COUNTRY

Country	# of People Protected	# of Structures Sprayed	Area Sprayed (100 m^2)	Avg. Size of Structure (m^2)	# People per Area Sprayed
Benin	802,597	252,706	114,160	45.2	3.2
Ethiopia	1,655,997	704,945	641,994	91.1	2.3
Ghana	553,954	205,935	113,285	55.0	2.7
Madagascar	1,016,841	247,902	113,493	45.8	4.1
Mali	494,205	133,527	146,180	109.5	3.7
Mozambique	1,631,058	337,433	649,370	192.4	4.8
Rwanda*	1,406,520	343,131	578,390	168.6	4.1
Senegal	514,833	130,170	98,010	75.3	4.0
Zambia	2,544,290	519,598	341,630	65.7	4.9
Zimbabwe	365,425	162,127	183,315	113.1	2.3

* Rwanda had two rounds of spraying in 2015 and there is some overlap in structures sprayed, therefore, some numbers are double counted.

The average structure size and number of people per area sprayed both provide additional contextual understanding of a country program's spray campaign. Structure size varied widely between countries, ranging from 45.2 m^2 in Benin to 192.4 m^2 in Mozambique, over four times as large. The average size of structures sprayed across all 2015 countries was 96.2 m^2 (not weighting for the different number of

structures sprayed between countries). On average each sachet/bottle of insecticide covered about 3.2 structures.

The average size of structures may differ across the four years, even in countries that sprayed the same target areas across the years. The average structure size is calculated based on the number of insecticide sachets/bottles used and the number of structures sprayed. Thus, variations in the average size may be due to changes in spray technique efficiencies, changing the geographic target area for spray operations, or a combination of the two.

Program Size

PMI, project staff and the general IRS community define "program size" using a combination of both the total number of structures sprayed and total number of population protected. For the purpose of this costing report, IRS country programs are separated into three program sizes, using the same cut-off criteria as used in the 2013 report (based on the number of structures sprayed). Note, however, that under this classification, none of the country programs in 2015 were classified as having a 'small' program size, and this category is not further included in the analyses. This breakdown is summarized in Table CC2.

TABLE CC2: IRS PROGRAM SIZES

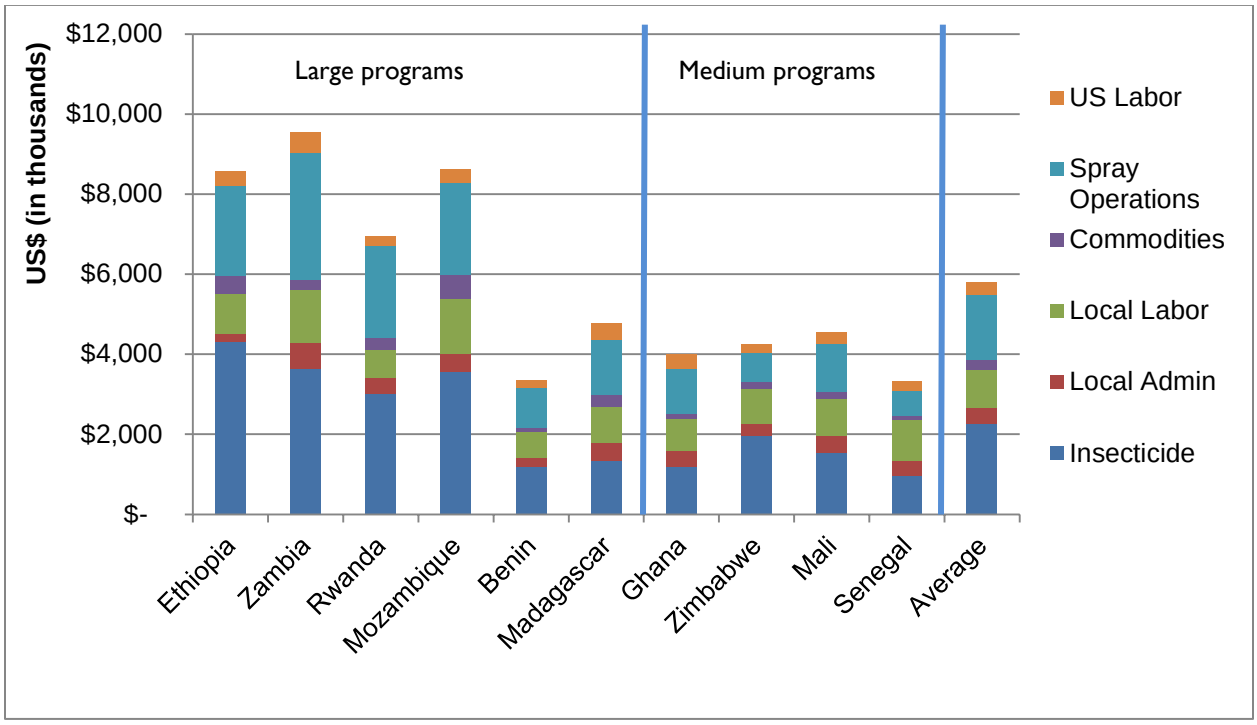
Program Size	# Structures Sprayed	Corresponding ranges within program size for following coverage variables:	
		# Population Protected	# Square Meters Sprayed
Large	230,001 – 705,000	800,001 - 2,600,000	113,401 - 650,000
Medium	100,001 – 230,000	350,000 - 800,000	98,000 - 113,400
Small	10,000 – 100,000	N/A	N/A

For a more detailed analysis, countries will be grouped and presented according to program size, as specified above.

3.2 Total Program Expenditures

This section presents the IRS country programs' total expenditures for 2015. Figure CC1 below includes all capital and recurrent costs of country IRS programs broken down by cost category. Countries are arranged in order of the number of structures sprayed during 2015 spray campaigns, from largest to smallest.

FIGURE CC1: CAPITAL AND RECURRENT EXPENDITURES, BY COST CATEGORY



The above figure shows that the U.S.-based labor and STTA cost category remains consistent across all country programs at an annual average of about $313,000. Local administration, while more variable than the U.S.-based labor cost category, is also considered a fixed cost and averaged about $390,000 across countries. These fixed costs are discussed in more detail in the cost-drivers analysis section. An average of 71 percent of total project expenditures is spent directly on spray operations, insecticide, and other commodities.

The average total program implementation expenditures for large and medium-sized programs are about $6.97 million and $4.03 million respectively.

3.3 Unit Cost Analysis

This section presents country IRS programs' capital and recurrent expenditures as unit costs: per person protected, per structure sprayed, and per area sprayed (in terms of 100 m^2). The unit costs, shown in Table CC3, are calculated using total program expenditures and the output measures provided in Table CC1.

TABLE CC3: 2015 IRS PROGRAM UNIT COSTS

Program Size	Country	Cost per Person Protected	Cost per Structure Sprayed	Cost per Area Sprayed
Large	Ethiopia	$ 5.17	$ 12.15	$13.34
	Zambia	$ 3.75	$ 18.36	$27.92
	Rwanda	$ 4.94	$ 20.26	$12.02

	Mozambique	$ 5.29	$ 25.59	$13.29
	Benin	$ 4.17	$ 13.23	$29.29
	Madagascar	$ 4.71	$ 19.30	$42.16
Medium	Ghana	$ 7.17	$ 19.28	$35.05
	Zimbabwe	$ 11.65	$ 26.26	$23.22
	Mali	$ 9.19	$ 34.02	$31.07
	Senegal	$ 6.46	$ 25.54	$33.92
Average (unweighted)		**$ 6.25**	**$ 21.40**	**$ 26.13**

The following figures show each of the country IRS programs' unit costs: per person protected, per structure sprayed, and per area sprayed. Countries are ordered by number of structures sprayed, from largest to smallest.

FIGURE CC2: UNIT COSTS PER PERSON PROTECTED, BY COST CATEGORY

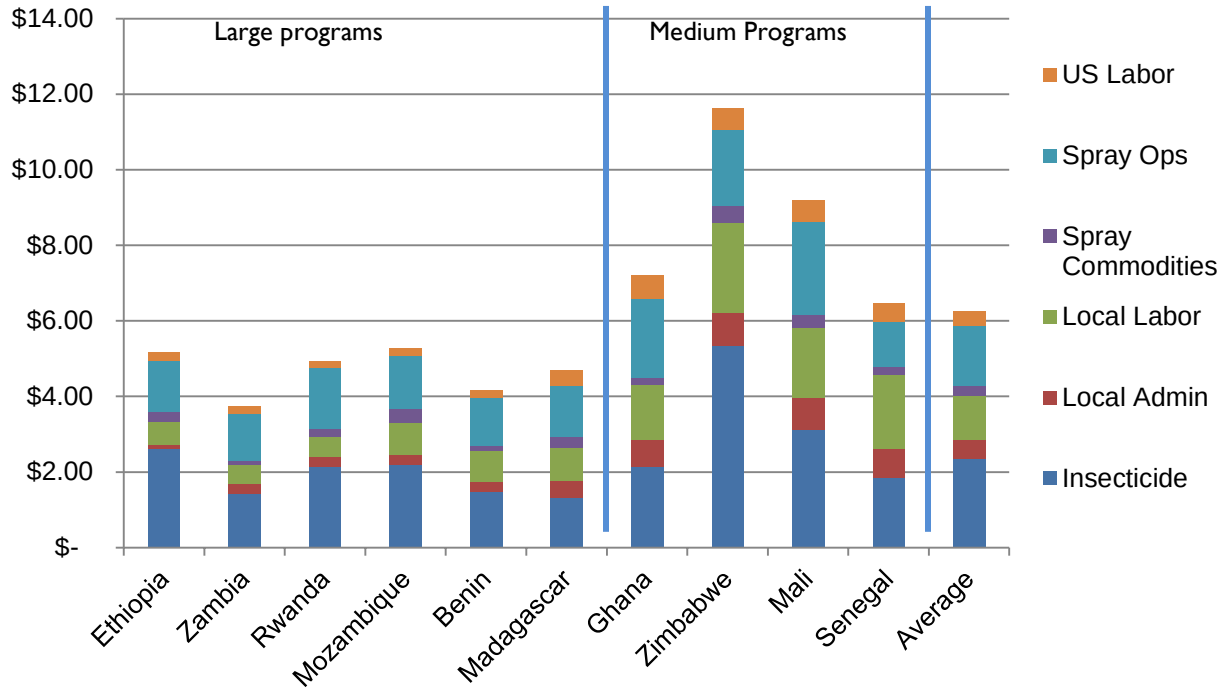


Figure CC2 shows cost per person protected, broken down by cost category. The overall unweighted average is $6.25. The average cost per person protected by program size is $4.67 for large programs, and $8.62 for medium programs. As observed in past studies, the size of the program is correlated with unit costs, with smaller programs tending to have higher unit costs. However, as explored in further sections, other factors in addition to program size also explain differences in unit costs across countries.

FIGURE CC3: UNIT COSTS PER STRUCTURE SPRAYED, BY COST CATEGORY

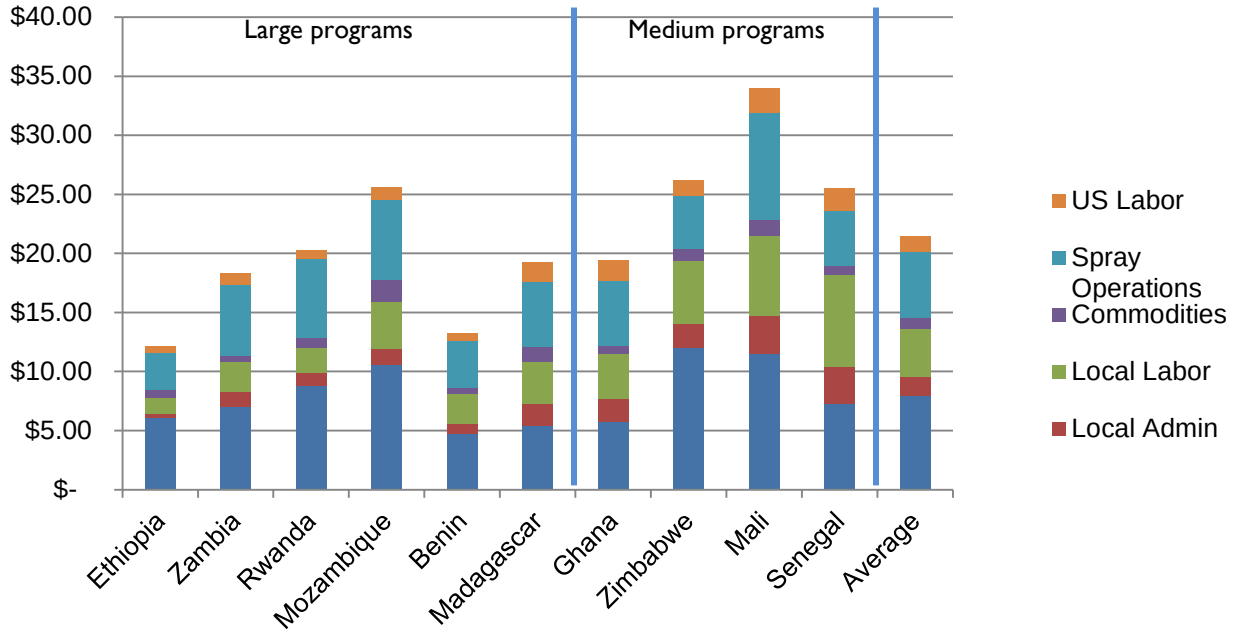


Figure CC3 shows country programs' unit costs per structure sprayed. The average cost across countries (not weighted by the number of structures sprayed in each country) was $21.40. The average cost per structure sprayed for large programs is $18.15, and for medium programs is $26.27.

As stated earlier, the average size of a structure may vary greatly from one country to another, which means that even if fewer structures were sprayed, the same amount of square meters may have been covered. For example, in Figure CC3, the unit costs per structure sprayed for Zambia is lower than Rwanda. However, in Figure CC4, the unit cost per area sprayed for Zambia is higher than for Rwanda (Zambia incurred $15.90 more per area sprayed than Rwanda). This is because in Rwanda the average size of a structure is 168.6 m^2, and in Zambia the average is 65.7 m^2. Therefore, presenting the cost per area sprayed (in terms of 100 m^2) in comparing costs across countries provides a standardized unit of measure that is not influenced by non-cost variables.

FIGURE CC4: UNIT COST PER AREA SPRAYED, BY COST CATEGORY

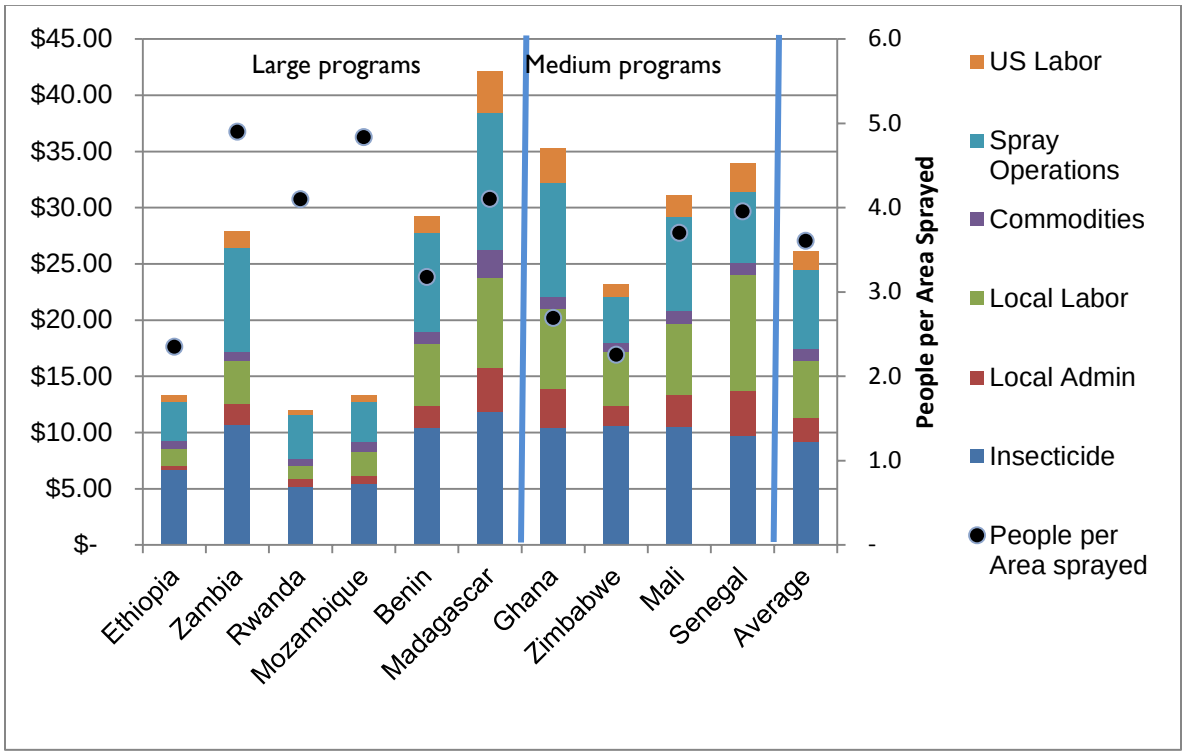


Figure CC4 shows the unit costs per area sprayed (in terms of 100 m^2) broken down by cost category, and also includes black dots for the number of people per area sprayed (in terms of 100 m^2) to provide context. The countries are in order of number of structures sprayed, from largest to smallest. The unweighted average of all countries is $26.13 per area. Among the large program countries, Zambia, Benin, and Madagascar had the highest cost per 100 m^2 sprayed. Zimbabwe, which incurred the higher cost per person protected and cost per structure sprayed, had the lowest cost per area sprayed of any of the medium-sized country programs. Zimbabwe, along with Ethiopia, also had the lowest number of people protected per area sprayed among all of the countries, which helps explain the comparatively higher unit costs in other areas relative to the cost per area sprayed.

3.4 Cost Drivers

This section focuses on the country IRS programs' costs per area (100 m^2) sprayed, in order to assess plausible explanations ("cost drivers") for differences in unit cost across the countries. A cost driver is the activity, or unit of an activity, that is responsible for significant differences in costs between one country and another. This section explores selected cost category separately to assess and explain the variation in unit costs. This section will also continue to categorize countries by program size.

Table CC4 provides the percentage of each cost category out of the total unit cost per area sprayed. This is the first step in determining which cost categories constitute the largest percentage of costs, and which cost categories show the most variance across countries in terms of their percentage of the total costs.

Table CC4 shows that on average, the largest cost category is insecticides, which accounts for an average of 37 percent of the unit costs. Spray operations and local labor follow as the next largest cost categories, making up an average of 25 and 18 percent of costs, respectively. There is variability in the

cost categories between countries. For example, local labor accounts for 30 percent of the cost per area sprayed in Senegal, but 11 percent in Ethiopia. Insecticides constituted between 28 percent of costs in Madagascar to 50 percent of costs in Ethiopia. The next step, which will be assessed later in this section, is to determine *why* these categories are different across countries.

TABLE CC4: BREAKDOWN OF FIXED AND VARIABLE COSTS, AS PERCENTAGE OF UNIT COST PER AREA SPRAYED

Country	Fixed Costs					Variable Costs				Total Unit Cost
	Local Admin	Capital Items	US Labor	Commodities	Total Fixed Costs	Spray Operations	Insecticide	Local Labor	Total Variable Costs	
Ethiopia	2%	23%	4%	1%	30%	9%	50%	11%	70%	$ 13.34
Zambia	7%	1%	5%	2%	15%	33%	38%	14%	85%	$ 27.92
Rwanda	5%	3%	3%	3%	14%	33%	43%	10%	86%	$ 12.02
Mozambique	4%	4%	4%	5%	16%	27%	41%	16%	84%	$ 13.29
Benin	5%	4%	5%	1%	16%	30%	36%	19%	84%	$ 29.29
Madagascar	7%	8%	9%	0%	25%	29%	28%	19%	75%	$ 42.16
Ghana	9%	3%	8%	1%	22%	29%	30%	20%	78%	$ 35.05
Zimbabwe	7%	3%	5%	2%	16%	17%	46%	21%	84%	$ 23.22
Mali	8%	4%	6%	2%	20%	26%	34%	20%	80%	$ 31.07
Senegal	10%	4%	7%	1%	22%	19%	29%	30%	78%	$ 33.92
Average	6%	6%	6%	2%	20%	25%	37%	18%	80%	$ 26.13

Ethiopia spent the largest percentage on fixed costs, and capital items represent a higher percentage of unit costs in Ethiopia than in any other country.

The following sub-sections provide a more in-depth cost driver analysis of the following components: fixed costs, insecticides, and spray operations.

3.4.1 Fixed Costs: U.S.-based Labor and Local Administration

On average, the fixed costs of country programs are about 20 percent (range: 14 percent to 30 percent) of the total unit cost, while the average of the variable costs is 80 percent (range: 70 percent to 86 percent) of the total unit cost per 100 m^2 sprayed.

