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Independent Development Evaluation
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*From **experience** to **knowledge**...*
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*From **action** to **impact***

Impact Evaluation of the AfDB-Supported Small-Scale Irrigation Projects in Malawi

Summary Report

AFRICAN DEVELOPMENT BANK GROUP

September 2020

An IDEV **Impact Evaluation**

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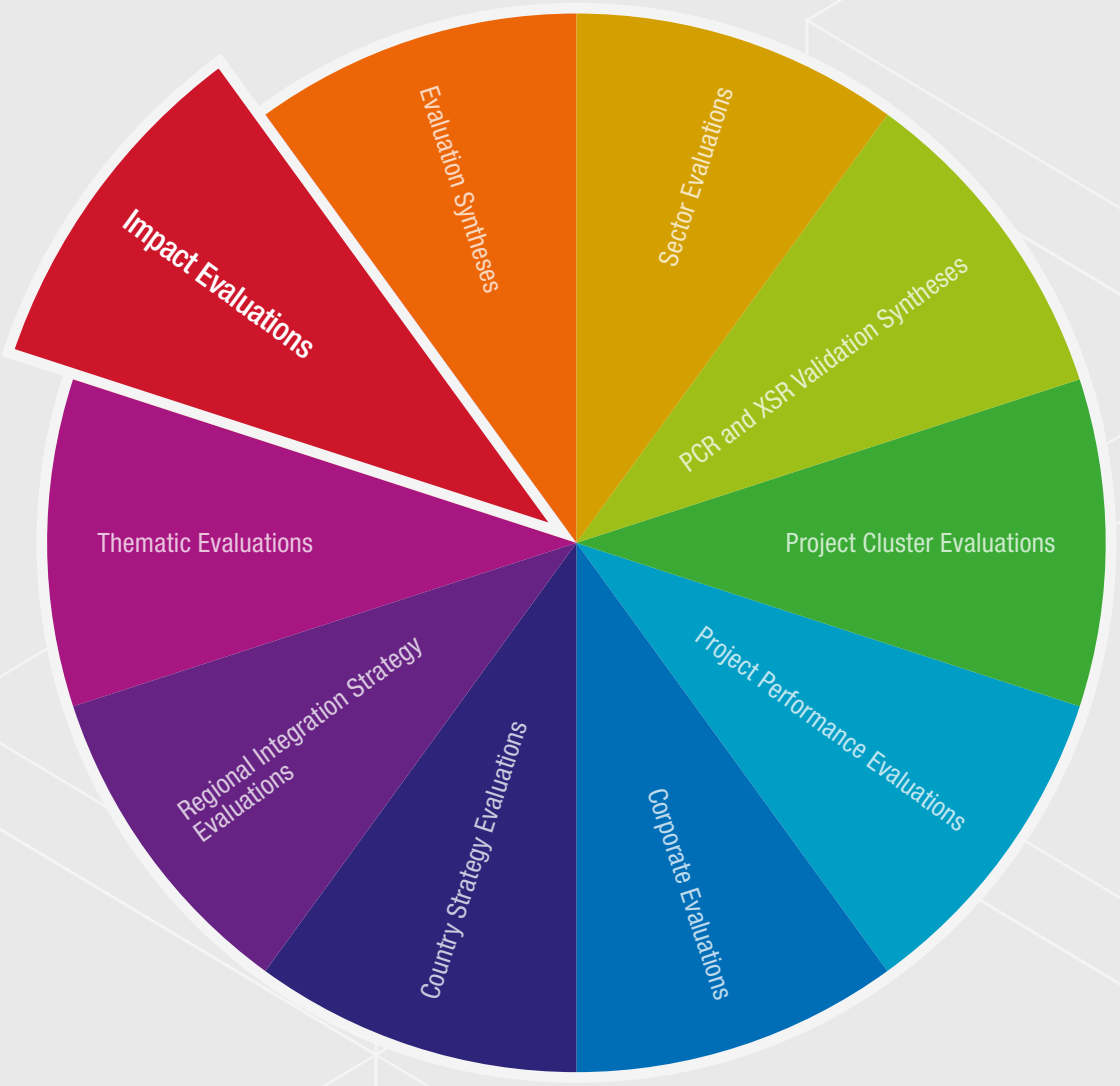

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AFRICAN DEVELOPMENT BANK GROUP

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An IDEV **Impact Evaluation**

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An IDEV Impact Evaluation, September 2020

About the AfDB

The overarching objective of the African Development Bank Group is to spur sustainable economic development and social progress in its regional member countries (RMCs), thus contributing to poverty reduction. The Bank Group achieves this objective by mobilizing and allocating resources for investment in RMCs and providing policy advice and technical assistance to support development efforts.

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The mission of Independent Development Evaluation at the AfDB is to enhance the development effectiveness of the institution in its regional member countries through independent and instrumental evaluations and partnerships for sharing knowledge.

Independent Development Evaluation (IDEV)

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Abbreviations and Acronyms

ADF	African Development Fund
AfDB	African Development Bank
AHAI.2	Agriculture Research, Production and Sustainability
AHFR.2	Rural Infrastructure Development
AISP	Agriculture Infrastructure Support Project
ATE	Average Treatment Effects
CI	Cropping Intensity
COMW	Country Office of Malawi
ECVP	Chief Economist/Vice Presidency for Economic Governance and Knowledge Management
ESR	Endogenous Switching Regression
FGD	Focus Group Discussion
GoM	Government of Malawi
HDDS	Household Dietary Diversity Score
HFIAS	Household Food Insecurity Access Scale
IMP	Irrigation Master Plan
IPWRA	Inverse Probability Weighting Regression Adjustment
KII	Key Informant Interviews
MPI	Multidimensional Poverty Index
PCR	Project Completion Report
PSM	Propensity Score Matching
RDGS.2	Regional South Sector Manager 2
SCPMP	Smallholder Crop Production and Marketing Project
UA	Unit of Account
WUA	Water User Association
WUG	Water User Group

Executive Summary

Introduction

This summary report presents the findings, conclusions, lessons and recommendations of an impact evaluation by the African Development Bank (AfDB, or the Bank) support to two irrigation infrastructure development projects in Malawi: Smallholder Crop Production and Marketing Project (SCPMP) and Agriculture Infrastructure Services Project (AISP). The two projects, each worth UA 15 million, were completed in 2014 and 2017, respectively. This report is prepared based on detailed technical reports.