FIGURE CC5: FIXED COSTS PORTION OF COST PER AREA SPRAYED

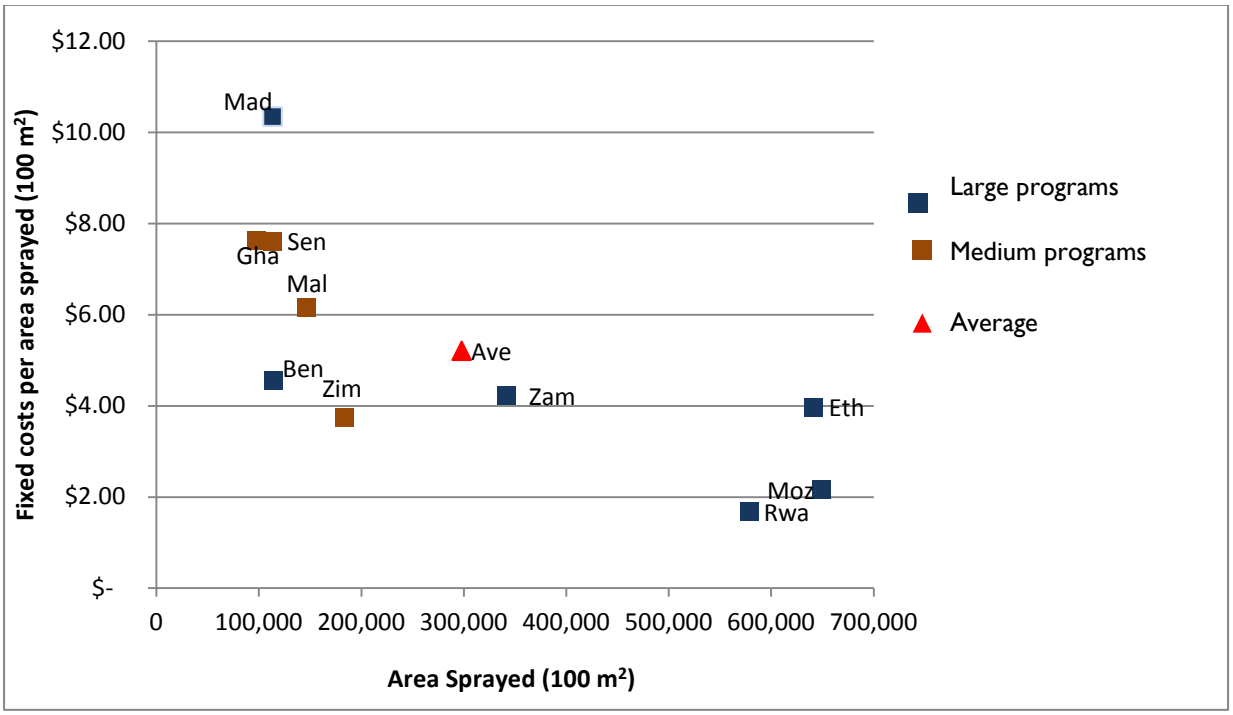


Figure CC5 shows the fixed unit cost per area sprayed (in terms of 100 m^2) on the y-axis. This includes capital expenditures, commodities (PPE and other spray equipment), U.S.-based labor and STTA, and local administration costs. The x-axis shows the total area sprayed. As expected, the fixed cost per area sprayed appears to be lower in countries that sprayed more area. The fixed costs per area sprayed ranged from $1.68 in Rwanda to $10.34 in Madagascar. Ethiopia, which had a high percentage of fixed cost, had the fourth lowest fixed cost per area sprayed. The average fixed cost per 100 m^2 sprayed of the large programs is $4.48, and for medium programs is $6.33.

However, there is still substantial variation in the amount of fixed cost per 100 m^2 that is not directly correlated with the total area sprayed. For example, Benin and Madagascar both sprayed similar amounts of area (114 million m^2 and 113 million m^2, respectively), yet Benin's fixed cost per area sprayed was $4.55, compared to $10.34 for Madagascar. Madagascar spent $1.60 to $2.30 dollar more per 100 m^2 sprayed for local administration, capital items, and US labor, but about $0.31 less per area sprayed for commodities. Madagascar also had two spray campaigns in different parts of the country (including in the remote Southeast Coast of the country which had not previously been sprayed), and had 33 local employees on its staff, compared to 14 local staff in Benin, which partly explains the difference in cost for local administration and the need for more equipment and capital items.

The two most expensive countries in terms of fixed costs per area sprayed were Ghana and Madagascar (as in 2014), followed closely by Senegal. Senegal had the lowest program size in terms of the number of structures and area sprayed, which help to explain its high fixed cost per area sprayed. Meanwhile, as shown in Table CC4, fixed cost makes up 22 percent of Ghana's total unit cost. Ghana's total unit costs is about 2 percent above average, which indicates that the expensive fixed cost per area sprayed is a function of Ghana's expensive cost per area sprayed overall.

The following two sections will focus on insecticide and spray operations as two major cost drivers.

3.4.2 Insecticide: The Cost of Resistance

As previously mentioned, the threat of insecticide resistance is forcing IRS programs to switch to more expensive classes of insecticide. The impact of using more expensive classes of insecticide is seen clearly in the PMI AIRS Project: given fixed budgets, use of more expensive insecticides results in fewer people being protected by IRS, unless funds can be appropriated from other areas.

The amount and class of insecticide purchased under AIRS country programs does not always reflect the amount and class of insecticide used during the same year's spray campaign. For example, IRS programs in 2015 may use leftover insecticide from the previous year, may use a mix of insecticide classes, or may have some remaining insecticide at the end of the spray campaign. Table CC5 lists the number and class of insecticide sachets/bottles purchased and used in 2015 of the country IRS programs.

TABLE CC5: CLASS AND NUMBER OF INSECTICIDE SACHETS/BOTTLES PURCHASED AND USED IN 2015

Country	Type of insecticide(s) used	Number of sachets/ bottles purchased	Number of sachets/ bottles used	Estimated cost of insecticides used per area sprayed
Benin	Organophosphates	50,580	45,664	$ 10.46
Ethiopia	Organophosphates (25% of insecticide used)	87,372	80,836	$ 6.73
	Carbamates		240,161	
Ghana	Organophosphates	52,928	45,314	$ 10.40
Madagascar	Organophosphates	40,632	45,397	$ 11.81
Mali	Organophosphates	54,287	58,472	$ 10.49
Mozambique	Organophosphates (49% of insecticide used)	186,192	126,328	$ 5.49
	Pyrethroids	345,500[4]	133,420	
Rwanda	Carbamates	295,330	289,195	$ 5.20
Senegal	Organophosphates (84% of insecticide used)	48,671	32,925	$ 9.70
	Carbamates		6,279	
Zambia	Organophosphates	145,000[5]	136,652	$ 10.67
Zimbabwe	Organophosphates	61,967	73,326	$ 10.65

In six countries (Benin, Ghana, Madagascar, Mali, Zambia, and Zimbabwe) the only class of insecticide purchased and used was organophosphates. In Senegal, 84 percent of sachets/bottles used were organophosphates, in Mozambique 49 percent were organophosphates, while in Ethiopia 25 percent

[4] Donated by the MOH and The Global Fund
[5] 70,000 of these bottles were donated by the NMCP

were organophosphates. Rwanda was the only country to not employ organophosphate insecticides for any of its spraying.

In Table CC5, there is a clear correlation between the insecticide class procured and the insecticide portion of the cost per area sprayed. The average cost of insecticides per 100 m^2 sprayed in organophosphate countries is over twice the cost of insecticides per 100 m^2 sprayed in Rwanda, where carbamates were used. Analysis of the countries which used a mix of organophosphate and other insecticide also shows that Senegal, which used a higher proportion of organophosphates compared to other insecticides, had the highest insecticide cost per area sprayed in that category. Mozambique had lower unit costs than Ethiopia even though it used organophosphates for a higher percentage of its spraying because it employed pyrethroids for the remainder of its spray area, which are markedly less expensive than the carbamates used in Ethiopia.

In Figure CC6, country programs are organized by insecticide class, and from largest to smallest within each class. The blue portion at the bottom of each bar is the insecticide portion of the unit cost. The correlation between the insecticide class procured and the insecticide portion of the cost per area sprayed remains apparent when the cost per area sprayed includes all costs, as in Figure CC6. The exception is Senegal, which used a high proportion of organophosphates, and also had the smallest program size among the countries. The cost of insecticides per 100 m^2 sprayed in Madagascar is $11.81, while the *total* cost per 100 m^2 sprayed in Rwanda is $12.02 (Annex II), indicating how the type of insecticide used may influence unit and total costs.

FIGURE CC6: ESTIMATED COST PER AREA SPRAYED, ORGANIZED BY INSECTICIDE CLASS

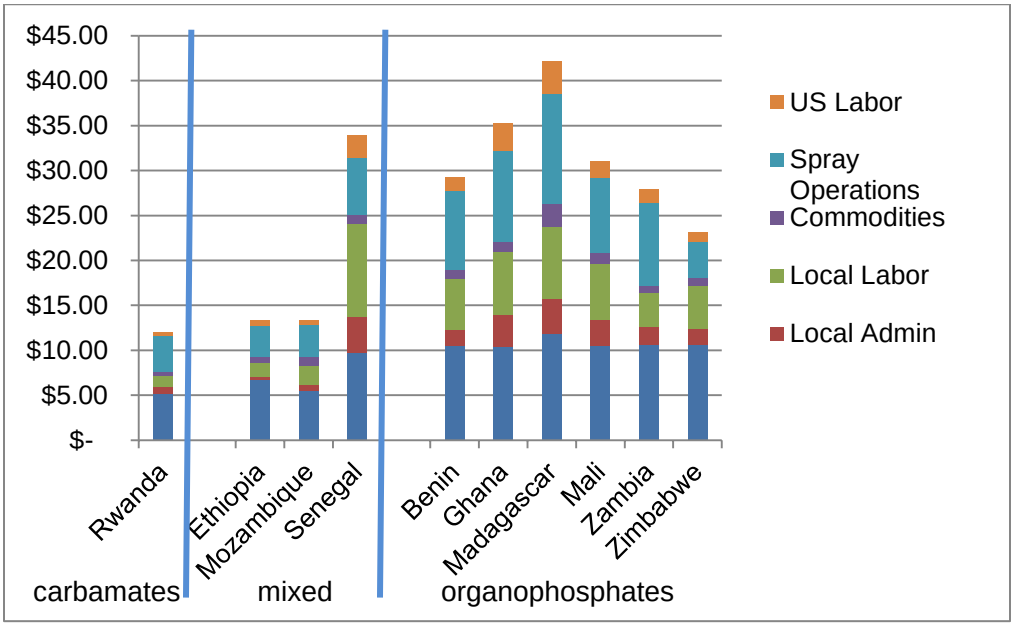


FIGURE CC7: COST PER PERSON PROTECTED, ORGANIZED BY INSECTICIDE CLASS

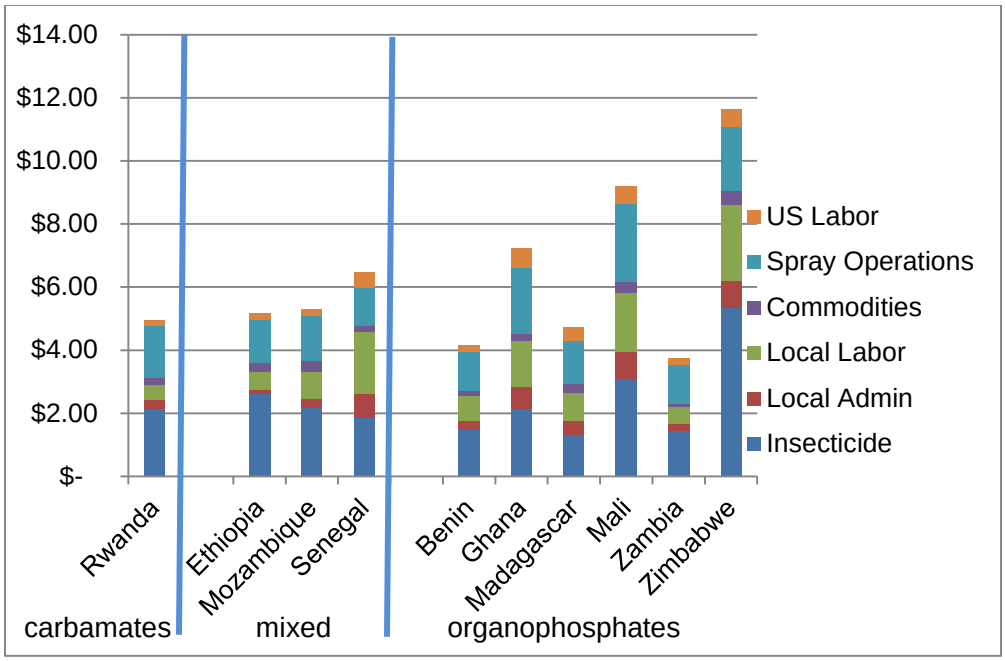


Figure CC7 shows the same data as Figure CC6 but reflects the cost per person protected. The average cost for insecticides used was $2.14 for carbamates (Rwanda), $2.21 for organophosphates mixed with other insecticide classes, and $2.47 for organophosphates only. The cost of insecticides used per person protected is not highly correlated with the type of insecticide used since Benin, Madagascar, and Zambia had the lowest cost per person and the lowest insecticide cost per person protected. The relative size of structures per person protected appears to mask the relationship between the cost of insecticides used and people protected.

Insecticide costs are not included in the following cost driver analyses in order to isolate the additional conclusions drawn in the following section from any consideration of the costs of insecticides.

3.4.3 Spray Operations: Program Scale

Spray operations, which includes temporary labor of spray operators (SOPs), ground transportation, and warehousing costs,[6] accounted for an average of 27 percent of the average cost per 100 m^2 sprayed across the countries.

The spray operations portion of the cost per 100 m^2 sprayed is a function of total expenditures, number of campaign days (efficiency), and size of the program (number of structures sprayed), as demonstrated in Figure CC8.

[6] For a full list of expenditure items included in the spray operations cost category, please refer to the 2014 report (Johns 2015).

FIGURE CC8: SPRAY OPERATIONS COST PER AREA SPRAYED, AREA SPRAYED PER CAMPAIGN DAY, AND TOTAL NUMBER OF STRUCTURES SPRAYED

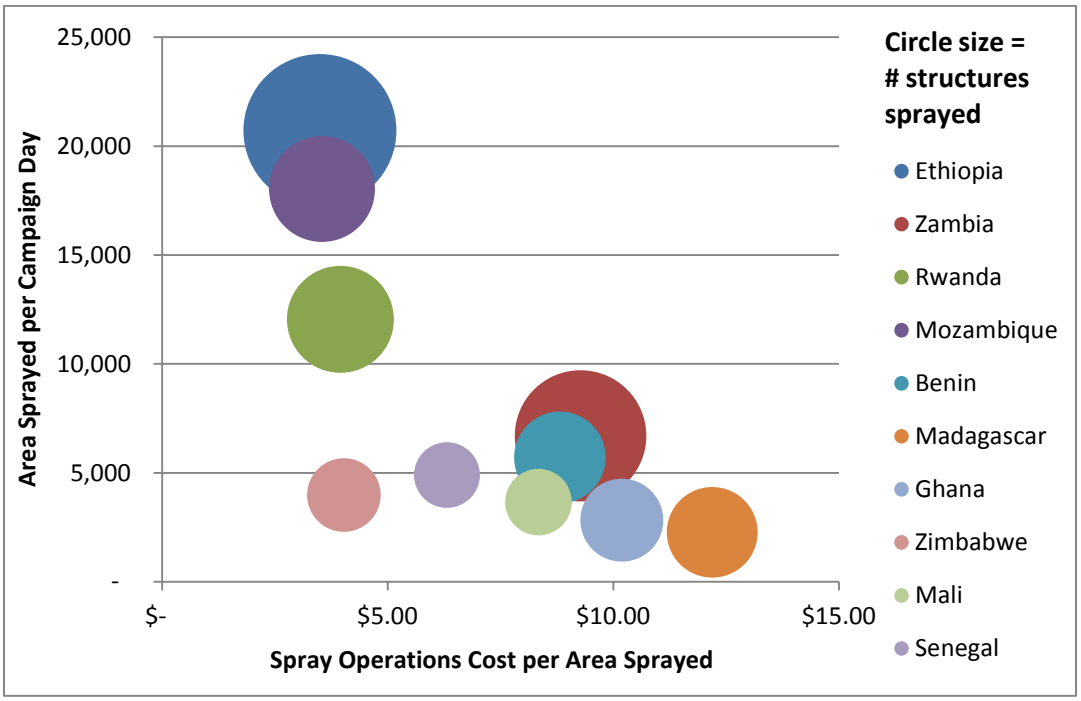


Figure CC8 shows the spread of country program spray operations, including the cost of spray operations per 100 m² sprayed (x-axis), the amount of area sprayed (in terms of 100 m²) per campaign day (y-axis), and the program size in terms of number of structures sprayed (circle size). Ethiopia, Mozambique, and Rwanda sprayed the largest amount of area per campaign day, and consequently had the lowest spray operations cost per 100 m² sprayed. The other country programs sprayed under 7.0 million m² per day. The spray operation cost per 100 m² sprayed in these countries were varied (although separated from Ethiopia, Mozambique, and Rwanda), ranging from $4.08 in Zimbabwe to $12.19 in Madagascar, while the spray operation cost per 100 m² sprayed in Ethiopia, Mozambique, and Rwanda were all under $4.00.

Thus, while being able to spray large amounts each campaign day likely provides cost efficiency, other factors also influence the cost per 100 m² sprayed. For example, while Senegal and Benin sprayed a relatively similar area per day (4.9 million m² and 5.7 million m², respectively, a factor of 1.16), the spray operations cost per area sprayed differed from $6.31 in Senegal to $8.81 in Benin (a factor of 1.39). The data presented in Table CC6 helps to explain these differences. Benin used a comparatively larger number of SOPs over a similar period of time than Senegal. Thus, the area sprayed per SOP per day in Benin was 56 percent of that in Senegal, offsetting the greater total area sprayed per day (SOPs in Benin also had higher daily wages than in Senegal). While this explains the differences mathematically, the underlying reasons for the lower area sprayed per SOP per day in Benin than Senegal are not fully clear, but may be related to geography, housing sizes, etc.

TABLE CC6: SEASONAL SPRAY OPERATORS (SOPS) AND CAMPAIGN DAYS

Country	Total # SOPs	Total # SOP Days	Avg. # Days/ SOP	Avg. Daily wage of SOP	Total # Campaign days	Total Area Sprayed (# 100 m^2)	Area Sprayed/ SOP day	Area Sprayed/ Campaign Day
Ethiopia	1,511	39,564	26	$6.00	31	641,994	16.2	20,709
Zambia	1,421	8,893	6	$6.25*	51	341,630	38.4	6,699
Rwanda	2,111	28,203	13	$9.19	48	578,390	20.5	12,050
Mozambique	1,122	38,816	35	$4.06	36	649,370	16.7	18,038
Benin	988	18,353	19	$6.00	20	114,160	6.2	5,708
Madagascar	960	12,529	13	$6.65	50	113,493	9.1	2,270
Ghana	446	12,529	28	$8.50	40	113,285	9.0	2,832
Zimbabwe	246	8,657	35	$15.00	46	183,315	21.2	3,985
Mali	391	33,244	85	$6.00	40	146,180	4.4	3,655
Senegal	539	8,893	16	$5.50	20	98,010	11.0	4,901
Average	**974**	**20,968**	**28**	**$ 6.69**	**38**	**297,983**	**15**	**8,085**

*SOPs are not paid; figure represents allowance given to SOPs for meals

Table CC6 provides a detailed breakdown of the number of SOPs that worked in each country spray campaign, as well as the total and average numbers of SOP days, and the average daily wage. Also provided are the total number of campaign days, the total amount of area sprayed (in terms of 100 m^2), and the average amount of area sprayed per SOP day and per campaign day (both also in terms of 100 m^2). There is no noticeable correlation or trend between the number of SOPs or number of SOP days and the amount of area sprayed per SOP day, especially when Zambia, which had much higher area sprayed per SOP per day than the other countries, is taken out of the analysis. For example, the three programs spraying the largest area, Mozambique, Ethiopia, and Rwanda, used very different numbers of SOPs in the program spray campaigns, but utilized the most SOP-days. However, the amount of area sprayed per SOP per day for these three countries is relatively close to the average amount sprayed per SOP per day in all countries (although all are above average).

Figure CC9 provides a comparison of efficiency in SOP productivity (measured by area sprayed per SOP per day) and the spray operations cost per 100 m^2 sprayed. The graph is sorted by the amount spent for spray operations per 100 m^2 sprayed, with countries spending less on the right and countries spending relatively more on the left. The red dots in Figure CC9 represent the average area sprayed per SOP per day for each country.

FIGURE CC9: SPRAY OPERATIONS EFFICIENCY AND COST PER AREA SPRAYED

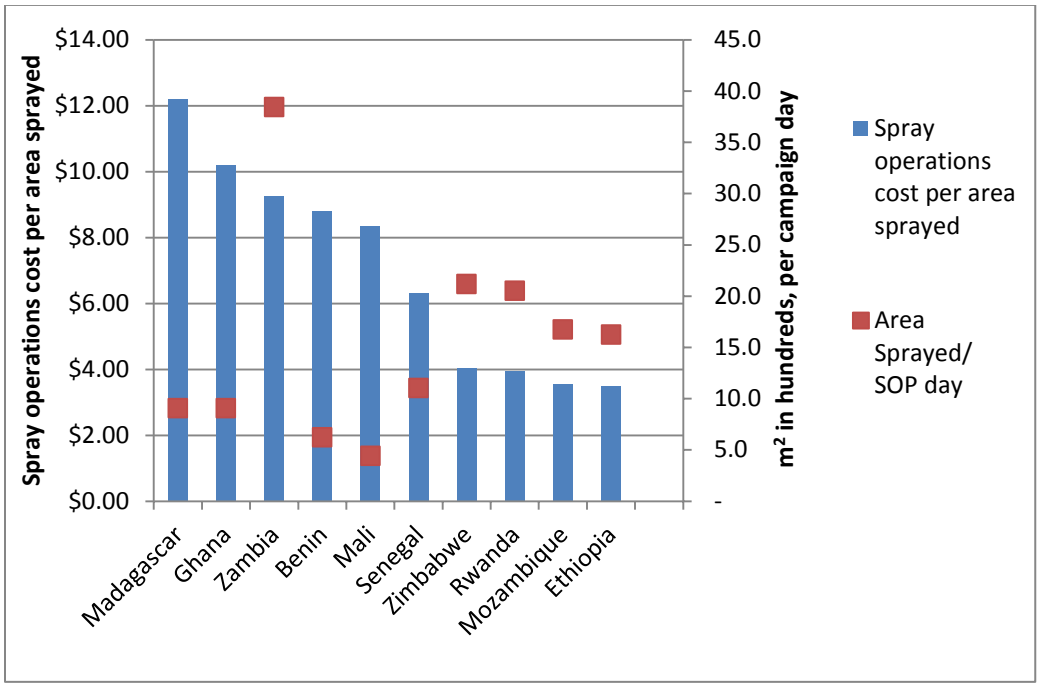


Figure CC9 suggests that countries with higher SOP productivity tend to have lower spray operations cost per 100 m² sprayed, although other factors are also involved and Zambia is an outlier. The countries with the lowest spray operations cost per 100 m² sprayed (Ethiopia, Mozambique, Rwanda, and Zimbabwe) had the highest SOP efficiency aside from Zambia. Mozambique and Ethiopia also had among the lowest daily wages for SOPs among the countries. The country with the highest area sprayed per SOP per day was Zambia. In Zambia, while productivity is high, the spray operations cost per area sprayed is also much higher than in other countries. It should be noted that wages for SOPs reflect only, on average, 8% of spray operations costs – thus the decreased spray operations associated with greater area sprayed per SOP per day likely reflect overall efficiencies in spray operations.

Efficiency in operations is only partly amenable to changes; as noted above, geography, transportation infrastructure, housing density, etc. also affect the ability of SOPs to spray. For example, spray operations cost per 100 m² sprayed for Madagascar is more than three times greater than Rwanda's, while SOPs spray 44 percent as much area per day in Madagascar as Rwanda. Madagascar's geographical coverage area is more spread out than Rwanda's, and its program incurred over $1.68 per 100 m² for ground transport vs. $0.45 per 100 m² sprayed in Rwanda.

3.5 CONCLUSIONS

Unit of Measure

As in past reports, we use area sprayed as the unit for comparing costs across countries. However, the true area sprayed is not measured routinely in AIRS country programs. Rather, we estimate the area sprayed based on the amount of insecticide used; thus, we are, in actuality, comparing the cost of programs per unit of insecticide used. While this remains, in our opinion, the best metric available for comparing between countries, there still remains the possibility for differences in the efficiency of insecticide use between countries (due to differing spray equipment, etc.) that affect the comparisons.

Further, the efficacy of use may change over time; for example, there may be higher efficiency in terms of flow rate when spray pumps are equipped with a control flow valve (CFV), such as those that come standard on Goizper pumps. Thus, some degree of inaccuracy in the comparisons is possible, and should be kept in mind when reading the results. For the country-specific chapters, we use the number of structures sprayed for comparison.

Program Scale

Broadly speaking, we find, similar to previous years, that unit costs for large programs are lower than for small programs (although larger programs tend to cost more in total). Using the most standardized comparison unit cost available, there is no 'one-price-fits-all' for IRS across countries. Large-sized programs averaged a cost per 100 m^2 sprayed of $23.00, and medium programs averaged $30.75 (Annex II).

There are some fixed costs for IRS programs which are not correlated to program scale, such as local administration and U.S.-based labor, which constitute an average of 7 percent ($193,300 to $654,000) and 5 percent ($170,900 to $508,000) of the total program costs, respectively.

Two of the important IRS program cost drivers, spray operations and local labor, constitute an average of 25 percent and 18 percent of the cost per area sprayed, respectively. Spray operations and local labor are both correlated with program scale (although there is a minimum level of local labor needed for any program). Programs with outlier costs in these areas are due to specific country context: geography of spray coverage area, number of spray rounds per year, and general cost of living (prices for labor, fuel, etc.).

Insecticide

The insecticides used in spray campaigns is the largest cost category across the IRS programs when looking at the cost per 100 m^2 sprayed (in 2014 it was the second largest cost category); it is also the largest cost category when assessing total expenditures. The costs for insecticides will continue to be increasingly important as the threat of insecticide resistance prompts IRS programs to switch to more expensive classes of insecticide. The insecticide portion of the cost per area sprayed constitutes an average of 37 percent of the total unit cost across country programs.

4. Year-on-Year Comparison

4.1 Changes in IRS Programs from 2012 to 2015

As an IRS program matures, lessons are learned, efficiencies are realized, and needs change. This section provides an overview of the major changes in countries' IRS programs across the years, focusing on changes from 2014 to 2015.

TABLE YR1: YEAR-ON-YEAR COMPARISON OF PROGRAM SIZE[7]

Program Size	2012	2013	2014	2015
Large	Ethiopia Mozambique Rwanda Madagascar Ghana Senegal	Ethiopia Mozambique Rwanda Madagascar	Ethiopia Mozambique Rwanda Zambia Madagascar Benin	Ethiopia Zambia Rwanda Mozambique Benin Madagascar
Medium	Mali Benin Angola Liberia	Mali Benin Ghana Senegal	Mali Ghana Senegal Zimbabwe	Ghana Zimbabwe Mali Senegal
Small	Nigeria Burkina Faso	Nigeria Angola Liberia	Angola	

As discussed in Section 3.1, program size is based on the number of structures sprayed by an IRS program. In 2015, PMI-supported IRS stopped in Angola.

Table YR2 provides details on the changes in output measures for all country programs between 2014 and 2015. A complete table of output measures for all country programs for the period 2012-2015 is included in Annex I. Table YR3 shows the changes in unit costs between 2014 and 2015. A complete table of unit costs for all country programs for the period 2012-2015 is included in Annex II. For more information, a comprehensive discussion of the changes in each country program is provided at the end of each individual country chapter.

TABLE YR2: YEAR-ON-YEAR COMPARISON OF OUTPUT MEASURES

	People Protected			Structures Sprayed			Area Sprayed (100 m^2)		
Country	2014	2015	Percent Change	2014	2015	Percent Change	2014	2015	Percent Change

[7] Listed in the order of program size, from largest to smallest

			2014-2015			2014-2015			2014-2015
Ethiopia	1,647,099	1,655,997	1%	667,236	704,945	6%	624,764	641,994	3%
Zambia	2,000,824	2,544,290	27%	409,544	519,598	27%	281,508	341,630	21%
Rwanda	1,217,837	1,406,520	15%	297,005	343,131	16%	482,958	578,390	20%
Mozambique	2,327,815	1,631,058	-30%	445,118	337,433	-24%	914,518	649,370	-29%
Benin	789,883	802,597	2%	254,072	252,706	-1%	110,505	114,160	3%
Madagascar	1,307,384	1,016,841	-22%	274,533	247,902	-10%	229,240	113,493	-50%
Avg. Large Programs	*1,548,474*	*1,509,551*	*-1%*	*391,251*	*400,953*	*2%*	*440,582*	*406,506*	*-5%*
Ghana	570,572	553,954	-3%	205,230	205,935	0%	112,370	113,285	1%
Zimbabwe	334,746	365,425	9%	147,949	162,127	10%	167,600	183,315	9%
Mali	836,568	494,205	-41%	228,123	133,527	-41%	224,868	146,180	-35%
Senegal	708,999	514,833	-27%	204,159	130,170	-36%	150,465	98,010	-35%
Avg. Medium Programs	*612,721*	*482,104*	*-16%*	*196,365*	*157,940*	*-17%*	*163,826*	*135,198*	*-15%*

In Table YR2, Ethiopia, Zambia, Rwanda, Benin, and Zimbabwe increased the number of people protected from 2014 to 2015, with all of these countries except Benin also increasing the number of structures sprayed. Ghana protected fewer people while spraying very close to the same number of structures between 2014 and 2015. Mozambique, Madagascar, Mali, and Senegal all saw substantial (10 percent or greater) decreases in the number of people protected and the number of structures sprayed between 2014 and 2015.

TABLE YR3: YEAR-ON-YEAR COMPARISON OF UNIT COSTS

	People Protected			Structures Sprayed			Area Sprayed (100 m^2)		
Country	**2014**	**2015**	**Percent Change 2014-2015**	**2014**	**2015**	**Percent Change 2014-2015**	**2014**	**2015**	**Percent Change 2014-2015**
Ethiopia	$4.31	$5.17	20%	$10.64	$12.15	14%	$11.36	$13.34	17%
Zambia	$3.06	$3.75	22%	$14.97	$18.36	23%	$21.78	$27.92	28%
Rwanda	$6.41	$4.94	-23%	$26.27	$20.26	-23%	$16.15	$12.02	-26%
Mozambique	$2.12	$5.29	150%	$11.09	$25.59	131%	$5.40	$13.29	146%
Benin	$4.32	$4.17	-4%	$13.43	$13.23	-1%	$30.87	$29.29	-5%
Madagascar	$4.62	$4.71	2%	$22.02	$19.30	-12%	$26.37	$42.16	60%
Avg. Large Programs	*$4.14*	*$4.67*	*28%*	*$16.40*	*$18.15*	*22%*	*$18.65*	*$23.00*	*37%*
Ghana	$6.97	$7.17	3%	$19.38	$19.28	-1%	$35.40	$35.05	-1%
Zimbabwe	$13.09	$11.65	-11%	$29.61	$26.26	-12%	$26.14	$23.22	-11%
Mali	$6.23	$9.19	48%	$22.85	$34.02	49%	$23.18	$31.07	34%
Senegal	$5.60	$6.46	15%	$19.46	$25.54	31%	$26.40	$33.92	28%
Avg. Medium Programs	*$7.97*	*$8.62*	*14%*	*$22.83*	*$26.27*	*17%*	*$27.78*	*$30.81*	*13%*

In Table YR3, country unit costs decreased in 2015 compared to 2014 for all three unit costs presented for Rwanda, Benin, and Zimbabwe. In Madagascar, the cost per person protected and per area sprayed increased, while the cost per structure sprayed decreased from 2014 to 2015, and in Ghana, the cost per person protected increased while the cost per structure and area sprayed slightly decreased. Unit costs in Ethiopia and Mozambique increased across the two years, in association with the introduction of organophosphate insecticides, and in the case of Mozambique, smaller scale of operations. Unit costs increased in Mali and Senegal in association with smaller program size and greater (for Senegal) or complete (for Mali) use of organophosphate insecticide. In Zambia, both output and unit costs increased from 2014 to 2015, due to several factors: the hiring of 20 District Coordinators and a TCN entomologist; the move to a new office which is no longer shared with other projects; and door to door community mobilization, which was conducted for the first time.

A detailed discussion of the changes in each country program is included in the individual country chapters. Figure YR1 below illustrates the cost per 100 m² sprayed in 2012, 2013, 2014, and 2015, including the type of insecticide used in each year. With the exception of Zambia, cost per 100 m² sprayed in 2015 were the same or lower than in 2014 for countries that did not change the type of insecticide used (Rwanda, Benin, Ghana, and Zimbabwe). In Rwanda, cost per 100 m² sprayed approached the same level as in 2012, when pyrethroid insecticides were used, although the costs for insecticides in 2012 is based on the cost of insecticides procured (not used), which makes direct comparison difficult.

FIGURE YR1: YEAR-ON-YEAR COMPARISON OF COST PER AREA SPRAYED

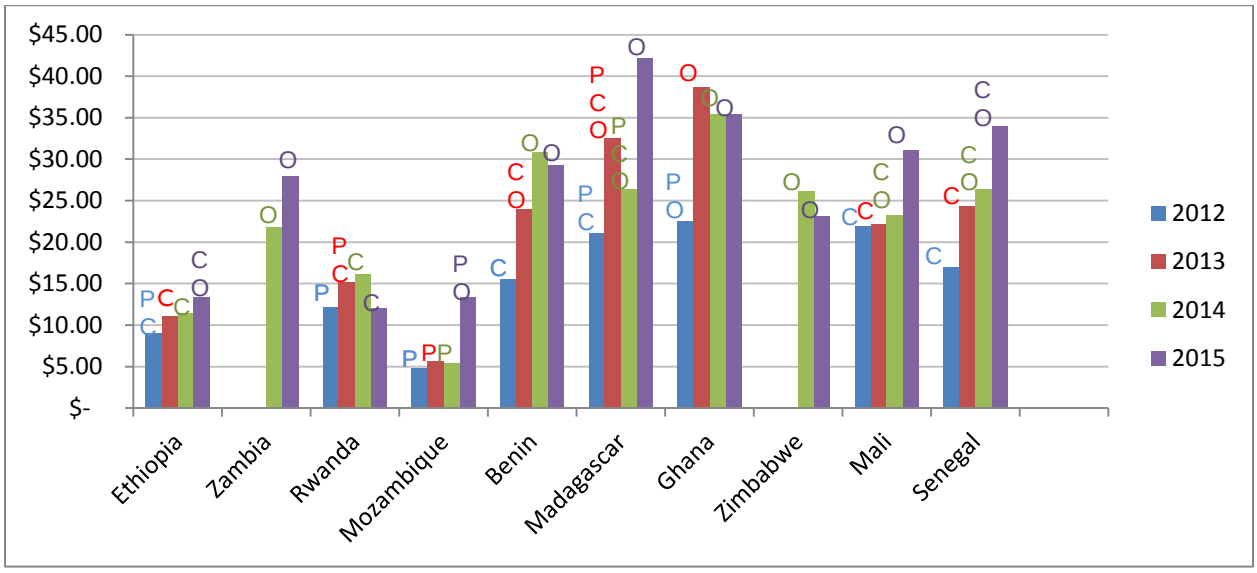


Table YR4 provides the cost per 100 m² sprayed for each country and a summary of average cost per 100 m² sprayed for various groups of country programs for 2014 and 2015, but is separated into two portions: one for insecticide costs and one for non-insecticide costs. For the non-insecticide portion of the cost per area sprayed, countries were grouped by program size, and the average unit cost was calculated (not weighted by the size of the program).

TABLE YR4: INSECTICIDE VERSUS NON-INSECTICIDE COST PER AREA SPRAYED

	Insecticide cost per 100 m² sprayed	Non-insecticide cost per 100 m² sprayed

Country/Average	2014	2015	Percent Change 2014-2015	2014	2015	Percent Change 2014-2015
Ethiopia	$4.58	$6.73	47%	$6.78	$6.61	-3%
Zambia	$12.05	$10.67	-11%	$9.73	$17.25	77%
Rwanda	$7.86	$5.20	-34%	$8.29	$6.82	-18%
Mozambique	$0.66	$5.49	736%	$4.74	$7.81	65%
Benin	$11.20	$10.46	-7%	$19.67	$18.84	-4%
Madagascar	$7.16	$11.81	65%	$19.21	$30.35	58%
Ghana	$10.39	$10.40	0%	$25.01	$24.65	-1%
Zimbabwe	$10.63	$10.65	0%	$15.51	$12.57	-19%
Mali	$9.34	$10.49	12%	$13.84	$20.58	49%
Senegal	$8.37	$9.70	16%	$18.03	$24.22	34%
Avg. Large Programs				$11.40	$14.61	28%
Avg. Medium Programs				$18.10	$20.51	13%
Avg. Carbamates	$7.86	$5.20	-34%	$8.29	$6.82	-18%
Avg. Mixed	$4.53	$7.30	61%	$9.85	$12.88	31%
Avg. Organophosphates	$10.13	$10.75	6%	$17.16	$20.71	21%

Countries that changed insecticides, or that changed the mix of insecticides used, all saw increases in the cost of insecticide used per 100 m^2 between 2014 and 2015 (Ethiopia, Mozambique, Madagascar, Mali, and Senegal). Among these countries, only Ethiopia increased the number of outputs (people protected, structures and area sprayed). Thus, Ethiopia saw a decrease in the non-insecticide costs per 100 m^2 sprayed over the period, although the non-insecticide costs decreased by $0.17 over the two years, while the insecticide cost increased by $2.15.

Five countries used the same insecticide in 2015 as in 2014. Among these, two countries saw little change in the cost of insecticides per 100 m^2 sprayed (Ghana and Zimbabwe). Rwanda, Zambia, and Benin saw a decrease in the cost of insecticides per 100 m^2 sprayed. These countries also ran IRS programs of similar or larger size in 2015 than in 2014. Thus, again with the exception of Zambia, the non-insecticide costs per 100 m^2 sprayed also tended to be similar between 2014 and 2015 (in Ghana), or lower (for Rwanda, Benin, and Zimbabwe). These patterns hold true when assessing the cost per structure sprayed as well.

The insecticide costs per 100 m^2 sprayed increased for countries using organophosphates, or mixing organophosphates with other insecticides. In the case of countries with programs using multiple insecticides, the increased cost reflects greater reliance on organophosphates. Generally, as discussed above, switching to organophosphates is associated with spraying fewer areas, and the non-insecticide cost per 100 m^2 sprayed increases as well. This drives the overall cost structures, as the non-insecticide cost per 100 m^2 sprayed and per structure sprayed increased from 2014 to 2015 for both large and medium sized programs, on average.

Table YR5 provides a summary of the changes in the costs, adjusted for inflation, for spray operations from 2012 to 2013, from 2013 to 2014, and from 2014 to 2015. Specific numbers are provided in each country chapter below. Additionally, Table YR5 provides the changes in the number of structures sprayed over the three time periods.

TABLE YR5: SUMMARY OF CHANGES IN SPRAY OPERATIONS COSTS AND STRUCTURES SPRAYED

Country	2012 to 2013		2013 to 2014		2014 to 2015	
	Change in spray operations cost	Change in number of structures sprayed	Change in spray operations cost	Change in number of structures sprayed	Change in spray operations cost	Change in number of structures sprayed
Ethiopia	33%	16%	-5%	5%	2%	6%
Zambia					118%	27%
Rwanda	56%	46%	-23%	-14%	1%	16%
Mozambique	-4%	-23%	35%	7%	18%	-24%
Benin	4%	11%	-1%	11%	-1%	-1%
Madagascar	708%	-8%	-22%	-20%	-40%	-10%
Ghana	-12%	-44%	4%	4%	-13%	0%
Zimbabwe					-10%	10%
Mali	31%	11%	-18%	0%	-29%	-41%
Senegal	0%	-33%	-25%	-1%	-37%	-36%

From 2014 to 2015, five of the ten countries (Mozambique, Benin, Madagascar, Mali, and Senegal) saw a decrease in the number of structures sprayed. Of these, Madagascar achieved a decrease in spray operations costs that was greater than the decrease in the number of structures sprayed (likely due to reduced transportation costs caused by no longer spraying in the Central Highlands), while Benin and Senegal saw a decrease in spray operations of the same order of magnitude as the decrease in the number of structures sprayed. In Mali, the decrease in spray operations costs was smaller, in percentage terms, than the decrease in the number of structures sprayed (implying higher spray operations costs per structure sprayed) (likely due to reduced economies of scale from spraying in fewer districts), while in Mozambique, the spray operations costs increased (likely due to increased costs to guarantee spray quality and coverage rates).

Ghana sprayed a similar number of structures between 2014 and 2015, while spray operations costs decreased by 13 percent. The other four countries (Ethiopia, Zambia, Rwanda, and Zimbabwe) all sprayed more structures in 2015 than in 2014. For three of these countries, the spray operations costs either decreased (Zimbabwe), or increased less, in percentage terms, than the number of structures sprayed (Ethiopia, and Rwanda). In Zambia, spray operations costs increased more than the number of structures sprayed, mainly due to the added cost of the door-to-door mobilization, which had not been conducted in prior years.

5. BENIN

5.1 BACKGROUND

TABLE BN1: BENIN QUICK FACTS

	2012	2013	2014	2015
Program Dates	Jan 10, 2012 – Dec 31, 2012	Jan 1, 2013 – Dec 31, 2013	Jan 1, 2014 – Dec 31, 2014	Jan 1, 2015 – Dec 31, 2015
Number of Districts	9	9	9	9
# Local Staff	13	13	13	14
Spray Start Date	May 14, 2012	May 20, 2013	May 4, 2014	April 30, 2015
# Spray Rounds	1	1	1	1
Insecticides Used	Carbamates	Carbamates Organophosphates	Organophosphates	Organophosphates
# Sachets & Bottles Used	50,842	50,242	44,202	45,664
# People Protected	762,146	694,729	789,883	802,597
# Structures Sprayed	206,295	228,951	254,072	252,706
# 100 Square Meters Sprayed	192,968	125,605	110,505	114,160

5.2 PROGRAM EXPENDITURES

This section will present an overview of Benin IRS program expenditures in 2015. Costs are organized by activity and cost category.

TABLE BN2: BENIN IRS PROGRAM CAPITAL AND RECURRENT EXPENDITURES, BY ACTIVITY AND COST CATEGORY

IRS Activity	Insecticide	Local Admin	Local Labor	Spray Commodities	Spray Operations	U.S. Labor & STTA	Grand Total	% of Total
Admin		216,401	277,306			108,789	**$ 602,496**	18.0%
Entomology			12,840		1,916	1,195	**$ 15,951**	0.5%
Environmental Compliance			73,912		26,884	13,139	**$ 113,934**	3.4%
Equipment Supplies			488	117,853		78	**$ 118,419**	3.5%
IEC			9,649			1,105	**$ 10,753**	0.3%
Insecticide	1,193,573		320			50	**$ 1,193,943**	35.7%
M&E			40,335		3,293	17,364	**$ 60,992**	1.8%
Post Spray			62,075		5,705	7,082	**$ 74,863**	2.2%

Spray Campaign			29,752		877,611	3,145	**$ 910,507**	27.2%
Spray Planning			132,086		90,898	19,019	**$ 242,003**	7.2%
Grand Total	**$ 1,193,573**	**$ 216,401**	**$ 638,763**	**$ 117,853**	**$ 1,006,307**	**$ 170,965**	**$ 3,343,863**	100.0%

Table BN2 displays the Benin IRS program total capital and recurrent expenditures from 2015. The first column lists the program activities as tracked by the PMI AIRS Project's financial systems, and the top row lists IRS program cost categories. The following figure illustrates the cost breakdown in the table.