What was the purpose and objectives of the evaluation?

The purpose of the impact evaluation was to generate lessons and provide recommendations to maximize the impact of ongoing and future irrigation development interventions. The objectives were to: i) estimate the impact of AfDB supported irrigation development interventions on key intermediate outcomes – yield, diversification, and crop intensity, and final outcomes – poverty reduction, food security, health and child nutrition; ii) identify explanatory factors that affect the development outcomes of these projects; and iii) generate lessons and provide recommendations for improving the impact of ongoing and future irrigation development interventions. The overarching evaluation question was, "what is the difference made by the Bank-supported irrigation projects in Malawi?"

What was evaluated by IDEV?

The impact evaluation covered the two aforementioned projects, SCPMP and AISP. The projects aimed at increasing agricultural productivity, farm income and food security in the project areas. Both projects provided a package of irrigation infrastructure and other complementary interventions such as capacity building of farmers and staff, storage facilities and market centers, and supporting the establishment of farmer organizations. The evaluation estimated the average impact of all components of the projects on development outcomes, that is, the estimation results reflect mainly the combined impact of all components of the projects.

How was the evaluation conducted?

The impact evaluation applied mixed evaluation methods comprising of quantitative and qualitative approaches. In quantitative methods, IDEV carried out household surveys in 1,800 households in 36 communities. To carry out the analysis, Endogenous Switching Regression (ESR) and Inverted Probability Weight Regression Adjustment (IPWRA) models were used to control for unobserved heterogeneity and selection bias. In qualitative methods, 14 sessions of Key Informant Interviews (KII) and 10 Focus Group Discussion (FGD) sessions took place in purposively selected six irrigation schemes across Malawi.

The results of the estimation had three limitations: i) there was no baseline data to capture changes over a period of time; ii) potential selection bias; and iii) results show only the average effect of all components of the projects.

What is the impact of irrigation projects on farmers' livelihoods?

The evaluation found positive results of the impact of irrigation projects on crop productivity. It estimated that the projects led to positive and statistically significant increases in maize yields (by 36%) and total crop productivity (by 72%).

It also found that participating farmers increased their revenues from crop production. The evaluation estimated that revenue from maize and vegetables production increased by 103% and 159%, respectively. These figures also show that the rate of increase in revenues from vegetable farming was more than the rate of increase in revenues from maize production in irrigation interventions. In addition, farmers indicated that vegetables fetched better selling prices than maize. The introduction of irrigation projects also increased total crop revenue by 120%.

While the irrigation projects had a positive impact on crop diversity, crop intensity did not change as expected. The findings show statistically significant positive effects of irrigation on crop diversification, i.e. number of crops grown. The estimated indicator for crop diversification, the Simpson Diversity Index, was 0.05 points higher for households in the treatment group. However, there was no evidence to show that the irrigation projects increased Cropping Intensity (CI), i.e. the number of times a piece of land is cultivated. Interviews with key informants and FGDs revealed the reasons for the lack of effects on crop intensity. First, underutilization of irrigation facilities due to poor governance and land conflicts; second, lack of ownership by farmers, and thirdly, absence of markets for the agricultural produce.

Irrigation activities improved food security where effective local leadership and markets existed. The findings show that Average Treatment Effects (ATE) of participation in irrigation on the Household Food Insecurity Scale (HFIAS) was statistically significant as expected. The estimated result showed that food insecurity had marginally reduced by 0.79 (on the 27-point scale) for households who participated in irrigation projects compared to who did not. This decrease in food insecurity is a result of both increased availability of food through increased productivity and food purchased using the increased revenues. The impact on Household Dietary Diversity Scale (HDDS) was also positive and statistically significant implying that participation in irrigation activities increased the diversity of diets. Households that participated in irrigation projects had a dietary diversity score of 0.55 higher than households that did not participate in the projects. Evidence from the FGDs and KIIs revealed that food security improved only for households covered by well-functioning irrigation schemes and good community leadership. Where the irrigation schemes are non-functional, the beneficiaries reported a deterioration in their food security status.

The evaluation found no evidence of impact of the irrigation projects on child nutrition. The results indicated that the treatment effects on child nutrition status was not statistically significant, which suggests that irrigation projects did not improve child nutrition. This may imply that other factors such as food safety and hygiene, knowledge of nutrition in food preparation, the health situation of children and other social factors are vital to improve child nutrition.

The results also indicated unexpected negative impact on health. The evaluation showed that participation in irrigation increased the incidence of illness in the households who participated in irrigation farming by 1%, which is statistically significant. This may be due to the conducive environment created by irrigation infrastructure for vector-borne diseases such as malaria and bilharzia. This fact was also supported by the projects' completion reports.

The evaluation demonstrated that Bank-supported irrigation projects had the desired effects on poverty reduction. Statistical evidence showed that, with irrigation development projects, expenditure per capita increased by about 42% and income per capita by 34%. There was also a reduction in multidimensional poverty when households participated in irrigation development projects. These results showed that irrigation projects reduced both income poverty and multidimensional poverty of the farmers' households. Additionally, in subjective poverty measures, the evaluation found that participation in irrigation projects had the desired effect on self-reported improvements in poverty and well-being.

How are the irrigation benefits distributed among farmers?