FIGURE BN1: BENIN IRS PROGRAM ACTIVITY EXPENDITURES, BY COST CATEGORY

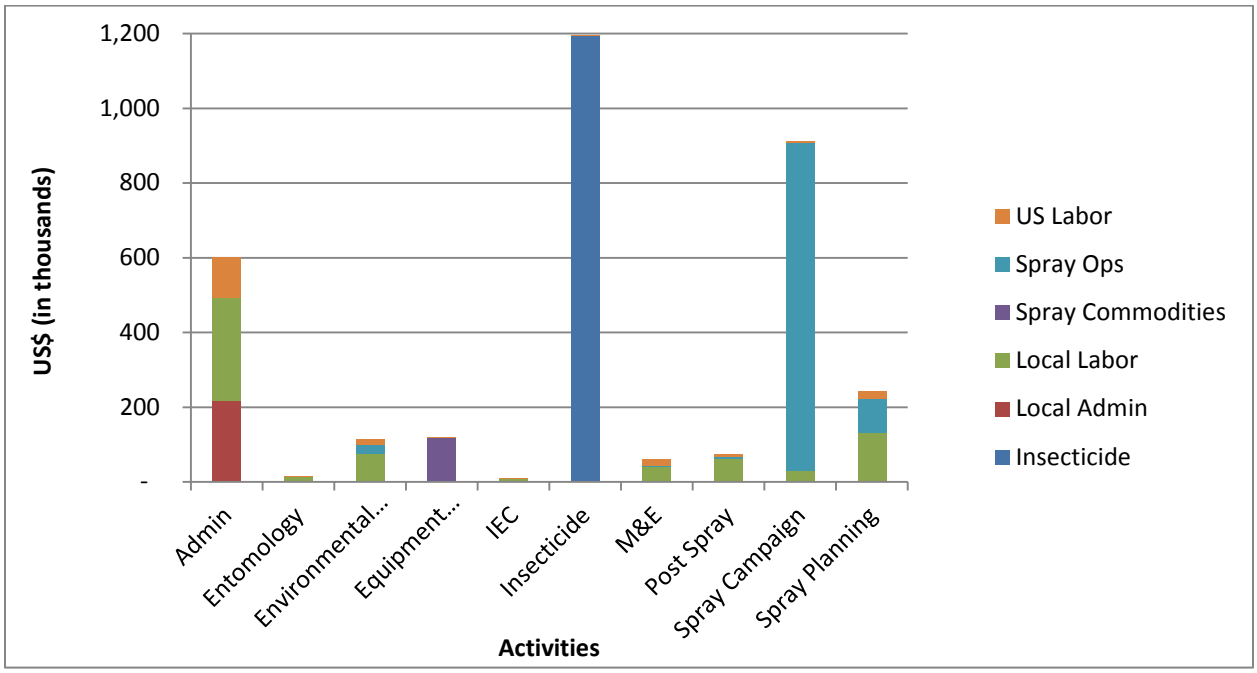


Figure BN1 shows the total capital and recurrent costs, but provides a depiction of cost distribution across program activities (X-axis), as well as the make-up of the activities' costs by cost category (legend). Insecticide is the most expensive IRS activity (35.7 percent of expenditures), followed by costs for the spray campaign (27.2 percent of expenditures) and local administrative activities (18.0 percent of expenditures). PMI AIRS Benin procured 50,580 bottles of insecticide, and used 45,664 (the cost of insecticide used is reflected in the figure above). About 64 percent of the total cost for administration consists of labor, both local and U.S.-based. Note that the 'U.S.-based Labor and STTA' expenditures are largely incurred under the administrative and M&E program activities (74 percent of US labor expenditures are in the two categories). Local administration, U.S. labor, and commodities costs are minimal compared to expenditures on insecticide, local labor, and spray operations.

5.3 Unit Cost Analysis

This section presents Benin IRS as unit costs: per person protected, per structure sprayed, and per area sprayed (in terms of 100 m^2).

TABLE BN3: BENIN UNIT COSTS

		Unit cost	
Cost per	Person protected	$	4.17
	Structure sprayed	$	13.23
	100 m^2 sprayed	$	29.29

5.4 COMPARISON BETWEEN THE LAST TWO YEARS

This section provides a comparison of the PMI AIRS Benin IRS program between 2014 and 2015, as implemented by the PMI AIRS Project. The comparison focuses on output measures, total expenditures, and unit costs.

TABLE BN4: BENIN IRS PROGRAM COMPARISON OF EXPENDITURES

Cost Category	2014 (Adjusted)	2015	Percentage Change (2014 to 2015)
Insecticide (used)	1,237,212	1,193,573	-4%
Local Admin	148,955	216,401	45.3%
Local Labor	689,801	638,763	-7.4%
Spray Operations	1,017,533	1,006,307	-1.1%
Commodities	168,686	117,853	-30.1%
U.S. Labor	148,759	170,965	14.9%
TOTAL	**$ 3,410,946**	**$ 3,343,863**	**-2.0%**

Table BN4, above, compares the year-on-year change in total program capital and recurrent expenditures. The total program cost decreased by 2.0 percent from 2014 to 2015, while spraying more area and protecting more people. However, when looking at the change in expenditures by cost category, reductions in net costs occurred mainly in three categories (local labor, commodities, and insecticides), while local administration accounted for the largest increase in costs.

The shorter timeframe adopted in 2014 for the spray campaign appears to continue to incur savings, with the costs for spray operations decreasing by over $11,000 between 2014 and 2015 (about 1.1 percent less than 2014 spray operation costs), while the costs for commodities decreased by over $50,000 between 2014 and 2015.

TABLE BN5: BENIN IRS PROGRAM COMPARISON OF OUTPUT MEASURES AND UNIT COSTS

	2014	2015	Percentage Change (2014 to 2015)
Output Measures			
People Protected	789,883	802,597	1.6%

Structures Sprayed	254,072	252,706	-0.5%
Area Sprayed (100 m^2)	110,505	114,160	3.3%
Unit Costs			
Per Person Protected	$ 4.32	$ 4.17	-3.5%
Per Structure Sprayed	$ 13.43	$ 13.23	-1.4%
Per Area Sprayed	$ 30.87	$ 29.29	-5.1%

Table BN5, above, compares the year-on-year change in Benin IRS program output measures and unit costs. Overall, in 2015, the program protected more people than in previous years, growing from 2014 by about 1.6 percent. While the number of structures sprayed declined from 2014 to 2015, the number of people per structure increased as did the average size of the structures sprayed (in 2014 the average size was 43.5 m^2 compared to 45.2 m^2 in 2015). Because the total program costs decreased more than the number of structures sprayed (while the number of people protected and area sprayed increased), the unit costs decreased for all three metrics presented in the table. For the cost per person protected and per structure sprayed, costs decreased by about 3.5 percent and 5.1 percent from 2014 to 2015 respectively.

TABLE BN6: YEAR ON YEAR CHANGES IN EFFICIENCY MEASURES

Efficiency measure	2014	2015	% Change from 2014 to 2015
Number of SOP days	17,760	18,353	3%
Number of structures sprayed	254,072	252,706	-1%
Structures sprayed per SOP per day	14.3	13.8	-4%
Spray operations cost per SOP Day	57.29	54.83	-4%
Spray operations and commodities cost per structure sprayed	9.54	9.17	-4%
Spray operations and commodities cost per structure sprayed (without insecticide)	4.67	4.45	-5%

Table BN6 displays various measures of implementation efficiency in the last two years. Of particular note is the change in the implementation model from 2013 to 2014 to hire more SOPs but for a shorter period of time, a model which was used again in 2015. In 2015, the number of SOPs-days increased by about 3 percent compared to 2014, while the number of structures sprayed decreased by about 1 percent, resulting in about 4 percent fewer structures sprayed per SOP per day than in 2014. As shown in Table BN5, however, the costs for spray operations, commodities, and insecticides also all decreased between 2014 and 2015. The decrease in the costs of these categories more than offset the decreased productivity (in terms of structures sprayed per SOP per day) of SOPs. Thus, spray operations, commodities, and insecticide costs decreased by about 4 percent per structure sprayed between 2014 and 2015.

6. ETHIOPIA

6.1 BACKGROUND

TABLE ET1: ETHIOPIA QUICK FACTS

	2012	2013	2014	2015
Program Dates	Feb 1, 2012 – Dec 31, 2012	Jan 1, 2013 – Dec 31, 2013	Jan 1, 2014 – Dec 31, 2014	Jan 1, 2015 – Dec 31, 2015
Number of Districts	36	36	36	36
# Local Staff	19	21	22	21
Spray Start Date	June 15, 2012 August 15, 2012	August 15, 2013	August 13, 2014	July 21, 2015 (organophosphates) August 11, 2015 (carbamates)
# Spray Rounds	2	1	1	1
Insecticides Used	Pyrethroids Carbamates	Carbamates	Carbamates	Carbamates Organophosphates
# Sachets & Bottles Used	262,167	308,721	312,382	320,997
# People Protected	1,506,273	1,629,958	1,647,099	1,655,997
# Structures Sprayed	547,421	635,528	667,236	704,945
# 100 Square Meters Sprayed*	524,334	617,442	624,764	641,994

* Reverse calculation using number of insecticide sachets/bottles used during campaign multiplied by the average of 200 m^2 estimated to be sprayed by one sachet and divided by the number of structures sprayed.

6.2 PROGRAM EXPENDITURES

This section will present an overview of Ethiopia IRS program expenditures in 2015. Costs are organized by activity and cost category.

TABLE ET2: ETHIOPIA IRS PROGRAM CAPITAL AND RECURRENT EXPENDITURES, BY ACTIVITY AND COST CATEGORY

IRS Activity	Insecticide	Local Admin	Local Labor	Spray Commodities	Spray Operations	U.S. Labor & STTA	Grand Total	% of Total
Admin		210,154	533,363			195,181	**$ 938,698**	10.8%
Entomology			104,421		182,316	10,315	**$ 297,051**	3.7%
Environmental Compliance			102,628		85,586	70,898	**$ 259,113**	5.0%
Equipment Supplies				544,720		32	**$ 544,753**	5.2%
IEC							**$ 0***	0.0%

Insecticide**	4,320,474						**$ 4,320,474**	50.4%
M&E			50,152		35,980	70,770	**$ 156,902**	1.7%
Post Spray					20,834		**$ 20,834**	0.4%
Spray Campaign			66,805		1,569,089	8,930	**$ 1,644,824**	18.0%
Spray Planning			37,934		293,854	11,741	**$ 343,530**	4.9%
Grand Total	**$ 4,320,474**	**$ 210,154**	**$ 895,303**	**$ 544,720**	**$ 2,187,660**	**$ 367,867**	**$ 8,565,181**	100%

* PMI AIRS Ethiopia delegated the mobilization responsibility to the government.
**Includes cost of insecticides procured through PMI but not as part of the PMI AIRS project.

Table ET2 displays the Ethiopia IRS program total capital and recurrent expenditures from 2015. The first column lists the program activities as tracked by the PMI AIRS project financial systems, and the top row lists IRS program cost categories. Further explanation of these designations is given in the 2014 report (Johns 2015)[8]. The following figure illustrates the cost breakdown in the table.

FIGURE ET1: ETHIOPIA IRS PROGRAM ACTIVITY EXPENDITURES, BY COST CATEGORY

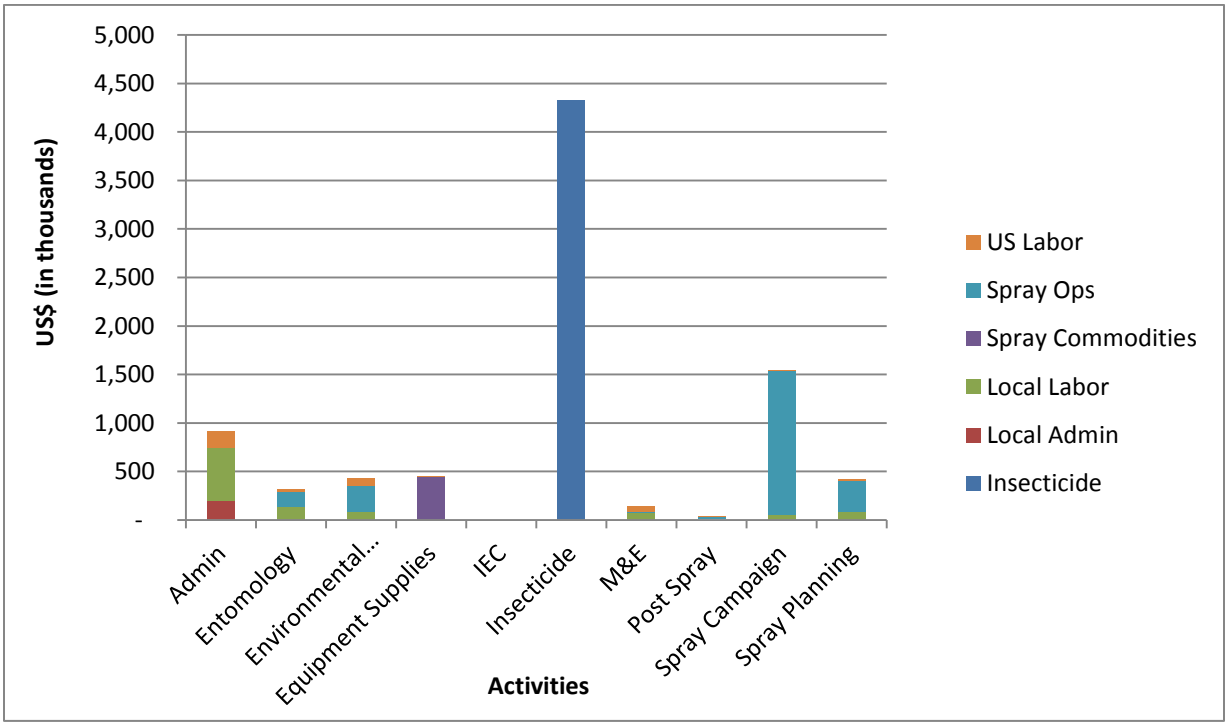


Figure ET1 shows the total capital and recurrent costs, but provides a depiction of cost distribution across program activities (X-axis), as well as the make-up of the activities' costs by cost category (legend). Insecticides represented the majority of the total costs at 50.4 percent of costs. The cost of insecticide substantially increased in 2015 due to the introduction of Actellic CS in 8 of the 36 districts. Spray campaign costs and administration were the next two largest categories of costs, representing 18.0 and 10.8 percent of costs, respectively. PMI AIRS procured 87,372 bottles of organophosphate insecticides. About 79 percent of the total cost for administration consists of labor, both local and U.S.-

[8] Available at http://www.pmi.gov/docs/default-source/default-document-library/implementing-partner-reports/africa-indoor-residual-spraying-project-pmi-irs-country-programs-2014-comparative-cost-analysis.pdf?sfvrsn=4.

based. Local administration, U.S. labor, and commodities costs are minimal compared to expenditures on insecticide, local labor, and spray operations.

6.3 Unit Cost Analysis

This section presents Ethiopia IRS as unit costs: per person protected, per structure sprayed, and per area sprayed (in terms of 100 m^2).

TABLE ET3: ETHIOPIA UNIT COSTS

			Unit costs
Cost per	Person protected	$	5.17
	Structure sprayed	$	12.15
	100 m^2 sprayed	$	13.34

6.4 Comparison between the last two years

This section provides a comparison of the Ethiopia IRS program between 2014 and 2015, as implemented by the PMI AIRS project. The comparison focuses on output measures, total expenditures, and unit costs.

TABLE ET4: ETHIOPIA IRS PROGRAM COMPARISON OF EXPENDITURES

Cost Category	2014 (Adjusted)	2015	Percentage Change (2014 to 2015)
Insecticide	2,859,243	4,320,474	51.1%
Local Admin	211,721	193,374	-8.7%
Local Labor	901,978	1,002,201	11.1%
Spray Operations	2,203,971	2,246,244	1.9%
Commodities	548,782	443,446	-19.2%
U.S. Labor	370,610	359,442	-3.0%
TOTAL	**$ 7,096,304**	**$ 8,565,181**	**20.7%**

Table ET4 compares the year-on-year change in total program capital and recurrent expenditures. The total program cost increased by 20.7 percent from 2014 to 2015, representing an increase in the total annual cost of about $1,469,000. In terms of the total increase between 2014 and 2015, insecticides represented the majority of the increase ($1,461,231), reflecting the start of the use of organophosphate class insecticides.

When the insecticide is excluded from the year-on-year comparison, costs were 0.2 percent greater in 2015 than in 2014. Costs decreased for: (i) spray commodities by about $105,000, (ii) local administration by about $18,000 and (iii) US labor by about $11,000 between the years, but this was

offset by an increase in the cost of local labor of about $100,000 and in spray operations of about $42,000.

TABLE ET5: ETHIOPIA IRS PROGRAM COMPARISON OF OUTPUT MEASURES AND UNIT COSTS

	2014	2015	Percentage Change (2014 to 2015)
Output Measures			
People Protected	1,647,099	1,655,997	0.5%
Structures Sprayed	667,236	704,945	5.7%
Area Sprayed (100 m^2)	624,764	641,994	2.8%
Unit Costs			
Per Person Protected	$ 4.31	$ 5.17	20.1%
Per Structure Sprayed	$ 10.64	$ 12.15	14.2%
Per Area Sprayed	$ 11.36	$ 13.34	17.5%

Table ET5 compares the year-on-year change in Ethiopia IRS program output measures and unit costs. In 2015, the program achieved higher coverage on all three indicators used in Table ET5 than in 2014. Between 2014 and 2015, the number of people protected increased 0.5 percent, the number of structures increased 5.7 percent, while the area sprayed increased by 2.8 percent.

Unit costs were higher per person protected, structure sprayed, and area sprayed in 2015 than 2014, reflecting the increase in the costs of insecticides.

TABLE ET6: YEAR ON YEAR CHANGES IN EFFICIENCY MEASURES

Efficiency measure	2014	2015	% Change from 2014 to 2015
Number of SOP days	39,481	39,564	<1%
Number of structures sprayed	667,236	704,945	6%
Structures sprayed per SOP per day	16.9	17.8	5%
Spray operations cost per SOP Day	55.82	56.77	2%
Spray operations and commodities cost per structure sprayed	8.41	9.94	18%
Spray operations and commodities cost per structure sprayed (without insecticide)	4.13	3.82	-8%

Table ET6 displays various measures of implementation efficiency in the last two years. The number of SOP-days decreased from 2014 to 2015. In 2015, however, about 6 percent more structures were sprayed than in 2014. However, spray operations costs increased, resulting in an increase in the cost per

SOP per day by 2 percent from 2014 to 2015. The increased productivity of SOPs and lower commodity costs offset the increased costs of spray operations, and the spray operations and commodity cost per structure sprayed fell by 8 percent from 2014 to 2015 to $3.82 per structure sprayed. The introduction of organophosphates in some areas offset these cost reductions, and cost of spray operations, commodities, and insecticides per structure sprayed increased 18 percent.

7. GHANA

7.1 BACKGROUND

TABLE GH1: GHANA QUICK FACTS

	2012	2013	2014	2015
Program Dates	Feb 10, 2012 – Dec 31, 2012	Jan 1, 2013 – Dec 31, 2013	Jan 1, 2014 – Dec 31, 2014	Jan 1, 2015 – Dec 31, 2015
Number of Districts	9	4	4	5*
# Local Staff	25	23	22	23
Spray Start Date	April 23, 2012	April 29, 2013	April 14, 2014	April 14, 2015
# Spray Rounds	1	1	1	1
Insecticides Used	Pyrethroids Organophosphates	Organophosphates	Organophosphates	Organophosphates
# Sachets & Bottles Used	77,288	43,284	44,948	45,314
# People Protected	941,240	534,060	570,572	553,954
# Structures Sprayed	355,278	197,655	205,230	205,935
# 100 Square Meters Sprayed	193,220	108,210	112,370	113,285

* Although the same areas were sprayed in 2015 as in 2014, the number of districts sprayed increased due to a reorganization of the districts in Ghana.

7.2 PROGRAM EXPENDITURES

This section will present an overview of Ghana IRS program expenditures in 2015. Costs are organized by activity and cost category.

TABLE GH2: GHANA IRS PROGRAM CAPITAL AND RECURRENT EXPENDITURES, BY ACTIVITY AND COST CATEGORY

IRS Activity	Insecticide	Local Admin	Local Labor	Spray Commodities	Spray Operations	U.S. Labor & STTA	Grand Total	% of Total
Admin		392,712	492,121			171,936	**$ 1,056,769**	26.6%
Entomology			96,553		242,304	22,342	**$ 361,199**	9.1%
Environmental Compliance			34,189		35,396	22,589	**$ 92,173**	2.3%
Equipment Supplies			429	110,672		300	**$ 111,401**	2.8%
IEC			15,347		80,836	5,647	**$ 101,830**	2.6%
Insecticide	1,178,488						**$ 1,178,488**	29.7%
M&E			32,629		22,453	72,427	**$ 127,509**	3.2%

Post Spray			76,978		16,930	21,653	**$ 115,561**	2.9%
Spray Campaign			22,451	7,813	658,406	5,582	**$ 694,251**	17.5%
Spray Planning			27,788		90,451	13,157	**$ 131,397**	3.3%
Grand Total	**$ 1,178,488**	**$ 392,712**	**$ 798,485**	**$ 118,485**	**$ 1,146,775**	**$ 335,633**	**$ 3,970,577**	100.0%

Table GH2 displays the Ghana IRS program total capital and recurrent expenditures from 2015. The first column lists the program activities as tracked by the PMI AIRS project financial systems, and the top row lists IRS program cost categories. Further explanation of these designations is given in the 2014 report (Johns 2015)[9]. Figure GH1 illustrates the cost breakdown in the table.

FIGURE GH1: GHANA IRS PROGRAM ACTIVITY EXPENDITURES, BY COST CATEGORY

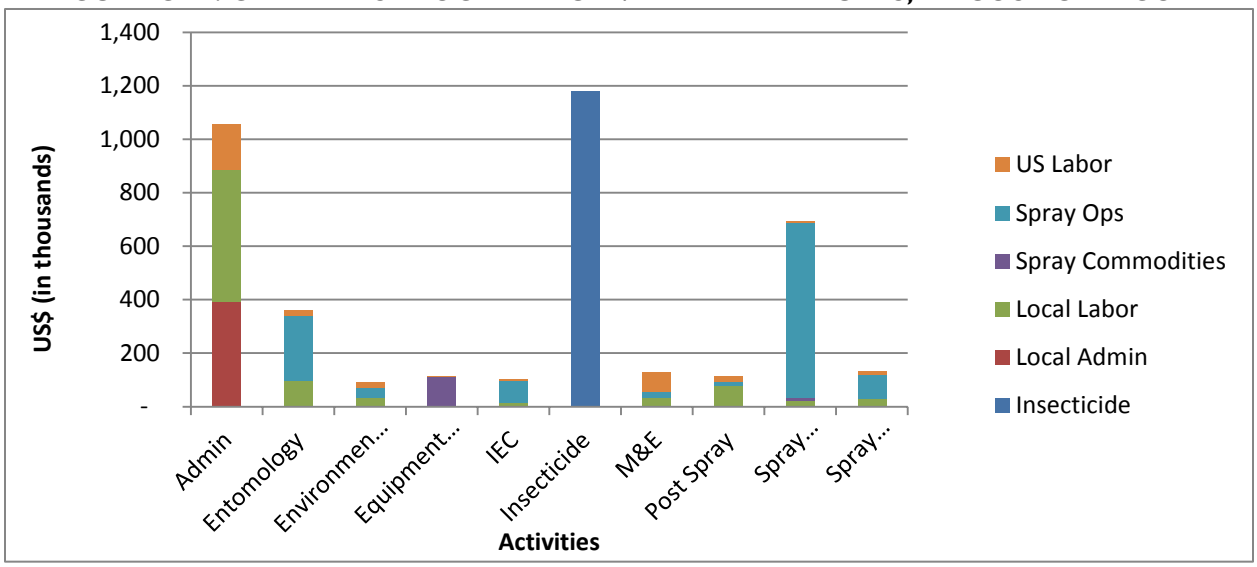


Figure GH1 shows the total capital and recurrent costs, but provides a depiction of cost distribution across program activities (X-axis), as well as the make-up of the activities' costs by cost category (legend). Costs for insecticides, administration, and the spray campaign constitute over 73 percent of costs (26.6, 29.7 and 17.5 percent of total costs, respectively). PMI AIRS procured 52,928 bottles of Actellic CS, and used 45,314 bottles; the cost for the latter is included here. About 63 percent of the total cost for administration consists of labor, both local and U.S.-based. Local administration, U.S. labor, and commodities costs are minimal compared to expenditures on insecticide, local labor, and spray operations.

7.3 Unit Cost Analysis

This section presents Ghana IRS expenditures as unit costs: per person protected, per structure sprayed, and per area sprayed (in terms of 100 m^2).

[9] Available at http://www.pmi.gov/docs/default-source/default-document-library/implementing-partner-reports/africa-indoor-residual-spraying-project-pmi-irs-country-programs-2014-comparative-cost-analysis.pdf?sfvrsn=4.

TABLE GH3: GHANA UNIT COSTS

			Unit costs
	Person protected	$	7.17
Cost per	**Structure sprayed**	$	19.28
	100 m^2 sprayed	$	35.05

When calculating the total unit cost using the estimated area sprayed, entomology, environmental compliance, and M&E activities make up 14.6 percent of the unit cost.

7.4 COMPARISON BETWEEN THE LAST TWO YEARS

This section provides a comparison of the Ghana IRS program between 2014 and 2015, as implemented by the PMI AIRS project. The comparison focuses on output measures, total expenditures, and unit costs. 2014 expenditures, excluding insecticides, have been adjusted to real 2015 U.S. dollars to allow for a more accurate comparison.

TABLE GH4: GHANA IRS PROGRAM COMPARISON OF EXPENDITURES

Cost Category	2014 (Adjusted)	2015	Percentage Change (2014 to 2015)
Insecticide	1,167,655	1,178,488	0.9%
Local Admin	307,662	392,712	27.6%
Local Labor	792,917	798,485	0.7%
Spray Operations	1,323,144	1,146,775	-13.3%
Commodities	85,586	118,485	38.4%
U.S. Labor	301,221	335,633	11.4%
TOTAL	**$ 3,978,184**	**$ 3,970,577**	**-0.2%**

Table GH4 compares the year-on-year change in total program capital and recurrent expenditures. It should be noted that while Ghana is experiencing inflation rates over 14 percent per year, this inflation has been more than mediated by changes in the exchange rate (one dollar in 2015 would buy about 44 percent more Ghanaian Cedis than in 2014). This means that costs for 2014 in Table GH4 are lower than the nominal amount spent in that year. In situations of high inflation and currency instability, the ability to adjust costs across years is likely to contain at least some inaccuracy, which should be borne in mind for the discussions below.

The total program cost decreased by 0.2 percent from 2014 to 2015, representing a decrease in the total annual cost of about $7,607. Reductions in costs from 2014 to 2015 were attained for spray operations, which amounted to a decrease in costs of over $170,000. Cost increased for the same period for all other categories; the largest increases in both percentage increase and total amount of increase were for administration (27.6 percent increase of over $85,000), US labor (11.4 percent increase of over $34,000), and commodities (38.4 percent increase of under $33,000), which were mainly due to the move to a new, larger office in Tamale and the procurement of three new vehicles, as well as to an increase in the payment of temporary staff in 2015.

TABLE GH5: GHANA IRS PROGRAM COMPARISON OF OUTPUT MEASURES AND UNIT COSTS

	2014	2015	Percentage Change (2014 to 2015)
Output Measures			
People Protected	570,572	553,954	-2.9%
Structures Sprayed	205,230	205,935	0.3%
Area Sprayed (100 m^2)	112,370	113,285	0.8%
Unit Costs			
Per Person Protected	$ 6.97	$ 7.17	2.8%
Per Structure Sprayed	$ 19.38	$ 19.28	-0.5%
Per Area Sprayed	$ 35.40	$ 35.05	-1.0%

Table GH5 compares the year-on-year change in Ghana IRS program output measures and unit costs. In 2015, the program sprayed roughly the same number of structures and area as in 2014 (the change is less than 1 percent from 2014 to 2015), but protected 2.9 percent fewer people. This indicates that in 2015 there were fewer people per structure sprayed than in 2014.

Because the number of people protected decreased by 2.9% from 2014 to 2015 while total costs only decreased by 0.2%, the cost per person protected increased from $6.97 to $7.17 (2.8 percent) across the two years. The decrease in total costs from 2014 to 2015 and the increase in the number of structures sprayed resulted in lower costs per structure sprayed in 2015 than in 2014. The increase in the area sprayed and the decrease in total costs also resulted in a lower cost per area sprayed in 2015 than in 2014.

TABLE GH6: YEAR ON YEAR CHANGES IN EFFICIENCY MEASURES

Efficiency measure	2014	2015	% Change from 2014 to 2015
Number of SOP days	13,183	11,611	-12%
Number of structures sprayed	205,230	205,935	0.3%
Structures sprayed per SOP per day	15.6	17.7	14%
Spray operations cost per SOP Day	100.37	98.77	-2%
Spray operations and commodities cost per structure sprayed	12.55	11.87	-5%
Spray operations and commodities cost per structure sprayed (without insecticide)	6.86	6.14	-10%

Table GH6 displays various measures of implementation efficiency in the last two years. The number of SOP-days used for the campaign in 2015 was lower than in 2014 by 12 percent. While the number of SOP-days declined, the number of structures sprayed increased by 0.3 percent from 2014 to 2015, indicating the number of structures sprayed per SOP per day increased by 14 percent. Further the cost of spray operation declined in total from 2014 to 2015, and the spray operations cost per SOP per day was under $100 in 2015. Thus, the spray operations and commodities cost per structure sprayed was 10 percent lower in 2015 than in 2014. When including the costs of spray operations, commodities, and insecticide in the costs per structure sprayed, 2015 again had lower costs than in 2014.

8. MADAGASCAR

8.1 BACKGROUND

TABLE MG1: MADAGASCAR QUICK FACTS

	2012	2013	2014	2015
Program Dates	Aug 15, 2012 – April 30, 2013	May 1, 2013 – April 30, 2014	May 1, 2014 – April 30, 2015	April 1, 2015 – March 31, 2016
Number of Districts	2[10]	2[10]	5[11]	4
# Local Staff	15	34	37	33
Spray Start Date				
Central Highlands	Nov 26, 2012	Nov 18, 2013	Nov 3, 2014	
Southern Madagascar	February 4, 2013	January 20, 2014		
East Coast			Sept 8, 2014	Aug 31, 2015
Southeast				Aug 3, 2015
# Spray Rounds	1	1	1	1
Insecticides Used	Carbamates Pyrethroids	Carbamates Pyrethroids Organophosphates	Carbamates Pyrethroids Organophosphates	Organophosphates
# Sachets & Bottles Used	88,567	79,594	91,696	45,397
# People Protected	1,781,990	1,588,138	1,307,384	1,016,841
# Structures Sprayed	371,391	343,470	274,533	247,902
# 100 Square Meters Sprayed	221,418	198,985	229,240	113,493

8.2 PROGRAM EXPENDITURES

This section will present an overview of Madagascar IRS program expenditures in 2015. Costs are organized by activity and cost category.

[10] Focalized spraying in 40 communes
[11] Blanket spraying in 3 districts and focalized spraying in 40 communes in the two remaining districts

TABLE MG2: MADAGASCAR IRS PROGRAM CAPITAL AND RECURRENT EXPENDITURES, BY ACTIVITY AND COST CATEGORY

IRS Activity	Insecticide	Local Admin	Local Labor	Spray Commodities	Spray Operations	U.S. Labor & STTA	Grand Total	% of Total
Admin		449,991	579,448			217,729	**$ 1,247,169**	26.1%
Entomology			139,998		229,427	75,104	**$ 444,529**	9.3%
Environmental Compliance			15,553		51,223	10,034	**$ 76,810**	1.6%
Equipment Supplies				290,489			**$ 290,489**	6.1%
IEC					23,093		**$ 23,093**	0.5%
Insecticide	1,339,821						**$ 1,339,821**	28.0%
M&E			31,652		83,078	70,394	**$ 185,124**	3.9%
Post Spray			38,937		39,386	16,926	**$ 95,249**	2.0%
Spray Campaign			19,953		619,337	7,115	**$ 646,405**	13.5%
Spray Planning			77,809		337,949	20,378	**$ 436,136**	9.1%
Grand Total	**$ 1,339,821**	**$ 449,991**	**$ 903,350**	**$ 290,489**	**$ 1,383,493**	**$ 417,680**	**$ 4,784,825**	100.0%

Table MG2 displays the Madagascar IRS program total capital and recurrent expenditures from 2015. The first column lists the program activities as tracked by the PMI AIRS Project's financial systems, and the top row lists IRS program cost categories. The following figure illustrates the cost breakdown in the table.

FIGURE MG1: MADAGASCAR IRS PROGRAM ACTIVITY EXPENDITURES, BY COST CATEGORY

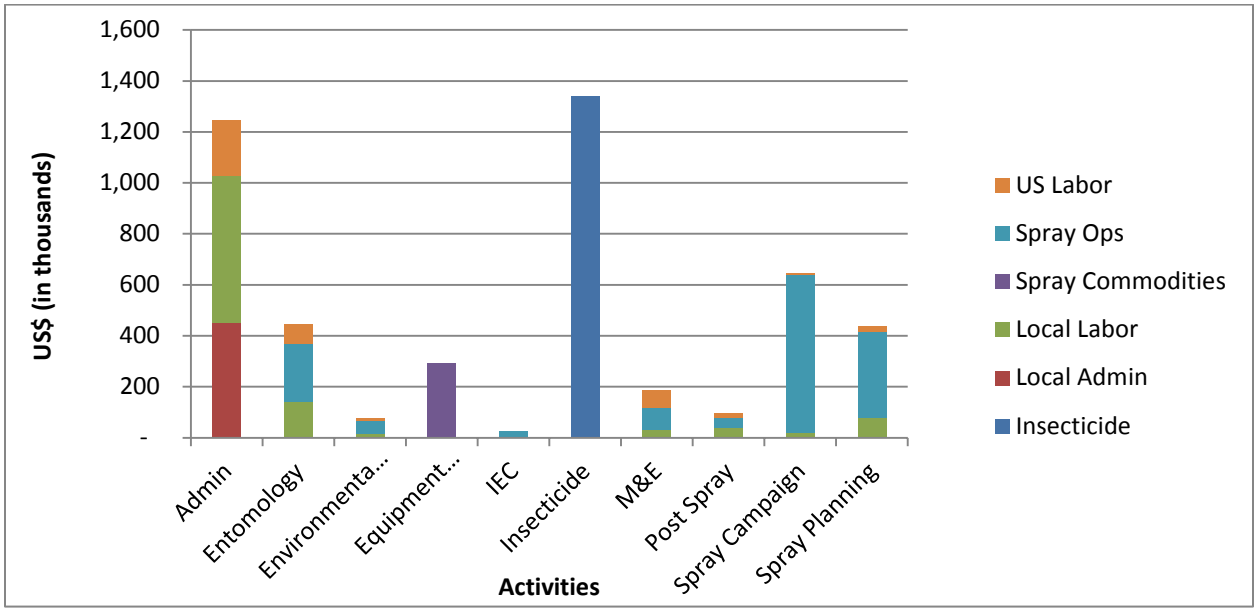


Figure MG1 shows the total capital and recurrent costs, but provides a depiction of cost distribution across program activities (X-axis), as well as the make-up of the activities' costs by cost category (legend). Insecticides and local administration were the two most expensive IRS activities (constituting 28.0 percent and 26.1 percent of expenditures, respectively), followed by spray campaign costs (13.5 percent of expenditures). PMI AIRS Madagascar procured 40,632 bottles of Actellic CS, and used 45,397 organophosphate bottles, the costs of the latter are reflected here. About 63.9 percent of the total cost for administration consists of labor, both local and U.S.-based. Local administration, U.S. labor, and commodities costs are minimal compared to expenditures on insecticide, local labor, and spray operations.

8.3 Unit Cost Analysis

This section presents Madagascar IRS expenditures as unit costs: per person protected, per structure sprayed, and per area sprayed (in terms of 100 m^2).

TABLE MG3: MADAGASCAR UNIT COSTS

		Unit costs
Person protected	$	4.71
Cost per Structure sprayed	$	19.30
100 m^2 sprayed	$	42.16

Entomology, environmental compliance, and M&E activities make up 14.8 percent of the unit cost.

8.4 Comparison between the last two years

This section provides a comparison of the PMI AIRS Madagascar IRS program between 2014 and 2015, as implemented by the project. The comparison focuses on output measures, total expenditures, and unit costs.

TABLE MG4: MADAGASCAR IRS PROGRAM COMPARISON OF EXPENDITURES

Cost Category	2014 (Adjusted)	2015	Percentage Change (2014 to 2015)
Insecticide	1,640,563	1,339,821	-18.3%
Local Admin	600,916	449,991	-25.1%
Local Labor	788,338	903,350	14.6%
Spray Operations	2,290,819	1,383,493	-39.6%
Commodities	290,714	290,489	-0.1%
U.S. Labor	433,819	417,680	-3.7%
TOTAL	**$ 6,045,169**	**$ 4,784,825**	**-20.8%**

Table MG4, above, compares the year-on-year change in total program capital and recurrent expenditures. The total program cost decreased by 20.8 percent from 2014 to 2015. The only category of expenditures with any increase from 2014 to 2015 was local labor, where costs increased by about $115,000 (14.6 percent).

The largest decrease in costs between 2014 and 2015 was for spray operations, which declined 39.6 percent (about $907,000). Insecticides decreased the second most between 2014 and 2015, in terms of net decrease, with costs for insecticide decreasing by about $301,000 (18.3 percent of 2014 costs). Together, decreases in spray operations and insecticide costs account for almost 88 percent of all cost decreases between 2014 and 2015.

TABLE MG5: MADAGASCAR IRS PROGRAM COMPARISON OF OUTPUT MEASURES AND UNIT COSTS

	2014	2015	Percentage Change (2014 to 2015)
Output Measures			
People Protected	1,307,384	1,016,841	-22.2%
Structures Sprayed	274,533	247,902	-9.7%
Area Sprayed (100 m^2)	229,240	113,493	-50.5%
Unit Costs			
Per Person Protected	$ 4.62	$ 4.71	1.8%
Per Structure Sprayed	$ 22.02	$ 19.30	-12.3%
Per Area Sprayed	$ 26.37	$ 42.16	59.9%

Table MG5 compares the year-on-year change in Madagascar IRS program output measures and unit costs. Overall, in 2015, the program sprayed the fewest structures, protected the fewest people, and sprayed the lowest amount of area of the two years presented. While the number of structures sprayed declined by 9.7 percent from 2014 to 2015, the number of people protected declined by 22.2 percent over the same period, indicating fewer people per structure in 2015 as compared to 2014. Additionally, the area sprayed declined by over 50 percent, which is likely due to the smaller structures in the Southeast Coast compared to the Central Highlands. Total program costs decreased by 20.3 percent, while the number of structures sprayed decreased by 9.7 percent between 2014 and 2015. Thus, the cost per structure sprayed decreased by 12.3 percent between the two years. The decrease in the number of people protected (22.2 percent) was larger than the decrease in the program costs between 2014 and 2015, indicating that the cost per person protected increased by 1.8 percent between the two years. The cost per area sprayed increased from $26.37 in 2014 to $42.16 in 2015, an increase of 59.9 percent.

TABLE MG6: YEAR ON YEAR CHANGES IN EFFICIENCY MEASURES

Efficiency measure	2014	2015	% Change from 2014 to 2015
Number of SOP days	19,483	17,884	-8%
Number of structures sprayed	274,533	247,902	-10%
Structures sprayed per SOP per day	14.1	13.9	-2%
Spray operations cost per SOP Day	117.58	77.36	-34%

Spray operations and commodities cost per structure sprayed	15.38	12.16	-21%
Spray operations and commodities cost per structure sprayed (without insecticide)	9.40	6.75	-28%

Table MG6 displays various measures of implementation efficiency in the last two years. It should be noted that the geographic areas sprayed changed in 2014 and 2015, and thus there may be changes in access and structure size that affected the efficiency measures across the years. In 2015, there was an 8 percent decrease in total SOP days employed compared to 2014, which was accompanied by 10 percent fewer structures sprayed, resulting in about 13.9 structures sprayed per SOP per day (2 percent less than in 2014). However, the spray operation cost per SOP per day decreased by about 34 percent from 2014 to 2015, reflecting the fact that total spray operation costs declined over the two years by a larger amount than the decrease in the number of SOP-days employed. Thus, spray operations and commodity costs per structure sprayed decreased by 28 percent despite the fewer structures sprayed per SOP per day. When including insecticides, commodities, and spray operations cost, the cost per structure sprayed decreased from $15.38 in 2014 to $12.16 in 2015, a decrease of about 21 percent.

9. MALI

9.1 BACKGROUND

TABLE ML1: MALI QUICK FACTS

	2012	2013	2014	2015
Program Dates	Feb 1, 2012 – Dec 31, 2012	Jan 1, 2013 – Dec 31, 2013	Jan 1, 2014 – Dec 31, 2014	Jan 1, 2015 – Dec 31, 2015
Number of Districts	3	3	3	2
# Local Staff	14	18	18	22
Spray Start Date	July 23, 2012	August 1, 2013	July 15, 2014 (Bla and Baroueli); August 11, 2014 (Koulikoro)	July 1, 2015
# Spray Rounds	1	1	1	1
Insecticides Used	Carbamates	Carbamates	Carbamates Organophosphates	Organophosphates
# Sachets & Bottles Used	77,187	93,435	89,947	58,472
# People Protected	762,146	850,104	836,568	494,205
# Structures Sprayed	206,295	228,985	228,123	133,527
# 100 Square Meters Sprayed	192,968	233,588	224,868	146,180

9.2 PROGRAM EXPENDITURES

This section will present an overview of Mali IRS program expenditures in 2015. Costs are organized by activity and cost category.

TABLE ML2: MALI IRS PROGRAM CAPITAL AND RECURRENT EXPENDITURES, BY ACTIVITY AND COST CATEGORY

IRS Activity	Insecticide	Local Admin	Local Labor	Spray Commodities	Spray Operations	U.S. Labor & STTA	Grand Total	% of Total
Admin		427,247	659,671			207,993	**$ 1,294,912**	28.5%
Entomology			68,955		126,912	26,690	**$ 222,557**	4.9%
Environmental Compliance			34,021		49,311	8,499	**$ 91,831**	2.0%
Equipment Supplies			11,997	172,735		1,086	**$ 185,818**	4.1%
IEC			1,818		302,713	175	**$ 304,706**	6.7%
Insecticide	1,533,373		5,601			551	**$ 1,539,524**	33.9%

M&E			50,722		18,056	28,064	**$ 96,842**	2.1%
Post Spray			27,092		54,768	1,076	**$ 82,937**	1.8%
Spray Campaign			27,401		638,868	1,227	**$ 667,495**	14.7%
Spray Planning			25,366		28,436	1,593	**$ 55,395**	1.2%
Grand Total	**$ 1,533,373**	**$ 427,247**	**$ 912,644**	**$ 172,735**	**$ 1,219,064**	**$ 276,953**	**$ 4,542,017**	100.0%

Table ML2 displays the Mali IRS program total capital and recurrent expenditures from 2015. The first column lists the program activities as tracked by the PMI AIRS project financial systems, and the top row lists IRS program cost categories. Further explanation of these designations is given in the 2014 report (Johns 2015)[12]. The following figure illustrates the cost breakdown in the table.