Gender: **Male-headed households had better intermediate development outcomes than female-headed households.** The estimated effects of irrigation on maize yield and revenue, vegetable revenue and total crop revenue were higher for male-headed households. For example, irrigation projects increased maize yield for male-headed households by 40% and for female-headed households by 22%. Similarly, the rate of increase in total crop revenues was higher for male-headed households: 127% increase compared to 118% for female-headed households. This may indicate the existence of a gender gap in the distribution of benefits obtained from irrigation development, which deserves further attention.

Although male-headed households earned more income per capita from irrigation, it is female-headed households who experienced higher welfare change. The estimates showed that the irrigation effects on per capita expenditure was higher for female-headed (38%) than for male-headed (16%) households. However, the effects on income per capita was greater for male-headed (32%) than for female-headed (26%) households. This may be an indication that female-headed households focused more on meeting basic needs and spent more to improve the welfare of the household.

Land size: **Land-constrained households benefited the most in terms of maize yield from the irrigation activities.** The evaluation estimated that the increase in maize yield was 55% for relatively smaller landholdings compared to 35% for relatively large ones. That is, the effects of irrigation on maize yields was smaller in relatively larger land holdings. However, the finding on poverty estimates showed that households with relatively larger land holdings had lower levels of multidimensional poverty.

Are development benefits from the projects sustainable?

The sustainability of development outcomes of the two Bank-supported irrigation projects was **highly unlikely.** Under these projects, many irrigation schemes and market storages were either partially used or not entirely functional. Interviews with beneficiaries revealed that market storage facilities were merely "shelters from rain" rather than serving as market infrastructure. Several reasons contributed to this: i) poor irrigation schemes' design, ii) weak organizational capacity of farmers – including poor leadership, iii) lack of market for agricultural products, iv) conflicts among beneficiaries on land and water resource management (upstream and downstream), and iv) beneficiaries' sense of dependency for farm inputs and irrigation schemes' maintenance.

Lessons

1. **Inadequate attention to the capacity and governance systems of local institutions undermines achievement of sustainable outcomes from irrigation development.** The evaluation found that weak organizational capacity and leadership problems hindered proper functioning of irrigation schemes. The Water User Associations (WUAs) or Water User Groups (WUGs) are the direct beneficiaries of

the irrigation schemes and are entrusted with the responsibility to maintain and operate them. Due to the weak capacity and lack of required legal status, these local organizations are unable to enforce rules for operating the schemes requisite to ensure sustained benefits. In addition, these organizations have the potential to influence the mindset of farmers towards taking up commercial farming, which is a shift from subsistence farming to farming as business. Thus, Bank support to enhance the capacity and governance systems of these local institutions could contribute to the effective use of the existing irrigation infrastructures and thereby yield sustainable development benefits.

2. **Building market infrastructure is necessary but not a sufficient condition to create markets for farmers.** The Bank supported construction of irrigation and other infrastructures related to marketing, such as market centers and storage facilities. However, the evaluation found that irrigation did not increase crop intensity, i.e., the frequency of use of a piece of land in a given year. Moreover, most of the market infrastructures remained unused. This is because although the irrigation schemes increased agricultural yield, it was difficult for farmers to find markets for their produce. The farmers lost interest in production as they failed to find a market, leading them to cultivate for subsistence only. It is essential that these infrastructures are adequately integrated into the country's marketing system so that the improved yield leads to sustainable incomes and livelihoods.

3. **Technical quality of the construction designs of irrigation schemes should be ensured to enhance the effectiveness of the projects' outcomes.** The evaluation found that faulty construction designs of irrigation schemes led to the underutilization of such schemes which in turn led to suboptimal agricultural production. For example, in the Mlambe scheme, which remains very active, the irrigation water can reach only part of the irrigable land due to design issues. Other schemes faced similar issues, which reduced their effectiveness e.g. pipe laying at the water intake was on a higher position, which made pumping difficult.

4. **Irrigated farming and resultant improved food security and food diversity may not necessarily lead to improvement in child nutrition.** The evaluation found that child nutrition did not improve in the project areas despite improvement in food security and food diversity. In order to enhance nutritional status of children, the irrigation project designs would need to provide targeted complementary interventions. Further studies are required to identify such interventions and incorporate them into project design.

5. **Empowering women to participate in irrigated farming can improve ultimate development outcomes, i.e., poverty reduction and household welfare.** The evaluation found that female-headed households spent more to satisfy the household's daily needs and the effect of irrigation on their per capita expenditure was statistically significant and higher compared to the male-headed households. Interestingly, the level of poverty reduction was found to be statistically significant only for female-headed households. However, the findings also show that the total income earned was higher for male-headed households compared to female-headed households. It is essential to further explore the underlying causes of this gender gap in the participation in irrigation farming and address them in project designs to further empower women farmers and maximize their benefit. This includes not only the participation of women in training activities but also their access to irrigation land and finance for the purchase of inputs, which requires policy dialogue with the government and other stakeholders.

Recommendations

Recommendation 1. Support capacity and governance systems of local institutions. The Bank should support institutional capacity building, including the governance systems of WUAs or WUGs, who are the direct beneficiaries of the irrigation schemes and entrusted with the responsibility of maintaining and operating the irrigation schemes. Capacity building should include: i) training for members of the associations or groups in financial management; ii) procedures for getting legal status; iii) commercial farming; iv) scheme management; and v) agronomic practices. In this approach, the Bank should first ensure the use of existing infrastructures before embarking on similar interventions in Malawi.

Recommendation 2. Enhance agricultural market access. The Bank should support agricultural market access by going beyond building marketing infrastructures to linking them to the wider agricultural market for farm produce. This will require: i) the coordination of actors along value chains; ii) the establishment of a framework to support producers in meeting quality standards; iii) marketing information; and iv) support in establishing fair conditions for contract farming. To benefit from a greater synergy, the Bank should partner with the government and other key actors to support market creation thereby ensuring sustainable income for farmers.

Recommendation 3. Engage in knowledge work and policy dialogue. The Bank should engage quickly in policy dialogue with governments and other stakeholders on sector policy issues including: i) land tenure; ii) knowledge and support services systems in irrigated farming; and iii) gender equality. To engage effectively in policy dialogue, the Bank should invest in analytical and knowledge work to better understand the complexities of the sector policy issues. Land tenure systems would require reforms to embrace poor farmers with relatively small landholdings. Better understanding of the power and social relations in the community would help bridge the existing gender gap. The Bank's dialogue with the government should urgently focus on fixing the design and operational problems of the existing irrigation schemes and provision of support services to maximize and sustain the benefits of irrigated agriculture.


Republic Of Malawi
Ministry of Agriculture, Irrigation and Water Development
Agriculture Infrastructure Support Project
Bwanje Irrigation Scheme
Funded by African Development Bank

Management Response

In 2019, the Bank's Independent Development Evaluation Department (IDEV) conducted an impact evaluation on the Bank's financed projects in Malawi. The study selected two projects, the Smallholder Crop Production and Marketing Project (SCPMP) and the Agriculture Infrastructure Support Project (AISP). The evaluation aims to improve knowledge and provide lessons that maximize the impacts of ongoing and future irrigation development interventions. Overall, Management agrees with the evaluation's lessons, conclusions and recommendations. The recommendations are particularly timely since Management is currently preparing the mid-term review of the Malawi Country Strategy Paper (2018-2022). The evaluation report will also inform new programs/projects in the region including establishment of the Special Agro-Industrial Processing Zone (SAPZ) in Malawi.

Introduction

Management welcomes the independent evaluation of the irrigation projects in Malawi. It provides guidance on areas that require attention by the Bank, the Government of Malawi and sector departments. Management is encouraged that IDEV found that the Bank supported irrigation projects had positive impacts on many development outcomes: maize productivity increased by 36% and revenue from vegetables and maize increased by 159% and 103% respectively. The project also demonstrated positive effect on poverty reduction as a result of increased expenditure (+42%) and increased income per capita (+34%) for the participating households.

The findings also showed positive effects of irrigation on crop diversification but failed to demonstrate that the irrigation projects increased cropping intensity (the number of times a piece of land is cultivated). Irrigation activities have also improved food security where effective local leadership and markets exist. On the other hand, the evaluation found no evidence of the impacts of irrigation projects on child nutrition and unexpected negative impacts on health.

Key lessons from the impact evaluation are summarised below:

- Inadequate attention to the capacity and Governance systems of local institutions undermines the achievement of sustainable outcomes from irrigation projects.
- Building market infrastructure is necessary but not enough condition to create markets for farmers.
- Technical quality of construction designs of irrigation schemes should be ensured to enhance the effectiveness of the project's outcomes.
- Irrigated farming and resultant improved food security and food diversity may not necessarily lead to improvement in child nutrition.
- Empowering women to participate in irrigated farming can improve ultimate development outcomes, i.e. poverty reduction and household welfare.

The evaluation's recommendations will inform the upcoming Malawi CSP Mid-Term Review and shall contribute to the overall improvement of the Malawi portfolio especially for the ongoing irrigation projects. The recommendations will also be critical in the design of future operations in the agriculture and water sectors.

While the outcomes of the evaluation are useful to Malawi, the lessons from this evaluation report will also inform regional and continental programs/strategies and policies in order to maximize the benefits from any large-scale irrigation investments. The Agriculture and Agro-Industry Department (AHAI) and the Agriculture Finance and Rural Development Department (AHFR) will use the outcomes of this evaluation in their pre-feasibility studies of the Special Agro-Industrial Processing Zone for Malawi. The SAPZs concept is summarized in the Box 1 below.

Cross Cutting Issues

Management welcomes and agrees with the findings on gender inequalities, access to land and failure by the investments to address child nutrition.

Gender. The evaluation found that male headed households have better intermediate development outcomes than female headed households. Thus, the estimated effects of irrigation on maize yield and revenue, vegetable revenue and total crop revenue were higher for male-headed households. For example, irrigation projects increased maize yield for male headed households by 40 % and for female headed by 22% according to IDEV Report. This may indicate existence of a gender gap in the distribution of benefits from irrigation.

The Bank is currently carrying out a gender profile study to inform sector dialogue and improve on gender participation and benefits in future Bank's interventions. Management will continue to ensure that any new operation under ADF-15 mainstream gender with clear baselines and targets and regularly monitor their implementation.

Land holding size. Management acknowledges the challenge faced by the agricultural sector in terms of access to land and security of tenure, either by leasing land or owning land since these are critical for investments in agriculture and support land consolidation. Security of tenure must be considered the main intervention and starting point to ensure that tenure is formally recognised and protected against illegal claims of land rights, for a successful land consolidation by the smallholder farmers. The Bank supports land consolidation by the smallholder farmers in order to enhance commodity aggregation, competitiveness and increase in the economies of scale. A case in point is the Shire Valley Transformation Program in Malawi where smallholder farmers will be given security of tenure (leasing or ownership) and grouped into cooperatives with their secured land aggregated to not less than 500 hectares per cooperative. Management will also use the evaluation findings in the designing of the future operations by ensuring that land governance issues are mainstreamed including land tenure issues. Currently Management is preparing land policy briefs for Malawi to find ways of expediting and scaling up the implementation of the 2016 land laws. The Bank is also mainstreaming land governance in the Agriculture Investments programs and projects in several regional member countries (see Box 2).

Box 1: Special Agro-Industrial Processing Zones will Boost Agricultural Productivity

SAPZ is an agro-based spatial development initiative designed to concentrate agro-processing activities within areas of high agricultural potential to boost productivity and integrate production, processing and marketing of agricultural commodities.