FIGURE ML1: MALI IRS PROGRAM ACTIVITY EXPENDITURES, BY COST CATEGORY

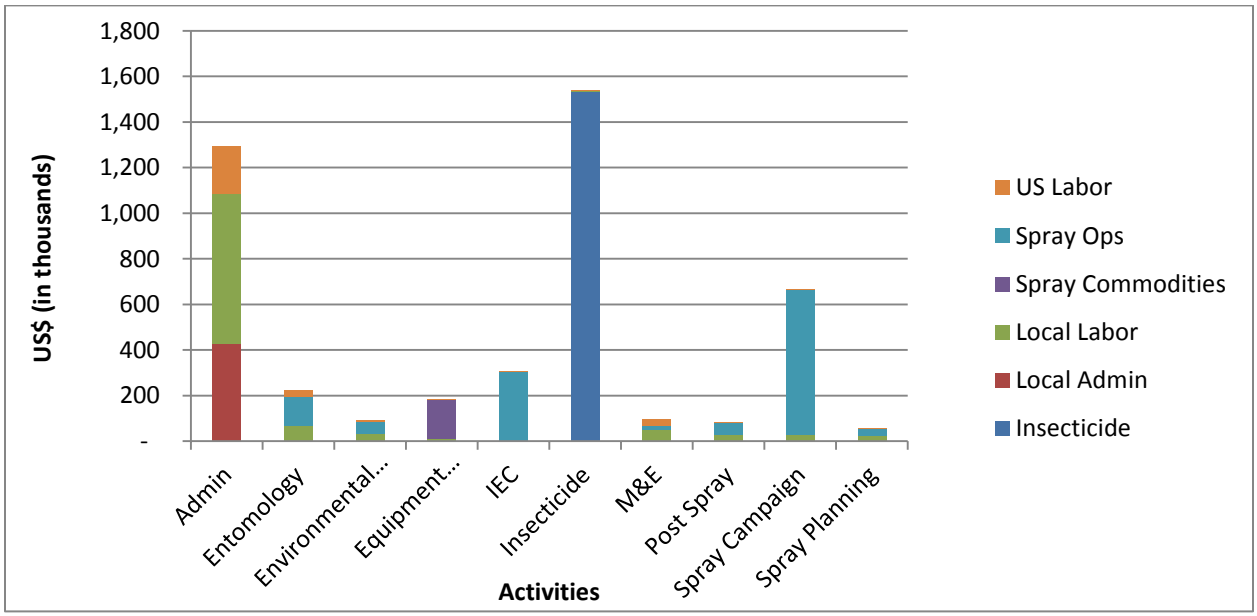


Figure ML1 shows the total capital and recurrent costs, but provides a depiction of cost distribution across program activities (X-axis), as well as the make-up of the activities' costs by cost category (legend). Insecticide is the most expensive IRS activity (33.9 percent of expenditures), followed by administration (28.5 percent of expenditures) and spray campaign activities (14.7 percent of expenditures). PMI AIRS procured 54,287 bottles of Actellic CS and used 58,472 bottles. About 67 percent of the total cost for administration consists of labor, both local and U.S.-based. Note that the 'U.S.-based Labor and STTA' expenditures are largely incurred under the administrative, entomology, and M&E program activities (95 percent of US labor expenditures are in the three categories). Local administration, U.S. labor, and commodities costs are minimal compared to expenditures on insecticide, local labor, and spray operations.

[12] Available at http://www.pmi.gov/docs/default-source/default-document-library/implementing-partner-reports/africa-indoor-residual-spraying-project-pmi-irs-country-programs-2014-comparative-cost-analysis.pdf?sfvrsn=4.

9.3 UNIT COST ANALYSIS

This section presents Mali IRS expenditures as unit costs: per person protected, per structure sprayed, and per area sprayed (in terms of 100 m^2).

TABLE ML3: MALI UNIT COSTS

		Unit costs
Cost per	Person protected	$ 9.19
	Structure sprayed	$ 34.02
	100 m^2 sprayed	$ 31.07

9.4 COMPARISON BETWEEN THE LAST TWO YEARS

This section provides a comparison of the Mali IRS program between 2014 and 2015, as implemented by the PMI AIRS project. The comparison focuses on output measures, total expenditures, and unit costs

TABLE ML4: MALI IRS PROGRAM COMPARISON OF EXPENDITURES

Cost Category	2014 (Adjusted)	2015	Percentage Change (2014 to 2015)
Insecticide	2,100,652	1,533,373	-27.0%
Local Admin	363,682	427,247	17.5%
Local Labor	667,829	912,644	36.7%
Spray Operations	1,707,190	1,219,064	-28.6%
Commodities	164,888	172,735	4.8%
U.S. Labor	208,250	276,953	33.0%
TOTAL	**$ 5,212,491**	**$ 4,542,017**	**-12.9%**

Table ML4, above, compares the year-on-year change in total program capital and recurrent expenditures. The total program cost decreased by 12.9 percent from 2014 to 2015. Costs declined for insecticides and spray operations by 27.0 percent (about $567,000) and 28.6 percent (about $488,000) respectively. Costs increased in real and nominal terms for all other categories, with the exception of spray commodities, where costs only increased in real terms (prices in Mali experienced about a 15 percent deflation in US dollar terms between 2014 and 2015). The category with the largest increase in costs was local labor, which increased by 36.7 percent, or almost $245,000. As mentioned above, the deflationary effect of the currency exchange rate accounted for some (just over 50%) of this increase. In nominal terms, salary increases (60% of nominal increase) resulting mainly from a significant increase in the FSN scale, new danger pay (9% of nominal increase) and new staff at district level for warehousing and coordination (31% of nominal increase) accounted for the increased cost.

TABLE ML5: MALI IRS PROGRAM COMPARISON OF OUTPUT MEASURES AND UNIT COSTS

	2014	2015	Percentage Change (2013 to 2014)
Output Measures			
People Protected	836,568	494,205	-40.9%
Structures Sprayed	228,123	133,527	-41.5%
Area Sprayed (100 m^2)	224,868	146,180	-35.0%
Unit Costs			
Per Person Protected	$ 6.23	$ 9.19	47.5%
Per Structure Sprayed	$ 22.85	$ 34.02	48.9%
Per Area Sprayed	$ 23.18	$ 31.07	34.0%

Table ML5 compares the year-on-year change in Mali IRS program output measures and unit costs. Overall, in 2015, the program had lower levels of outputs than in previous year. The difference in the number of people protected and structures sprayed from 2014 to 2015 had an over 40 percent decrease, while the area sprayed decreased by 35 percent. While the total expenditures decreased from 2014 to 2015, there was a greater decrease in the number of outputs, meaning that the unit costs were higher in 2015 than in 2014 across the three types of outputs. For the cost per person protected and per structure sprayed, unit costs increased by more than 47 percent from 2014 to 2015, while cost per 100 m^2 sprayed increased by 34 percent.

TABLE ML6: YEAR ON YEAR CHANGES IN EFFICIENCY MEASURES

Efficiency measure	2014	2015	% Change from 2014 to 2015
Number of SOP days	16,293	6,866	-58%
Number of structures sprayed	228,123	133,527	-41%
Structures sprayed per SOP per day	14.0	19.4	39%
Spray operations cost per SOP Day	104.78	177.55	69%
Spray operations and commodities cost per structure sprayed	17.41	21.91	26%
Spray operations and commodities cost per structure sprayed (without insecticide)	8.21	10.42	27%

Table ML6 displays various measures of implementation efficiency in the last two years. The spray campaign was of the same length in 2015 as in 2014, although the area covered was smaller. Thus, the number of SOP-days decreased 58 percent from 2014 to 2015. The number of structures sprayed decreased by 41 percent over the same period, indicating that SOPs were able to spray 5.4 more structures per day on average in 2015 than in 2014 (a 39 percent increase). The cost of spray operations fell by 28.6 percent between 2014 and 2015, which was a smaller decline than the decline in the number

of SOP-days over the same period. Thus, the spray operations cost per SOP per day increased from about $105 in 2014 to $178 in 2015, a 69 percent increase. When spray commodities are included, the cost per structure sprayed increased 27 percent, and when including insecticides, the cost per structure sprayed increased by 26 percent, which is likely due to diseconomies of scale from spraying in fewer districts.

10. MOZAMBIQUE

10.1 BACKGROUND

TABLE MZ1: MOZAMBIQUE QUICK FACTS

	2012	2013	2014	2015
Program Dates	April 1, 2012 – March 31, 2013	April 1, 2013 – March 31, 2014	April 1, 2014 – March 31, 2015	April 1, 2015 – March 31, 2016
Number of Districts	6	4	5	6
# Local Staff	28	23	21	25
Spray Start Date	October 8, 2012	October 7, 2013	October 20, 2014	October 19,2015
# Spray Rounds	1	1	1	1
Insecticides Used	Pyrethroids	Pyrethroids	Pyrethroids	Pyrethroids Organophosphates
# Sachets Used	389,788	329,094	356,807	259,748
# People Protected	2,716,176	2,181,896	2,327,815	1,631,058
# Structures Sprayed	536,558	414,232	445,118	337,433
# 100 Square Meters Sprayed	974,470	822,735	914,518	649,370

10.2 PROGRAM EXPENDITURES

This section presents an overview of Mozambique IRS program expenditures in 2015. Costs are organized by activity and cost category.

TABLE MZ2: MOZAMBIQUE IRS PROGRAM CAPITAL AND RECURRENT EXPENDITURES, BY ACTIVITY AND COST CATEGORY

IRS Activity	Insecticide	Local Admin	Local Labor	Spray Commodities	Spray Operations	U.S. Labor & STTA	Grand Total	% of Total
Admin		442,193	579,341			186,942	**$ 1,208,475**	14.0%
Entomology			135,070		319,826	10,786	**$ 465,683**	5.4%
Environmental Compliance			81,661		42,288	15,901	**$ 139,850**	1.6%
Equipment Supplies				601,870			**$ 601,870**	7.0%
IEC							**$ 0***	0.0%
Insecticide	3,575,458**						**$ 3,575,458**	41.4%
M&E			116,735		234,388	74,722	**$ 425,845**	4.9%
Post Spray			109,691		51,850	10,101	**$ 171,642**	2.0%
Spray Campaign			117,722		1,180,943	29,126	**$ 1,327,791**	15.4%

Spray Planning			239,718		471,624	18,080	**$ 729,422**	8.4%
Grand Total	**$ 3,575,458**	**$ 442,193**	**$ 1,379,939**	**$ 601,870**	**$ 2,300,918**	**$ 345,658**	**$ 8,646,036**	100.0%

* Community mobilization efforts were led by the Provincial Directorate of Health (PDH).

**Includes estimated cost of pyrethroid insecticides based on 2014 unit costs.

Table MZ2 displays the Mozambique IRS program total capital and recurrent expenditures from 2015. The first column lists the program activities as tracked by the PMI AIRS project's financial systems, and the top row lists IRS program cost categories. Further explanation of these designations is given in the 2014 report (Johns 2015)[13]. The following figure illustrates the cost breakdown in the table.

FIGURE MZ1: MOZAMBIQUE IRS PROGRAM ACTIVITY EXPENDITURES, BY COST CATEGORY

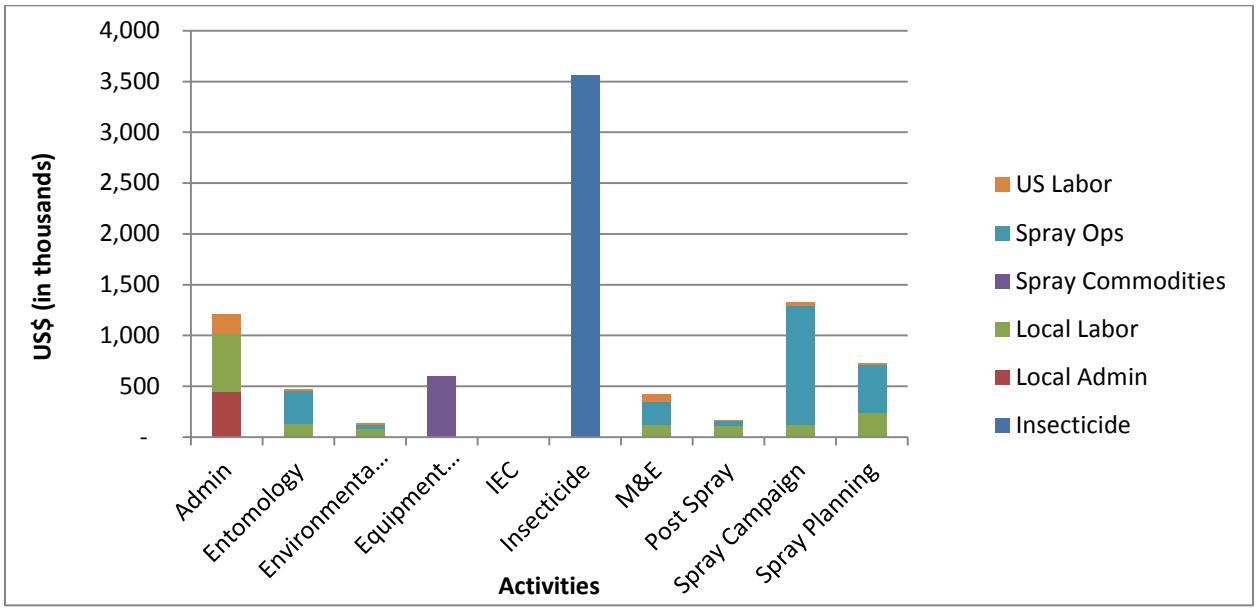


Figure MZ1 shows the total capital and recurrent costs, but provides a depiction of cost distribution across program activities (X-axis), as well as the make-up of the activities' costs by cost category (legend). Insecticides and spray campaign are the two most expensive IRS activities (41.4 percent and 15.4 percent of expenditures, respectively), followed by the local administration (14.0 percent of expenditures). PMI AIRS Mozambique procured 186,192 bottles of organophosphate class insecticides and received 345,500 sachets of pyrethroids from the MOH, while using 126,328 bottles of organophosphate class insecticides and 133,420 sachets of pyrethroids. About 63 percent of the total cost for administration consists of labor, both local and U.S.-based. Local administration, U.S. labor, and commodities costs are minimal compared to expenditures on local labor and spray operations.

10.3 Unit Cost Analysis

This section presents Mozambique IRS expenditures as unit costs: per person protected, per structure sprayed, and per area sprayed (in terms of 100 m^2).

[13] Available at http://www.pmi.gov/docs/default-source/default-document-library/implementing-partner-reports/africa-indoor-residual-spraying-project-pmi-irs-country-programs-2014-comparative-cost-analysis.pdf?sfvrsn=4.

TABLE MZ3: MOZAMBIQUE UNIT COSTS

		Unit costs	
Cost per	Person protected	$	5.29
	Structure sprayed	$	25.59
	100 m^2 sprayed	$	13.29

Entomology, environmental compliance, and M&E activities make up 11.9 percent of the unit cost.

10.4 COMPARISON BETWEEN THE LAST TWO YEARS

This section provides a comparison of the PMI AIRS Mozambique IRS program between 2014 and 2015, as implemented by the PMI AIRS Project.

TABLE MZ4: MOZAMBIQUE IRS PROGRAM COMPARISON OF EXPENDITURES

Cost Category	2014 (Adjusted)	2015	Percentage Change (2014 to 2015)
Insecticide	599,972	3,562,669	493.8%
Local Admin	666,274	442,193	-33.6%
Local Labor	1,120,220	1,379,939	23.2%
Spray Operations	1,948,731	2,300,918	18.1%
Commodities	313,203	601,870	92.2%
U.S. Labor	285,888	345,658	20.9%
TOTAL	$ 4,934,289	$ 8,633,246	75.0%

Table MZ4, above, compares the year-on-year change in total program capital and recurrent expenditures. The total program cost increased by 75.0 percent from 2014 to 2015. The switch to use of organophosphates in some areas resulted in an increase in the costs of insecticide by almost 494 percent from 2014 to 2015, which accounts for over 75 percent of the increased cost. The second largest increase in costs in absolute terms was for spray operations, which increased by over $352,000 (18.1 percent increase) compared to 2014, while the costs for commodities increased over 92 percent from 2014 to 2015 (almost $289,000). Costs decreased between 2014 and 2015 for local administration by over 33 percent, or almost $225,000.

TABLE MZ5: MOZAMBIQUE IRS PROGRAM COMPARISON OF OUTPUT MEASURES AND UNIT COSTS

	2014	2015	Percentage Change (2014 to 2015)
Output Measures			
People Protected	2,327,815	1,631,058	-29.9%

Structures Sprayed	445,118	337,433	-24.2%
Area Sprayed (100 m^2)	914,518	649,370	-29.0%
Unit Costs			
Per Person Protected	$ 2.12	$ 5.29	149.7%
Per Structure Sprayed	$ 11.09	$ 25.59	130.8%
Per Area Sprayed	$ 5.40	$ 13.29	146.4%

Table MZ5 compares the year-on-year change in Mozambique IRS program output measures and unit costs. Overall, in 2015, the program sprayed fewer structures, less area, and protected fewer people than in 2014.Because the program size decreased while the total expenditures increased from 2014 to 2015, the unit costs increased across all categories of output measures by 131 percent to almost 150 percent. This increase demonstrates the effect of introducing organophosphate on program scale and unit costs.

TABLE MZ6: YEAR ON YEAR CHANGES IN EFFICIENCY MEASURES

Efficiency measure	2014	2015	% Change from 2014 to 2015
Number of SOP days	49,342	38,816	-21%
Number of structures sprayed	445,118	337,433	-24%
Structures sprayed per SOP per day	9.0	8.7	-4%
Spray operations cost per SOP Day	39.49	59.28	50%
Spray operations and commodities cost per structure sprayed	6.43	19.16	198%
Spray operations and commodities cost per structure sprayed (without insecticide)	5.08	8.60	69%

Table MZ6 displays various measures of implementation efficiency in the last two years. From 2014 to 2015, the number of SOP-days used for the campaign decreased by 21 percent while the number of structures sprayed decreased by 24 percent, resulting in fewer structures sprayed per operator per day in 2015 than in 2014 (9.0 structures per SOP per day in 2014 vs. 8.7 structures per SOP per day in 2015). Additionally, the cost of spray operations increased between 2014 and 2015, despite fewer SOP-days employed, resulting in a 50 percent increase in the spray operations cost per SOP per day between the two years, and an increase in the spray operations and commodities cost per structure sprayed of 69 percent. These increases in spray operations costs per SOP were largely incurred to remedy the problematic spray campaign in 2015 and to ensure spray coverage, spray quality, and spray data integrity. For example, PMI AIRS Mozambique mobilized additional international STTA support to lead the supply chain assessment to account for missing insecticide and to correct identified weaknesses. Also, PMI AIRS Mozambique conducted a mid-campaign audit of spray data to verify which structures were properly sprayed and which were victims of suspected falsification of spray data. These corrective measures added spray operations costs especially when compared with previous years, but they were necessary to ensure spray coverage, spray quality, and spray data integrity.

11. RWANDA

11.1 BACKGROUND

TABLE RW1: RWANDA QUICK FACTS

	2012	2013	2014	2015
Program Dates	March 1, 2012 – Dec 31, 2012	Jan 1, 2013 – Dec 31, 2013	Jan 1, 2014 – Dec 31, 2014	Jan 1, 2015 – Dec 31, 2015
Number of Districts	3	3	3	4
# Local Staff	16	19	17	16
Spray Start Date	August 20, 2012	Feburary 11, 2013 September 2, 2013	February 10, 2014 September 8, 2014	February 9, 2015 September 14, 2015
# Spray Rounds	1	2	2	2
Insecticides Used	Pyrethroids	Pyrethroids Carbamates	Carbamates	Carbamates
# Sachets & Bottles Used	172,620	265,189	241,483	289,195
# People Protected	1,025,181	1,479,342	1,217,837	1,406,520
# Structures Sprayed	236,610	345,862	297,005	343,131
# 100 Square Meters Sprayed	332,522	529,940	482,958	578,390

11.2 PROGRAM EXPENDITURES

This section presents an overview of Rwanda IRS program expenditures in 2015. Costs are organized by activity and cost category.

TABLE RW2: RWANDA IRS PROGRAM CAPITAL AND RECURRENT EXPENDITURES, BY ACTIVITY AND COST CATEGORY

IRS Activity	Insecticide	Local Admin	Local Labor	Spray Commodities	Spray Operations	U.S. Labor & STTA	Grand Total	% of Total
Admin		400,759	387,805			139,419	**$ 927,983**	13.3%
Entomology			56,073		230,467	8,942	**$ 295,482**	4.3%
Environmental Compliance			40,643		4,491	14,948	**$ 60,082**	0.9%
Equipment Supplies			92	307,133		384	**$ 307,608**	4.4%
IEC					11,338		**$ 11,338**	0.2%
Insecticide	3,007,913						**$ 3,007,913**	43.3%
M&E			54,013		6,793	43,703	**$ 104,509**	1.5%

Post Spray					14,054		**14,054**	0.2%
Spray Campaign					1,694,076		**$ 1,694,076**	24.4%
Spray Planning			167,037		326,155	36,029	**$ 529,221**	7.6%
Grand Total	**$ 3,007,913**	**$ 400,759**	**$ 705,663**	**$ 307,133**	**$ 2,287,373**	**$ 243,424**	**$ 6,952,266**	100.0%

Table RW2 displays the Rwanda IRS program total capital and recurrent expenditures from 2015. The first column lists the program activities as tracked by the PMI AIRS project financial systems, and the top row lists IRS program cost categories. Further explanation of these designations is given in the 2014 report (Johns 2015)[14]. The following figure illustrates the cost breakdown in the table.