It aims to increase production efficiency and provide a dedicated alternative market for agricultural producers and inputs suppliers. SAPZ is purposely built on shared facilities, with the aim of enabling agricultural producers, processors, aggregators and distributors to operate within the same vicinity to reduce transaction costs, share economies of scale and benefit from shared business development services for increased productivity and competitiveness.

SAPZ also aims to bring adequate infrastructure (irrigation, energy, water, roads, ICT etc.) to rural areas of high agricultural potential and attract investments from private agro-industrialists/entrepreneurs to contribute to the economic and social development of the rural economy.

Box 2: Mainstreaming Land Governance in Regional Member Countries

Burundi-the Bank's focus is on land restoration and provision of security of tenure;

South Africa-Land related activities have been incorporated into the Bank's COVID 19 Response Programme;

Namibia-the Bank managed to develop a Mid-term to long term COVID 19 response plan that will address existing land sector vulnerabilities and reduce failures that might result in low investment in agriculture, and a low level of farm modernization.

Madagascar-the Bank is supporting the development of a local land use maps and provision of Tenure security (land certificates based on developed local land use maps) to small-scale farmers.

Child nutrition. Management agrees that the irrigation investments failed to improve child nutrition. Management notes that nutrition is a critical outcome for any agricultural operation and as such needs to be considered as one of the non-lending priority areas during the CSP mid-term review. Furthermore, Management will investigate the underlying causes of this finding and identify the complementary interventions that could lead to improved child nutrition and health from irrigation investments. These findings will inform the on-going and future operations on how effective food utilization could be attained. The on-going projects include Agriculture Infrastructure and Youth in Agribusiness Project (AIYAP), Multinational Post Cyclone Idai and Kenneth Emergency Recovery and Resilience Program (PCIREP) and the Sustainable Fisheries, Aquaculture Development and Watershed Management (SFAD-WM).

Impact of Irrigation Projects on Livelihoods

The failure by the irrigation investments to increase the crop intensification as desired during the project appraisals is due to structural constrains which included design flaws, land tenure issues, and weak farmer organizations. The evaluation findings also agree with the findings of the Bank's Project Completion Reports on the two projects under evaluation (Smallholder Crop Production and Marketing Project & Agriculture Infrastructure Support Project) conducted in 2016 and 2017 respectively. Management will ensure that these issues are fully addressed in the on-going and future operations for the farmers to realize maximum benefits from the investments.

Sustainability of Development Benefits

Management acknowledges the challenges highlighted in the evaluation report such as underutilization of the irrigation and markets and storage facilities due to weak governance systems at irrigation scheme level, inadequate designs, lack of markets and farmers dependency syndrome on subsidies. Management is currently addressing the governance gaps and markets in the on-going Shire Valley Transformation Program Phase 1 through strengthening the management structures of cooperatives by including professional staff to guide farmers in agronomic practices and business management. In addition, land consolidation and linkages with large scale companies will be enhanced under the project in order to improve access to markets.

The Bank has started developing SAPZs in the Regional Member Countries. Management will continue to consider the establishment of a Special Agro-Industrial Processing Zone. This will comprehensively provide the required markets for farmers including contract farming through off taker agreements, improve agronomic production practices and market access, quality and standards and provide the basis for vibrant farmer associations and value chain financing.

Management also notes the challenges related to land conflicts, power and social relations and the negative effects on child health and nutrition. In this regard the Malawi Country Office has identified possible entry points for discussions with Government which include institutional and capacity building support to the Ministry of Lands, supporting the construction of customized district land registries that will fast track tenure security interventions, civic education and awareness and mainstreaming of land governance in future investment programs and projects. The on-going Malawi Gender Profile Study and planned Child Health Nutrition study will contribute to addressing the challenges on power and social relations as well as findings ways of improving the impact of irrigation investments on child health and nutrition.

Management is also putting more emphasis on the inclusion of the catchment conservation in order to ensure that the infrastructures constructed downstream are more resilient and sustainable. Issues of water drainage and other environmental and social safeguards are well addressed in the design of current irrigation operations and the same will apply to future operations.

Management will also continue engaging Government and other key stakeholders on analytical and knowledge work on the complex issues affecting the agricultural sector.

Conclusion

The valuable lessons and recommendations in the IDEV's evaluation report will further strengthen dialogue with Government to provide enabling environment for future investments and sustained benefits. Management will share the findings of the IDEV report with Government, Development Partners and other stakeholders for effective implementation of the outcomes of the evaluation. At the sector level, the evaluation report will inform the pre-feasibility studies for the establishment of the Special Agro-Industrial Processing Zones (SAPZ) for Malawi.

Management Action Record	
Recommendation	**Management's Response**
Recommendation 1 - *Support capacity and governance systems of local institutions*	
The Bank should support the institutional capacity building including the governance systems of water user's associations or water user groups, which are the direct beneficiaries of the irrigation schemes and entrusted with the responsibility of maintaining and operating the schemes. Capacity building will include training of members of the associations or groups in financial management, procedures for getting legal status, commercial farming, scheme management and agronomic practices. In this approach, the Bank should first ensure the use of existing infrastructures before embarking on similar interventions in Malawi.	**AGREED.** Management agrees with the recommendation and proposed actions and suggests the following measures: **Country Specific Actions:** ▪ Malawi Country office (COMW) will ensure that Waters Users Associations established under the on-going projects are adequately trained in best agronomic practices, operation and maintenance, financial management and leadership skills and acquire water and land legal rights for sustainability and effective management of the water infrastructures developed **(COMW, Q4 2021)**. ▪ COMW will engage Government of Malawi as part of the upcoming Country Strategy Paper Mid Term Review to ensure that institutional capacity building of the Ministry of Lands; construction of customized district land registries; and civic education and awareness are embedded in future operations **(COMW, Q4 2022)**. **Sector Level Action:** ▪ COMW will finalize the land policy brief (Q4, 2020) that will analyse the Malawi's land tenure system, the existing bottlenecks and how they affect agricultural productivity. Subsequently, the Department of Agriculture and Agro-Industry (AHAI) will identify different financing options including Trust Funds to support the implementation of the recommended actions from the land policy brief **(AHAI, Q3 2022)**.