FIGURE RW1: RWANDA IRS PROGRAM ACTIVITY EXPENDITURES, BY COST CATEGORY

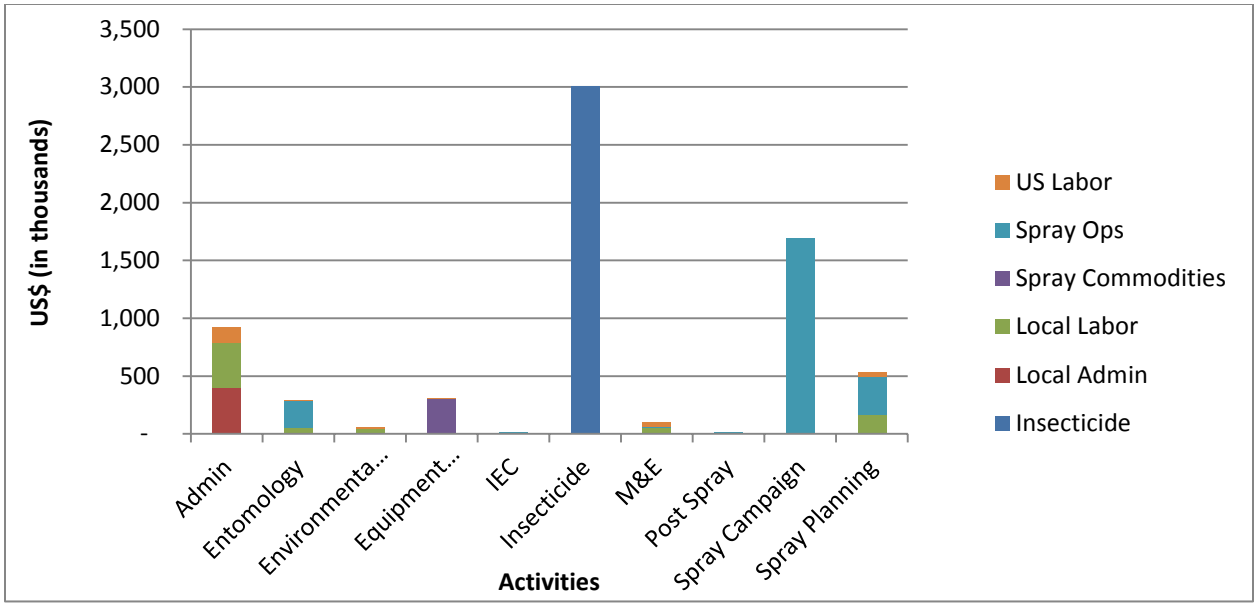


Figure RW1 shows the total capital and recurrent costs, but provides a depiction of cost distribution across program activities (X-axis), as well as the make-up of the activities' costs by cost category (legend). Insecticides represented 43.3 percent of costs. Spray campaign costs and administration were the next two largest categories of costs, representing 24.4 and 13.3 percent of costs, respectively. The Project procured 295,330 sachets of carbamate, and used 289,195 sachets; the costs above reflect the cost of insecticide used. About 57 percent of the total cost for administration consists of labor, both local and U.S.-based. Local administration, U.S. labor, and commodities costs are minimal compared to expenditures on insecticide, local labor, and spray operations.

11.3 Unit Cost Analysis

This section presents Rwanda IRS expenditures as unit costs: per person protected, per structure sprayed, and per area sprayed (in terms of 100 m^2).

[14] Available at http://www.pmi.gov/docs/default-source/default-document-library/implementing-partner-reports/africa-indoor-residual-spraying-project-pmi-irs-country-programs-2014-comparative-cost-analysis.pdf?sfvrsn=4.

TABLE RW3: RWANDA UNIT COSTS

			Unit costs
	Person protected	$	4.94
Cost per	Structure sprayed	$	20.26
	100 m^2 sprayed	$	12.02

The cost of entomology, environmental compliance, and M&E activities make up 6.6 percent of the unit cost.

11.4 Comparison between the last two years

This section provides a comparison of the Rwanda IRS program between 2014 and 2015, as implemented by the PMI AIRS project. The comparison focuses on output measures, total expenditures, and unit costs.

TABLE RW4: RWANDA IRS PROGRAM COMPARISON OF EXPENDITURES

Cost Category	2014 (Adjusted)	2015	Percentage Change (2014 to 2015)
Insecticide	3,796,965	3,007,913	-20.8%
Local Admin	413,228	400,759	-3.0%
Local Labor	897,874	705,663	-21.4%
Spray Operations	2,263,615	2,287,373	1.0%
Commodities	160,973	307,133	90.8%
U.S. Labor	269,250	243,424	-9.6%
TOTAL	**$ 7,801,905**	**$ 6,952,266**	**-10.9%**

Table RW4 compares the year-on-year change in total program capital and recurrent expenditures. The total program cost decreased by 10.9 percent from 2014 to 2015, representing a decrease in the total annual cost of almost $850,000. Increases in costs from 2014 to 2015 were incurred for spray operations (about $24,000) and commodities (about $146,000). Costs decreased in other categories by about $1.0 million. Decreases in the cost of insecticide constituted the bulk of the cost reduction (about 77 percent of the cost decrease from 2014 to 2015 was due to insecticide), with a decrease in the cost of local labor by about $192,000.

The costs of insecticides decreased from 2014 to 2015 due to a change in the unit cost of the insecticide procured from $15.72 to $10.40.

TABLE RW5: RWANDA IRS PROGRAM COMPARISON OF OUTPUT MEASURES AND UNIT COSTS

	2014	2015	Percentage Change (2014 to 2015)
Output Measures			
People Protected	1,217,837	1,406,520	15.5%
Structures Sprayed	297,005	343,131	15.5%
Area Sprayed (100 m^2)	482,958	578,390	19.8%
Unit Costs			
Per Person Protected	$ 6.41	$ 4.94	-22.8%
Per Structure Sprayed	$ 26.27	$ 20.26	-22.9%
Per Area Sprayed	$ 16.15	$ 12.02	-25.6%

Table RW5 compares the year-on-year change in PMI AIRS Rwanda program output measures and unit costs. In 2015, the program achieved higher coverage on all three indicators used in Table RW4 than in 2014. Between 2014 and 2015, the number of people protected increased 15.5 percent, the number of structures increased 15.5 percent, and the area sprayed increased by 19.8 percent. Because the program size increased (for all measured in Table RW5), while the total expenditures decreased from 2014 to 2015, the unit costs decreased by almost 23 percent for cost per person protected and per structure sprayed.

TABLE RW6: YEAR ON YEAR CHANGES IN EFFICIENCY MEASURES

Efficiency measure	2014	2015	% Change from 2014 to 2015
Number of SOP days	40,126	32,844	-18%
Number of structures sprayed	297,005	343,131	16%
Structures sprayed per SOP per day	7.4	10.4	41%
Spray operations cost per SOP Day	56.41	69.64	23%
Spray operations and commodities cost per structure sprayed	20.95	16.33	-22%
Spray operations and commodities cost per structure sprayed (without insecticide)	8.16	7.56	-7%

Table RW6 displays various measures of implementation efficiency in the last two years. Between 2014 and 2015, the number of SOP-days used for the campaign decreased by 18%. At the same time, the number of structures sprayed increased by 16 percent from 2014 to 2015, resulting in more structures sprayed per SOP per day. However, the cost of spray operations increased per SOP per day by about 23 percent, and costs for spray operations commodities also increased. Nonetheless, the increased

productivity of the SOPs offset these increased costs, and the spray operations and commodities costs per structure sprayed declined by 7 percent from 2014 to $7.56. As noted above, costs for insecticide also decreased between 2014 and 2015.

12. SENEGAL

12.1 BACKGROUND

TABLE SN1: SENEGAL QUICK FACTS

	2012	2013	2014	2015
Program Dates	Jan 1, 2012 – Dec 31, 2012	Jan 1, 2013 – Dec 31, 2013	Jan 1, 2014 – Dec 31, 2014	Jan 1, 2015 – Dec 31, 2015
Number of Districts	6	4	4	4
# Local Staff	14	16	19	18
Spray Start Date	June 6, 2012	July 15, 2013	May 15, 2014	May 22, 2015
# Spray Rounds	1	1	2	2
Insecticides Used	Carbamates	Carbamates	Carbamates Organophosphates	Carbamates Organophosphates
# Sachets & Bottles Used	106,874	65,049	60,186	39,204
# People Protected	1,095,093	690,029	708,999	514,833
# Structures Sprayed	306,916	207,116	204,159	130,170
# 100 Square Meters Sprayed*	267,185	162,623	150,465	98,010

* Reverse calculation using number of insecticide sachets/bottles used during campaign multiplied by the average of 250 m^2 estimated to be sprayed by one sachet and divided by the number of structures sprayed.

12.2 PROGRAM EXPENDITURES

This section presents an overview of Senegal IRS program expenditures in 2015. Costs are organized by activity and cost category.

TABLE SN2: SENEGAL IRS PROGRAM CAPITAL AND RECURRENT EXPENDITURES, BY ACTIVITY AND COST CATEGORY

IRS Activity	Insecticide	Local Admin	Local Labor	Spray Commodities	Spray Operations	U.S. Labor & STTA	Grand Total	% of Total
Admin		398,798	602,500			144,836	**$ 1,146,134**	34.5%
Entomology			25,071		71,676	1,506	**$ 98,253**	3.0%
Environmental Compliance			64,703		28,890	20,175	**$ 113,768**	3.4%
Equipment Supplies			2,949	97,777		56	**$ 100,783**	3.0%
IEC			41,328		25,182	5,882	**$ 72,392**	2.2%
Insecticide	950,237		957			53	**$ 951,247**	28.6%
M&E			83,400		34,329	28,100	**$ 145,829**	4.4%

Post Spray			65,019		18,805	12,455	**$ 96,278**	2.9%
Spray Campaign			35,922		301,138	5,270	**$ 342,330**	10.3%
Spray Planning			89,501		138,828	28,685	**$ 257,014**	7.7%
Grand Total	**$ 950,237**	**$ 398,798**	**$ 1,011,349**	**$ 97,777**	**$ 618,848**	**$ 247,017**	**$ 3,324,027**	**100.0%**

Table SN2 displays the Senegal IRS program total capital and recurrent expenditures from 2015. The first column lists the program activities as tracked by the PMI AIRS Project's financial systems, and the top row lists IRS program cost categories. The following figure illustrates the cost breakdown in the table.

FIGURE SN1: SENEGAL IRS PROGRAM ACTIVITY EXPENDITURES, BY COST CATEGORY

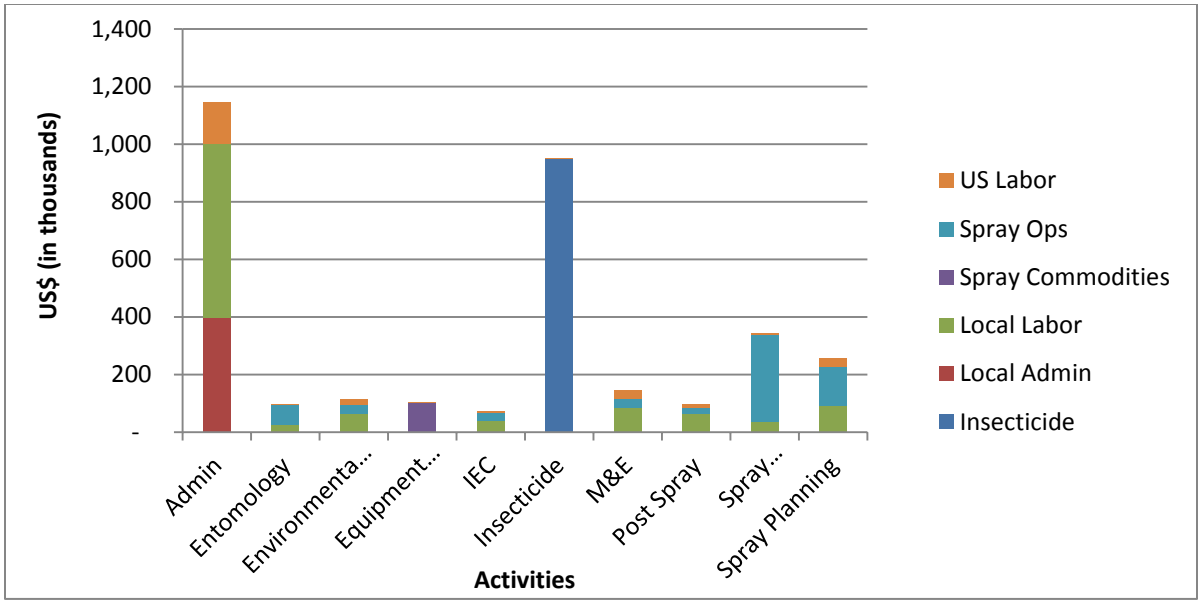


Figure SN1 shows the total capital and recurrent costs, but provides a depiction of cost distribution across program activities (X-axis), as well as the make-up of the activities' costs by cost category (legend). Administration is the most expensive IRS activity (34.5 percent of expenditures), followed by the insecticides (28.6 percent of expenditures) and spray campaign activities (10.3 percent of expenditures). PMI AIRS procured 48,671 bottles of organophosphate class insecticide, and used about 32,925 bottles, in addition to 6,279 sachets of carbamates left from previous years (costs reflect the insecticides – both organophosphate and carbamate – used). About 65 percent of the total cost for administration consists of labor, both local and U.S.-based. Local administration, U.S. labor, and commodities costs are minimal compared to expenditures on insecticide, local labor, and spray operations.

12.3 Unit Cost Analysis

This section presents Senegal IRS expenditures as unit costs: per person protected, per structure sprayed, and per area sprayed (in terms of 100 m^2).

TABLE SN3: SENEGAL UNIT COSTS

		Unit costs	
Cost per	**Person protected**	$	6.46

Structure sprayed	$	25.54
100 m^2 sprayed	$	33.92

12.4 COMPARISON BETWEEN THE LAST TWO YEARS

This section provides a comparison of the Senegal IRS program between 2014 and 2015, as implemented by the PMI AIRS project. The comparison focuses on output measures, total expenditures, and unit costs.

TABLE SN4: SENEGAL IRS PROGRAM COMPARISON OF EXPENDITURES

Cost Category	2014 (Adjusted)	2015	Percentage Change (2014 to 2015)
Insecticide	1,258,953	950,237	-24.5%
Local Admin	366,884	398,798	8.7%
Local Labor	1,053,474	1,011,349	-4.0%
Spray Operations	983,746	618,848	-37.1%
Commodities	105,544	97,777	-7.4%
U.S. Labor	203,900	247,017	21.1%
TOTAL	**$ 3,972,501**	**$ 3,324,027**	**-16.3%**

Table SN4, above, compares the year-on-year change in total program capital and recurrent expenditures. The total program cost decreased by 16.3 percent from 2014 to 2015, representing a decrease in the total annual cost of about $648,500. Reductions in costs were seen across all costs categories from 2014 to 2015 except for US labor and local administration.

The costs of insecticides used decreased 24.5 percent from 2014 to 2015, reflecting lower use of carbamates (from 25,337 sachets to 6,279 sachets) and a more moderate decrease in the amount of organophosphates used (from 34,849 bottles to 32,925 bottles). However, the greatest relative and absolute decrease in costs was for spray operations, which decreased by over 37 percent from 2014 to 2015 (roughly $365,000), reflected in the shorter campaigns and lower coverage of spray operations.

TABLE SN5: SENEGAL IRS PROGRAM COMPARISON OF OUTPUT MEASURES AND UNIT COSTS

	2014	2015	Percentage Change (2014 to 2015)
Output Measures			
People Protected	708,999	514,833	-27.4%
Structures Sprayed	204,159	130,170	-36.2%
Area Sprayed (100 m^2)	150,465	98,010	-34.9%
Unit Costs			

Per Person Protected	$	5.60	$	6.46	15.2%
Per Structure Sprayed	$	19.46	$	25.54	31.2%
Per Area Sprayed	$	26.40	$	33.92	28.5%

Table SN5, above, compares the year-on-year change in Senegal IRS program output measures and unit costs. In 2015, the program had the lowest coverage metrics over the last two years. The number of people protected decreased by 27.4 percent from 2014 to 2015, which was a lesser decline than in the number of structures sprayed (36.2 percent) and area sprayed (34.9 percent) over the same period. Thus, the average size of the structures sprayed in 2015 was 75.3 m^2 compared to 73.7 m^2 in 2014.Because the program size decreased by a greater relative amount than the total expenditures, unit costs increased from 2014 to 2015. The cost per person protected increased by about 15 percent, while costs per structure sprayed and area sprayed increased on the order of 30 percent from 2014 to 2015.

TABLE SN6: YEAR ON YEAR CHANGES IN EFFICIENCY MEASURES

Efficiency measure	2014	2015	% Change from 2014 to 2015
Number of SOP days	15,045	8,893	-41%
Number of structures sprayed	204,159	130,170	-36%
Structures sprayed per SOP per day	13.6	14.6	8%
Spray operations cost per SOP Day	65.39	69.59	6%
Spray operations and commodities cost per structure sprayed	11.50	12.81	11%
Spray operations and commodities cost per structure sprayed (without insecticide)	5.34	5.51	3%

Table SN6 displays various measures of implementation efficiency in the last two years. While there was decrease in the cost of spray operations, this was not commensurate with the decrease in the number of SOP-days used, and the spray operations cost per SOP per day increased by 6 percent from 2014 to 2015. The decrease in the scale of operations was also reflected in the spray operations and commodities cost per structure sprayed (which increased by 3 percent from 2014 to 2015). The greater proportionate use of organophosphate class insecticides relative to carbamate class insecticides in 2015 is also reflected in the increase in spray operations, commodities, and insecticide cost per structure sprayed.

13. ZAMBIA

13.1 BACKGROUND

TABLE ZA1: ZAMBIA QUICK FACTS

	2014	2015
Program Dates	March 1, 2014 – Feb 28, 2015	March 1, 2015 – Feb 28, 2016
Number of Districts	40	39
# Local Staff	27	48
Spray Start Date	October 13, 2014	September 28, 2015
# Spray Rounds	1	1
Insecticides Used	Organophosphates	Organophosphates
# Bottles Used	112,603	136,652
# People Protected	2,000,824	2,544,290
# Structures Sprayed	409,544	519,598
# 100 Square Meters Sprayed	281,508	341,630

13.2 PROGRAM EXPENDITURES

This section presents an overview of Zambia IRS program expenditures in 2015. Costs are organized by activity and cost category.

TABLE ZA2: ZAMBIA IRS PROGRAM CAPITAL AND RECURRENT EXPENDITURES, BY ACTIVITY AND COST CATEGORY

IRS Activity	Insecticide	Local Admin	Local Labor	Spray Commodities	Spray Operations	U.S. Labor & STTA	Grand Total	% of Total
Admin		653,017	728,321			241,327	**$ 1,622,665**	17.0%
Entomology			131,458		288,788	30,690	**$ 450,936**	4.7%
Environmental Compliance			34,617		260,785	44,133	**$ 339,534**	3.6%
Equipment Supplies			571	256,671		93	**$ 257,335**	2.7%
IEC			1,334		3,214		**$ 4,548**	0.0%
Insecticide	3,645,151						**$ 3,645,151**	38.2%
M&E			66,260		211,460	88,789	**$ 366,510**	3.8%
Post Spray			35,675		45,722	11,780	**$ 93,178**	1.0%
Spray Campaign			118,241		1,561,503	52,118	**$ 1,731,862**	18.2%

Spray Planning			191,288		796,115	38,464	**$ 1,025,867**	10.8%
Grand Total	**$ 3,645,151**	**$ 653,017**	**$ 1,307,766**	**$ 256,671**	**$ 3,167,587**	**$ 507,394**	**$ 9,537,586**	100.0%

Table ZA2 displays the Zambia IRS program total capital (including disposition) and recurrent expenditures from 2015. The first column lists the program activities as tracked by the PMI AIRS Project's financial systems, and the top row lists IRS program cost categories. Further explanation of these designations is given in the 2014 report (Johns 2015)[15]. The following figure illustrates the cost breakdown in the table.

FIGURE ZA1: ZAMBIA IRS PROGRAM ACTIVITY EXPENDITURES, BY COST CATEGORY

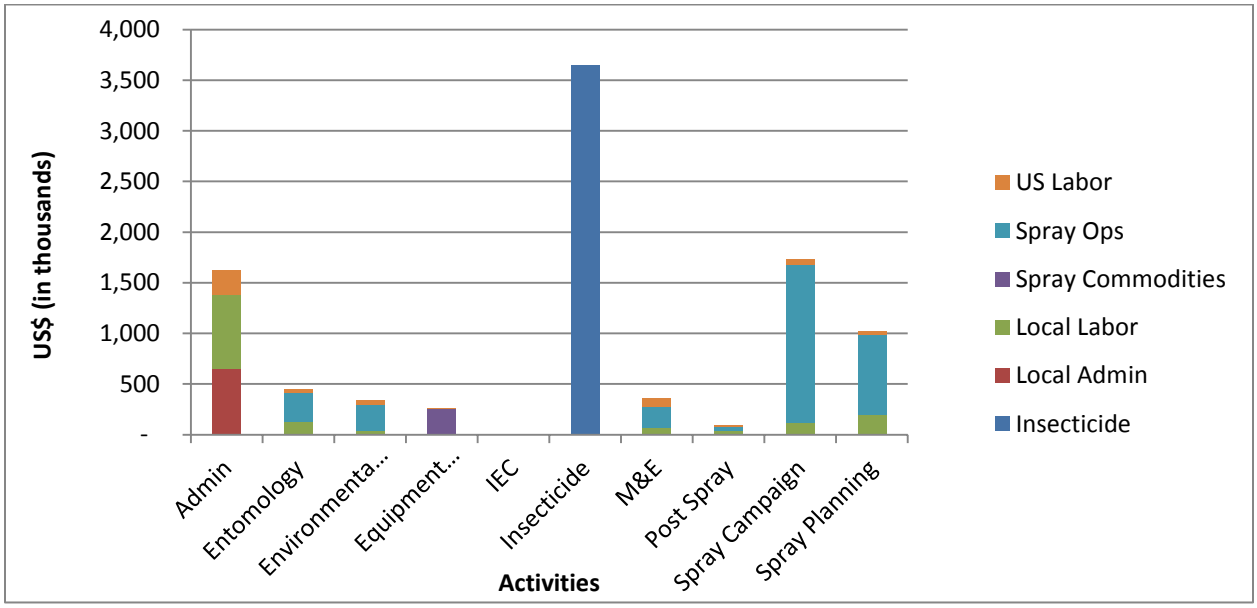


Figure ZA1 shows the total capital and recurrent costs, but provides a depiction of cost distribution across program activities (X-axis), as well as the make-up of the activities' costs by cost category (legend). Insecticides and spray campaign costs are the two most expensive IRS activities (38.2 percent and 18.2 percent of expenditures, respectively), followed by the administration (17.0 percent of expenditures). PMI AIRS Zambia procured 45,000 bottles of organophosphate insecticide; 136,652 bottles were used. About 59.8 percent of the total cost for administration consists of labor, both local and U.S.-based. Local administration, U.S. labor, and commodities costs were less than expenditures on insecticide, local labor, and spray operations.