Management Action Record	
Recommendation	**Management's Response**
Recommendation 2 - *Enhance agricultural market access.*	
The Bank should support agricultural market access by going beyond building marketing infrastructures by linking them to the wider agricultural market for farm produce. This will require coordination of actors along value chains, the establishment of a framework to support producers in meeting quality standards, marketing information and support to establishing fair conditions for contract farming. To benefit from greater synergy, the Bank should partner with the government and other key actors to support market creation and thereby ensure sustainable income for farmers.	**AGREED**. Management agrees with the recommendation and acknowledges the need to address the challenge on market access. One of the key areas to address this challenge is to undertake a full diagnostic study to provide a clear strategy for Special Agro-Processing Zones development. **Country Level Actions:** ▪ COMW will facilitate the establishment of the Risk Sharing Facility under the ongoing Agriculture Infrastructure and Youth in Agribusiness Project (AIYAP) to enhance access to agro-processing equipment (in kind loans) by agripreneurs who will eventually create market for the smallholder farmers' produce **(COMW, Q4 2021)**. ▪ COMW will advise the Government of Malawi to utilize the market depot constructed under the Agriculture Infrastructure Support Project and to expand the coverage of the Information Communication Technology and Value Chain Governance Platform (ICT-VCG) (electronic platform) established under the Smallholder Irrigation and Value Chain Project (SIVAP) to at least 15 districts, in order to link the producers, including the smallholder farmers and buyers **(COMW, Q3 2022)**. **Sector level Actions:** ▪ Agriculture Finance and Rural Development Department (AHFR) will mobilize resource for a diagnostic study and identify co-financing options for a Special Agro-Industrial Processing Zone from bilateral donors and Multilateral Development Banks in Malawi **(AHFR, Q3 2021)**. ▪ Agriculture Finance and Rural Development Department (AHFR) will ensure that Special Agro-Industrial Processing Zones are prioritized in the next CSP for Malawi and in selected Regional Member Countries, with a view to improve market access **(AHFR, Q3 2023)**.
Recommendation 3 - *Engage in knowledge work and policy dialogue.*	
The Bank should engage quickly in policy dialogue with governments and other stakeholders on sector policy issues including land tenure, knowledge and support services systems in irrigated farming, and gender equality. To engage effectively in policy dialogue, the Bank should invest in analytical and knowledge work to better understand the complexities of the sector policy issues. Land tenure systems would require reforms to embrace poor farmers with relatively small landholdings. Better understanding of the power and social relations in the community would help bridge the existing gender-gap. The Bank's dialogue with the government should urgently focus on fixing the design and operational problems of the existing schemes and provision of support services to maximize and sustain the benefits of irrigated agriculture.	**AGREED**. Management agrees with this recommendation and recognizes the urgent need to engage Government on sector policy issues: COMW will share the findings of IDEV report with Government and Development partners before the end of Q4. Management suggests the following specific actions to be undertaken: **Country level Actions:** ▪ COMW: The findings of the Evaluation will be shared with the Government, Development Partners and other relevant stakeholders to enhance the Bank's evidence- based sector /policy dialogue as well as to inform designs of future irrigation interventions financed by the Bank and non-Bank stakeholders. **(COMW, Q4 2020)**. ▪ COMW will ensure that the upcoming CSP MTR (Q4, 2020) and future operations in the sector (Q4, 2023) will be informed by the outcomes of the land policy brief, gender profile study and the irrigation impact evaluation **(COMW, Q4 2023)**. ▪ COMW will conduct a child health and nutrition study to further investigate and identify appropriate complementary interventions to inform future irrigation investments **(COMW, Q4 2021)**.

Introduction

This summary report presents the findings, conclusions and recommendations of an impact evaluation of the African Development Bank's (AfDB, or the Bank) support to the Smallholder Crop Production and Marketing Project (SCPMP) and the Agriculture Infrastructure Services Project (AISP) in Malawi. The two projects, each worth UA 15 million, were completed in 2014 and 2017, respectively. This report is prepared based on detailed technical reports and is laid out in eight sections:

Section 1 presents the purpose, objectives, scope, questions, and limitations of the evaluation. Section 2 highlights the context of agriculture and irrigation in Malawi. Section 3 provides an overview of Bank's projects covered by this impact evaluation. Section 4 elaborates the methodological approaches. Sections 5 to 7 presents the key findings of the evaluation. Finally, section 8 provides the conclusions, lessons and recommendations.

Purpose, Objectives, Scope, and Questions

The purpose of this impact evaluation was to generate knowledge and provide lessons to maximize the impact of ongoing and future irrigation development interventions. The objectives were: i) to estimate the impact of AfDB-supported irrigation development interventions on poverty, food security, health and child nutrition; and ii) to identify explanatory factors that affect the development outcomes of the projects.

The key evaluation question was to identify the difference made by the Bank's projects. Specific questions were:

- What is the impact of irrigation interventions on intermediate outcomes such as yields, income, crop diversification and crop intensity?
- What is the impact of irrigation interventions on key impact indicators: smallholder farmer's poverty situation, food security, health and child nutrition?
- What are the factors that explain the presence or absence of impact of irrigation interventions on outcome variables?
- Is the impact sustainable?

Both SCPMP and AISP provided packages of irrigation infrastructure and other complementary interventions such as capacity building of farmers and staff, storage facilities and market centers and supporting the establishment of farmer organizations. The evaluation estimates the average impact of all components of the projects on development outcomes. As it is methodologically challenging to separate the impact of each component of the projects in the absence of baseline data, the estimation results reflect mainly the combined impact of all component of the projects.

Limitations of this Impact Evaluation

The main limitations of this evaluation were: i) absence of baseline data – there was no baseline data to make comparison over a period of time, which would have helped to capture the changes over time. The impact estimates are therefore based only on cross-section data; ii) potential selection bias – the projects selected beneficiaries non-randomly to participate in the irrigation farming. This means any systematic differences between irrigation participant and non-participants were not considered, which could lead to biased impact estimators. In such a situation, robustness of the impact estimates depends on the estimation techniques and the identification of comparison groups. The evaluation combined rigorous quantitative methods with qualitative study to mitigate this limitation (see section 4); and iii) both projects provided a package of irrigation infrastructure and other complementary treatments such as capacity building of farmers and staff, storage facilities and market centers, and supporting the establishment of farmer organizations. This implies that it is methodologically challenging to separate the impact of each treatment on outcome variables for post-impact evaluation. Thus, the evaluation estimated the average impact of all components of the projects on development outcomes in the questions.

Agriculture and Irrigation in Malawi

Agriculture remains a priority sector in Malawi's pursuit of economic transformation and poverty reduction. Many Malawians derive their livelihoods from the agricultural sector. Agriculture accounts for 30% of Gross Domestic Product, generates over 80% of national export earnings, and employs 64% of the country's workforce (GoM, 2017 and AfDB, 2018). Agriculture is also the main source of livelihood for more than 90% of the rural population.

The agriculture sector in Malawi is dualistic in nature. The sector comprises both the estate sub-sector and the smallholder sub-sector. The estate sub-sector specializes in the cultivation of high value export crops such as tobacco, tea, sugarcane and coffee. These estates are on leasehold land and own large parcels of land, holding more than 30 hectares per estate. The smallholder agriculture sub-sector remains an important source of livelihood for most of the rural population and approximately 84% of agriculture value-added comes from 1.8 to 2 million smallholder farmers who, on average, own only 1 hectare of land under customary tenure (World Bank, 2003).

The irrigation potential in Malawi remains underutilized. Smallholder farmers mainly focus on rain-fed cultivation producing maize, largely to meet subsistence needs, with limited participation in cash crops. Smallholder farmers cultivate small and fragmented land under customary land tenure with yields lower than those obtained on estates for similar crops (GoM, 2010). Low irrigation development is one of the factors that undermines the productive capacity of the agricultural sector (GoM, 2017). The country has over 600,000 hectares of estimated irrigation potential but only about 103,000 hectares have been developed (MAlWD website). However, more recently, government and non-governmental organizations, with the support of development partners, have been promoting irrigated cropping using various systems such as gravity, solar pump, motorized pumps and treadle pumps.

The country's development strategies, such as the Malawi Growth and Development Strategy II and III, have emphasized the importance of irrigation in agricultural intensification. The strategic intention is to: i) develop and rehabilitate irrigation infrastructure; ii) promote research in irrigation technology; iii) develop potential groundwater resources; and iv) promote user-friendly technologies for water resource conservation and utilization (GoM, 2012 and 2017). Over the years, the Government of Malawi (GoM) and development partners have supported the development and rehabilitation of irrigation schemes. In 2015, the GoM developed the Irrigation Master Plan (IMP) to facilitate coordinated investments in irrigated agriculture (GoM, 2015). Currently, the Government is promoting irrigation through a number of interventions such as the Greenbelt Initiative and the Shire Valley Transformation Program which were identified under the ongoing Malawi Growth and Development Strategy III (2017-2022).

Although several irrigation projects have been implemented in Malawi, there is limited evidence on the impact of such investments on outcome indicators. One of the recent impact assessment studies in Malawi found positive impact of irrigation on incomes, assets, expenditure, rice output and maize output (Ng'ong'ola & Associates, 2015). However, the selection of comparison sites for the study was purposive, raising questions about the external validity of the estimates.

Bank Projects Covered in the Evaluation

The impact evaluation focused on two projects that were financed by the AfDB: The Smallholder Crop Production and Marketing Project (SCPMP) and Agriculture Infrastructure Support Project (AISP), which were completed in 2014 and 2017, respectively. Table 1 shows the key intervention areas of SCPMP and AISP. The projects had the same package of activities, except for construction of community storage facilities in the SCPMP. Since the projects were implemented in different geographical locations, it is unlikely that the same households benefitted from both projects.

The Theory of Change of these projects is presented in Annex 1. The subsection below briefly presents the characteristic and status of the two projects.

Smallholder Crop Production and Marketing Project (SCPMP)

The SCPMP was approved for financing in May 2006 and completed in 2014. The main purpose of the project was to increase productivity, income and nutrition of rural households in the project areas. SCPMP interventions included: i) construction of irrigation infrastructure; ii) development of market infrastructure; iii) farmer support programs such as formation of water user groups for irrigation scheme management; and iv) farmer cooperatives for production and marketing capacity building. Table 2 below summarizes the main results expected and their achievements.

Table 1: Key Design Features of SCPMP and AISP at Project Appraisal

Feature	SCPMP	AISP
Objectives	▮ Agricultural productivity ▮ Smallholder farmer income ▮ Food security	▮ Agricultural productivity ▮ Food security
Activities	▮ Construction of irrigation infrastructure ▮ Construction of community storage facilities ▮ Construction of market centers ▮ Training of farmers and staff in production and marketing ▮ Supporting establishment of Water User Association ▮ Supporting establishment of farmer cooperatives	▮ Construction of irrigation infrastructure ▮ Establishment of market platforms or centers ▮ Training of staff and smallholder farmers or farmer groups or clubs ▮ Supporting establishment of Water User Association ▮ Supporting establishment of farmer cooperatives
Implementation Period	2006-2014	2009-2017
AfDB Support	UA 15 million	UA 15 million
Coverage	6,320 beneficiaries 19 districts	3,350 beneficiaries 7 districts

Table 2: Summary of Key Expected Results and Achievement under the SCPMP

Indicator	Units	Target	Actual	Percentage achieved
Area of irrigated land Small scale irrigation schemes	Hectare Number	3,055 39	1,539 31	50 80
Farmers trained on marketing principles	Number	3,440	7,260	211
Farmers trained on irrigation and crop production techniques	Number	3,600	9,293	258
Water User Associations	Groups	39	23	59
Community storages	Number	26	24	92
Market centers	Number	14	13	93
Cooperatives	Number	23	22	96

Source: SCPMP project completion report and its validation note by IDEV.