13.3 Unit Cost Analysis

This section presents Zambia IRS expenditures as unit costs: per person protected, per structure sprayed, and per area sprayed (in terms of 100 m^2).

[15] Available at http://www.pmi.gov/docs/default-source/default-document-library/implementing-partner-reports/africa-indoor-residual-spraying-project-pmi-irs-country-programs-2014-comparative-cost-analysis.pdf?sfvrsn=4.

TABLE ZA3: ZAMBIA UNIT COSTS

		Unit costs
Person protected	$	3.75
Cost per Structure sprayed	$	18.36
100 m^2 sprayed	$	27.92

Entomology, environmental compliance, and M&E activities make up 12.1 percent of the unit cost.

13.4 COMPARISON BETWEEN THE LAST TWO YEARS

This section provides a comparison of the Zambia IRS program for 2014 and 2015, as implemented by the PMI AIRS project. The comparison focuses on output measures, total expenditures, and unit costs.

TABLE ZA4: ZAMBIA IRS PROGRAM COMPARISON OF EXPENDITURES

Cost Category	2014 (Adjusted)	2015	Percentage Change (2014 to 2015)
Insecticide	3,392,635	3,645,151	7.4%
Local Admin	294,469	653,017	121.8%
Local Labor	692,529	1,307,766	88.8%
Spray Operations	1,450,977	3,167,587	118.3%
Commodities	50,925	256,671	404.0%
U.S. Labor	250,319	507,394	102.7%
TOTAL	**$ 6,131,854**	**$ 9,537,586**	**55.5%**

Table ZA4, above, compares the year-on-year change in total program capital and recurrent expenditures. While Zambia experienced net inflation in terms of prices in Kwacha, the exchange rate with the US dollar fell more than local prices increased, indicating that costs (excepting insecticides) were adjusted downward by 78 percent. This volatility should be kept in mind when assessing changes in program costs, although costs for all the categories listed in Table ZA4 increased in nominal, as well as real, terms. The total program cost increased by 55.5 percent from 2014 to 2015, representing an increase in the total annual cost of about $3.4 million.

The largest cost increase in absolute terms was for spray operations, which increased by about $1.7 from 2014 to 2015 (a 118.3 percent increase), accounting for over half of the increased cost between the two years. One reason for the increase in spray operations was that door to door mobilization was conducted for the first time. Local administration costs increased substantially because the team moved to a new larger office to accommodate the larger team and no longer shared an office with another project, as was the case in 2014. New furniture and IT equipment was purchased for the new office. The price of commodities increased by over 400 percent, but represented just over $205,000, which was the smallest increase in absolute terms among the categories listed in Table ZA4. PMI AIRS Zambia replaced several items, like overalls and pumps, that were worn out from several years of use. Local labor increased substantially because PMI AIRS Zambia hired and trained 20 new district coordinators which cost approximately $108,000/year. It was decided that this position was necessary to add to increase the oversight and supervision for IRS at the lower level. In addition, a TCN entomologist was hired and

moved to Zambia in August 2015 to supervise Zambia's growing entomology activities and new operational research studies.

TABLE ZA5: ZAMBIA IRS PROGRAM COMPARISON OF OUTPUT MEASURES AND UNIT COSTS

	2014	2015	Percentage Change (2014 to 2015)
Output Measures			
People Protected	2,000,824	2,544,290	27.2%
Structures Sprayed	409,544	519,598	26.9%
Area Sprayed (100 m^2)	281,508	341,630	21.4%
Unit Costs			
Per Person Protected	$ 3.06	$ 3.75	22.3%
Per Structure Sprayed	$ 14.97	$ 18.36	22.6%
Per Area Sprayed	$ 21.78	$ 27.92	28.2%

Table ZA5, above, compares the year-on-year change in Zambia IRS program output measures and unit costs. In 2015, the program had higher output metrics across the three categories considered, with increases in program outputs of over 25 percent compared to 2014 for the number of people protected and structures sprayed, and over 20 percent greater area sprayed. While the program size increased between 21 percent and 28 percent across the different outputs, total expenditures increased by over 55%. Thus, unit costs increased from 2014 to 2015 by over 22 percent to over 28 percent across the three output metrics.

TABLE ZA6: YEAR ON YEAR CHANGES IN EFFICIENCY MEASURES

Efficiency measure	2014	2015	% Change from 2014 to 2015
Number of SOP days	22,535	33,597	49%
Number of structures sprayed	409,544	519,598	27%
Structures sprayed per SOP per day	18.2	15.5	-15%
Spray operations cost per SOP Day	64.39	94.28	46%
Spray operations and commodities cost per structure sprayed	11.95	13.61	14%
Spray operations and commodities cost per structure sprayed (without insecticide)	3.67	6.59	80%

Table ZA6 displays various measures of implementation efficiency in the last two years. From 2014 to 2015, SOP productivity decreased from spraying 18.2 structures per day to spraying 15.5 structures per day (representing a 15 percent decrease). Further, while the number of SOP-days employed in the

campaign increased by 49 percent between the two years, costs for spray operations increased by over 118 percent, indicating that the spray operations cost per SOP per day increased by 46 percent between the two years. With lower productivity and increased spray operations and commodities costs, the spray operations and commodities cost per structure sprayed increased by 80 percent from 2014 to 2015, rising from $3.67 to $6.59. The costs for insecticides increased by 7.4 percent between the two years, which is an increase less than the increase in the number of structures sprayed or SOP days employed. The increased efficiency in use of insecticide indicate that when including costs for spray operations, commodities, and insecticides per structure sprayed, costs increased from $11.95 to $13.61, and increase of 14 percent (compared to the 80 percent increase when insecticide costs are not included).

14. ZIMBABWE

14.1 BACKGROUND

TABLE ZW1: ZIMBABWE QUICK FACTS

	2014	2015
Program Dates	March 1, 2014 – Feb 28, 2015	March 1, 2015 – Feb 28, 2016
Number of Districts	4	4
# Local Staff	10	12
Spray Start Date	November 1, 2014	October 11, 2015
# Spray Rounds	1	1
Insecticides Used	Organophosphates	Organophosphates
# Bottles Used	67,040	73,326
# People Protected	334,746	365,425
# Structures Sprayed	147,949	162,127
# 100 Square Meters Sprayed	167,600	183,315

14.2 PROGRAM EXPENDITURES

This section presents an overview of Zimbabwe IRS program expenditures in 2015. Costs are organized by activity and cost category.

TABLE ZW2: ZIMBABWE IRS PROGRAM CAPITAL AND RECURRENT EXPENDITURES, BY ACTIVITY AND COST CATEGORY

IRS Activity	Insecticide	Local Admin	Local Labor	Spray Commodities	Spray Operations	U.S. Labor & STTA	Grand Total	% of Total
Admin		310,676	570,555			120,217	**$ 1,001,449**	23.5%
Entomology		2,151	173,448		126,794	14,137	**$ 316,531**	7.4%
Environmental Compliance		1,817	93,269		463,736	18,808	**$ 577,630**	13.6%
Equipment Supplies			1,861	159,273		203	**$ 161,337**	3.8%
IEC							**$ 0**	0.0%
Insecticide	1,952,140						**$ 1,952,140**	45.9%
M&E					15,081	45,349	**$ 60,429**	1.4%
Post Spray					8,852		**$ 8,852**	0.2%
Spray Campaign			40,207		132,992	5,332	**$ 178,531**	4.2%

Spray Planning							**$ 0**	0.0%
Grand Total	**$ 1,952,140**	**$ 314,645**	**$ 879,341**	**$ 159,273**	**$ 747,455**	**$ 204,046**	**$ 4,256,899**	**100.0%**

Table ZW2 displays the Zimbabwe IRS program total capital (including requisition) and recurrent expenditures from 2015. The first column lists the program activities as tracked by the PMI AIRS project's financial systems, and the top row lists IRS program cost categories. Further explanation of these designations is given in the 2014 report (Johns 2015)[16]. The following figure illustrates the cost breakdown in the table.

FIGURE ZW1: ZIMBABWE IRS PROGRAM ACTIVITY EXPENDITURES, BY COST CATEGORY

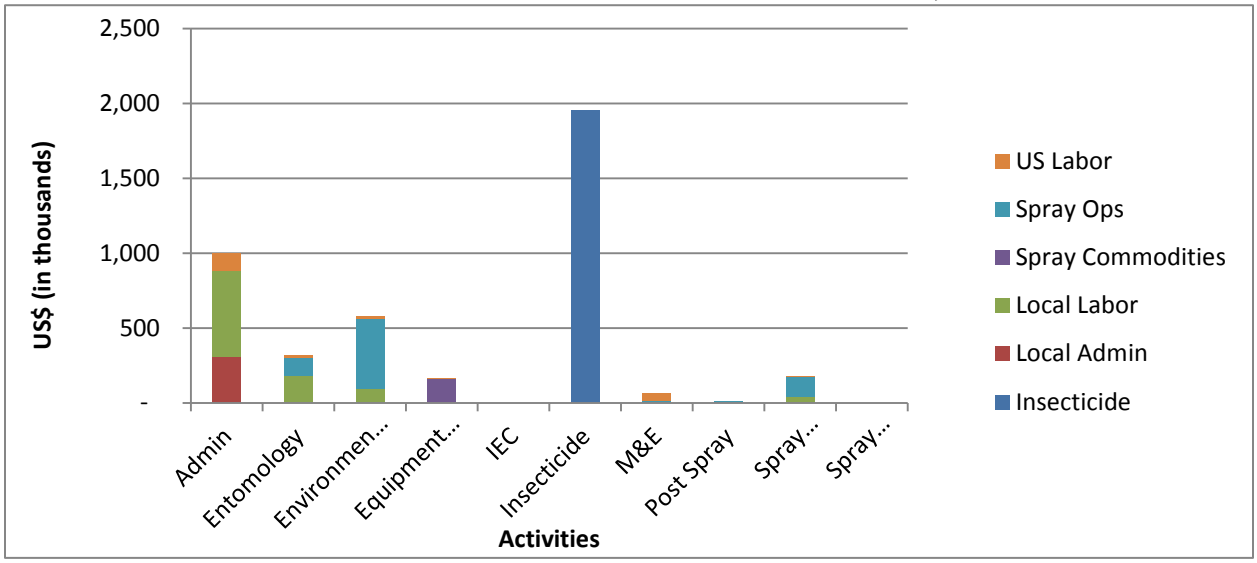


Figure ZW1 shows the total capital and recurrent costs, but provides a depiction of cost distribution across program activities (X-axis), as well as the make-up of the activities' costs by cost category (legend). Insecticides and administration are the two most expensive IRS activities (45.9 percent and 23.5 percent of expenditures, respectively), followed by environmental compliance (13.6 percent of expenditures). PMI AIRS Zimbabwe procured 61,967 bottles of organophosphate insecticide; 73,326 bottles were used (reflected in figure above). About 69.0 percent of the total cost for administration consists of labor, both local and U.S.-based. Local administration, U.S. labor, and commodities costs are minimal compared to expenditures on insecticide, local labor, and spray operations.

14.3 Unit Cost Analysis

This section presents Zimbabwe IRS expenditures as unit costs: per person protected, per structure sprayed, and per area sprayed (in terms of 100 m^2).

[16] Available at http://www.pmi.gov/docs/default-source/default-document-library/implementing-partner-reports/africa-indoor-residual-spraying-project-pmi-irs-country-programs-2014-comparative-cost-analysis.pdf?sfvrsn=4.

TABLE ZW3: ZIMBABWE UNIT COSTS

		Unit costs
Person protected	$	11.65
Cost per Structure sprayed	$	26.26
100 m^2 sprayed	$	23.22

Entomology, environmental compliance, and M&E activities make up 22.4 percent of the unit cost.

14.4 Comparison between the last two years

This section provides a comparison of the Zimbabwe IRS program for 2014 and 2015, as implemented by the PMI AIRS project. The comparison focuses on output measures, total expenditures, and unit costs.

TABLE ZW4: ZIMBABWE IRS PROGRAM COMPARISON OF EXPENDITURES

Cost Category	2014 (Adjusted)	2015	Percentage Change (2014 to 2015)
Insecticide	1,782,034	1,952,140	9.5%
Local Admin	337,296	314,645	-6.7%
Local Labor	902,325	879,341	-2.5%
Spray Operations	831,645	747,455	-10.1%
Commodities	226,574	159,273	-29.7%
U.S. Labor	300,981	204,046	-32.2%
TOTAL	**$ 4,380,855**	**$ 4,256,899**	**-2.8%**

Table ZW4, above, compares the year-on-year change in total program capital and recurrent expenditures. The total program cost decreased by 2.8 percent from 2014 to 2015, representing a decrease in the total annual cost of about $124,000. Reductions in costs were seen across all costs categories from 2014 to 2015 except for costs for insecticides.

The costs of insecticides used increased 9.5 percent from 2014 to 2015, approximately reflecting the increased structures and area sprayed. The greatest absolute decreases in costs between the two years were for US labor, which decreased by over 32 percent from 2014 to 2015 (roughly $97,000), and spray operations, which decreased by 10.1 percent ($84,000).

TABLE ZW5: ZIMBABWE IRS PROGRAM COMPARISON OF OUTPUT MEASURES AND UNIT COSTS

	2014	2015	Percentage Change (2014 to 2015)
Output Measures			

People Protected	334,746	365,425	9.2%
Structures Sprayed	147,949	162,127	9.6%
Area Sprayed (100 m^2)	167,600	183,315	9.4%
Unit Costs			
Per Person Protected	$ 13.09	$ 11.65	-11.0%
Per Structure Sprayed	$ 29.61	$ 26.26	-11.3%
Per Area Sprayed	$ 26.14	$ 23.22	-11.2%

Table ZW5, above, compares the year-on-year change in Zimbabwe IRS program output measures and unit costs. In 2015, the program had higher output metrics across the three categories considered, with increases in program outputs of just over 9 percent compared to 2014. Because the program size increased while total expenditures decreased, unit costs decreased from 2014 to 2015 by over 11 percent across the three output metrics.

TABLE ZW6: YEAR ON YEAR CHANGES IN EFFICIENCY MEASURES

Efficiency measure	2014	2015	% Change from 2014 to 2015
Number of SOP days	9,321	8,657	-7%
Number of structures sprayed	147,949	162,127	10%
Structures sprayed per SOP per day	15.9	18.7	18%
Spray operations cost per SOP Day	89.22	86.34	-3%
Spray operations and commodities cost per structure sprayed	19.20	17.63	-8%
Spray operations and commodities cost per structure sprayed (without insecticide)	7.15	5.59	-22%

Table ZW6 displays various measures of implementation efficiency in the last two years. From 2014 to 2015, SOP productivity increased and 7 percent fewer SOP days were used for the spray campaign in 2015 than in 2014, while the number of structures sprayed increased by 10 percent over the same period. Thus, the number of structures sprayed per SOP per day increased from 15.9 to 18.7, an increase of 18 percent. The decline in the cost of spray operations between 2014 and 2015 was less than the decline in the number of SOP-days employed, so the spray operations cost per SOP per day fell by 3 percent. This increased productivity and decreased cost across the two years resulted in the spray operations and commodities cost per structure sprayed decreasing from $7.15 in 2014 to $5.59 (22 percent); when including the costs of insecticides in the calculation, the cost of spray operations, commodities, and insecticides decreased by 8 percent across the two years.

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Annex I: Year-on-year comparison of output measures

	People Protected					Structures Sprayed					Area Sprayed (100 m^2)				
Country	**2012**	**2013**	**2014**	**2015**	**Percent Change 2014-2015**	**2012**	**2013**	**2014**	**2015**	**Percent Change 2014-2015**	**2012**	**2013**	**2014**	**2015**	**Percent Change 2014-2015**
Ethiopia	1,506,273	1,629,958	1,647,099	1,655,997	1%	547,421	635,528	667,236	704,945	6%	524,334	617,442	624,764	641,994	3%
Zambia			2,000,824	2,544,290	27%			409,544	519,598	27%			281,508	341,630	21%
Rwanda	1,025,181	1,479,342	1,217,837	1,406,520	15%	236,610	345,862	297,005	343,131	16%	332,522	529,940	482,958	578,390	20%
Mozambique	2,716,176	2,181,896	2,327,815	1,631,058	-30%	536,558	414,232	445,118	337,433	-24%	974,470	822,735	914,518	649,370	-29%
Benin	762,146	694,729	789,883	802,597	2%	206,295	228,951	254,072	252,706	-1%	192,968	125,605	110,505	114,160	3%
Madagascar	1,781,990	1,588,138	1,307,384	1,016,841	-22%	371,391	343,470	274,533	247,902	-10%	221,418	198,985	229,240	113,493	-50%
Avg. Large Programs	*1,558,353*	*1,514,813*	*1,548,474*	*1,509,551*	*-1%*	*379,655*	*393,609*	*391,251*	*400,953*	*2%*	*478,297*	*441,192*	*440,582*	*406,506*	*-5%*
Ghana	941,240	534,060	570,572	553,954	-3%	355,278	197,655	205,230	205,935	0%	193,220	108,210	112,370	113,285	1%
Zimbabwe			334,746	365,425	9%			147,949	162,127	10%			167,600	183,315	9%
Mali	762,146	850,104	836,568	494,205	-41%	206,295	228,985	228,123	133,527	-41%	192,968	233,588	224,868	146,180	-35%
Senegal	1,095,093	690,029	708,999	514,833	-27%	306,916	207,116	204,159	130,170	-36%	267,185	162,623	150,465	98,010	-35%
Avg. Medium Programs	*932,826*	*691,398*	*612,721*	*482,104*	*-16%*	*289,496*	*211,252*	*196,365*	*157,940*	*-17%*	*217,791*	*168,140*	*163,826*	*135,198*	*-15%*

ANNEX II: YEAR-ON-YEAR COMPARISON OF UNIT COSTS

	People Protected					Structures Sprayed					Area Sprayed (100 m^2)				
Country	**2012**	**2013**	**2014**	**2015**	**Percent Change 2014-2015**	**2012**	**2013**	**2014**	**2015**	**Percent Change 2014-2015**	**2012**	**2013**	**2014**	**2015**	**Percent Change 2014-2015**
Ethiopia	$3.12	$4.17	$4.31	$5.17	20%	$8.59	$10.71	$10.64	$12.15	14%	$8.97	$11.02	$11.36	$13.34	17%
Zambia			$3.06	$3.75	22%			$14.97	$18.36	23%			$21.78	$27.92	28%
Rwanda	$3.94	$5.43	$6.41	$4.94	-23%	$17.08	$23.22	$26.27	$20.26	-23%	$12.15	$15.16	$16.15	$12.02	-26%
Mozambique	$1.70	$2.11	$2.12	$5.29	150%	$8.59	$11.14	$11.09	$25.59	131%	$4.73	$5.61	$5.40	$13.29	146%
Benin	$3.93	$4.32	$4.32	$4.17	-4%	$14.54	$13.11	$13.43	$13.23	-1%	$15.54	$23.91	$30.87	$29.29	-5%
Madagascar	$2.61	$4.06	$4.62	$4.71	2%	$12.52	$18.79	$22.02	$19.30	-12%	$21.00	$32.43	$26.37	$42.16	60%
Avg. Large Programs	*$3.06*	*$4.02*	*$4.14*	*$4.67*	*28%*	*$12.26*	*$15.39*	*$16.40*	*$18.15*	*22%*	*$12.48*	*$17.62*	*$18.65*	*$23.00*	*37%*
Ghana	$4.61	$7.83	$6.97	$7.22	4%	$12.22	$21.17	$19.38	$19.43	0%	$22.46	$38.66	$35.40	$35.33	0%
Zimbabwe			$13.09	$11.62	-11%			$29.61	$26.20	-12%			$26.14	$23.17	-11%
Mali	$5.54	$6.07	$6.23	$9.19	48%	$20.45	$22.55	$22.85	$34.02	49%	$21.87	$22.10	$23.18	$31.07	34%
Senegal	$4.14	$5.72	$5.60	$6.46	15%	$14.76	$19.05	$19.46	$25.54	31%	$16.96	$24.26	$26.40	$33.92	28%
Avg. Medium Programs	*$4.76*	*$6.54*	*$7.97*	*$8.56*	*13%*	*$15.81*	*$20.92*	*$22.83*	*$26.15*	*17%*	*$20.43*	*$28.34*	*$27.78*	*$30.75*	*12%*