The Project Completion Reports (PCRs) show that several project outputs were delivered although most fell short of their targets. Only 1,539 hectares (50% of the target at appraisal) of small-scale irrigation land was developed and 23 (59%) WUAs were established. About 9,293 farmers (258%) were trained in irrigation production techniques with 7,260 farmers (211%) trained in marketing principles. In terms of market infrastructure, 24 community storage facilities and 13 market centers were constructed to support production activities on irrigated smallholder land. The updated list of irrigation schemes under SCPMP obtained during the evaluation shows that seven of the 31 schemes are dysfunctional, mostly motorized pump-based schemes, due to a high cost of fuel. One gravity-fed scheme was dysfunctional due to poor design. Lastly, most of the market facilities were not utilized.

SCPMP supported capacity building for the government technical staff. This included training of 102 district engineers/extension agents on irrigation and crop production, 95 field agents as trainer of trainers, and 212 district staff in marketing principles.

The PCR also showed an increase in maize and rice yields, based on the 2011 national agricultural production survey, as some of outcome achievements. More specifically, maize yield increased from 1.18 tons per hectare to 2.18 tons (186% increase) while rice yield increased from 1.26 tons per hectare to 2.80 tons (222% increase). However, IDEV's validation of the PCR emphasized three issues: i) the extent to which the 2011 survey was representative of the project beneficiaries is unknown; ii) the gains in yield and marketable surplus reflect the situation only in a small proportion of cultivated irrigable lands; and, iii) the PCR's reporting on outcomes was incomplete; for example, it did not cover performance in the proportion of irrigated land, increase in CI, and any change in cropping composition.

Project document reviews identified several factors that affected the project's performance including:

- Inadequate project cost estimation at design stage and increased cost during implementation.

- Some of the completed irrigation schemes were taken over with defects and thus remain non-operational.

- Some of the marketing centers and storages are not in use and some cooperatives were not active. Technical defects that needed to be rectified (poor command of canals/conveyance canals, flood damage etc.), land disputes and inadequate technical support from extension staff contributed to a low utilization of infrastructure.

Agriculture Infrastructure Support Project (AISP)

AISP was approved in June 2009 and was completed in May 2017. Its main objective was to increase agricultural productivity and strengthen food security in the country through increasing irrigated agricultural output and productivity by efficient water management and enhancing the participation of smallholder farmers in commercial agriculture. The AISP was also an UA 15 million African Development Fund (ADF)-funded project, of which 98.6% was disbursed. Table 3 below summarizes the main results expected and their achievements.

The planned outputs of AISP were partially delivered. A total of 1,137 ha (64% under solar pump-based schemes and 36% under gravity fed schemes) were developed against the appraisal target of 2,320 ha. This low achievement is mainly due to protracted land disputes in sugarcane expansion areas and unanticipated high costs of solar technologies. In terms of the market infrastructure component, only six of the 13 market centers and one market depot were constructed.

AISP provided support to capacity building to farmers and scheme operators. AISP trained 175 government staff (32% women) against a target of 45 staff and 6,308 farmers (71% women) against a target of 3,350. It also trained 22 farmers (18 male and 4 females) and 14 solar pump operators (12 male and 2 females) for solar operated irrigation schemes. As the capacity building for farmers surpassed the targets, it may have contributed to the increase in crop productivity.

A total of 11 irrigation schemes and nine WUAs and Cooperatives were established. However, the updated list of project status obtained during the evaluation showed that of the 11 irrigation schemes, four were nonfunctional and the market depot constructed in Lilongwe was not operational. Project document reviews indicated that technical defects, land ownership, inadequate technical support from extension staff, and weak farmer organizations contributed to the low utilization of the constructed infrastructure.

Table 3: Summary of Key Expected Results and Achievement under the AISP

Indicator	Unit	Target	Actual	Percentage achieved
Irrigation development	Hectare	2,320	1,137	49
Capacity building of farmers	Farmer	3,350	6,308	194
Water User Associations	Number	18	11	61
Farmers' cooperative	Number	9	9	100
Market centers	Number	13	6	46
Market depot	Number	1	1	100

Source: AISP PCR and its validation note by IDEV.

Methodological Approaches

This impact evaluation applied mixed-method approaches comprising of quantitative and qualitative studies to address the evaluation questions. In the quantitative studies, an attempt was made to estimate the impact of the irrigation development on key variables of interest (poverty, food security, health and child nutrition) using household and community survey. Qualitative studies helped to get more insights into contextual (social and cultural) issues; the project processes and implementation challenges; governance and challenges of WUAs and cooperatives; and other factors that enabled or constrained the effectiveness and sustainability of the impact of irrigation interventions. The details of both quantitative and qualitative methods are presented in Annex 2 subsection I and II, respectively.

The Evaluation Design

The evaluation used the 'pipeline' approach in determining the counterfactual of the projects. The GoM developed an Irrigation Master Plan (IMP) in 2015, which identifies potential irrigable sites with viable economic returns. This implies that the implementation of irrigation projects from the master plan was carried out in a phased manner. Comparison groups for this impact evaluation were drawn from potentially irrigable sites from the master plan.

The pipeline approach captures the comparison groups which may have similar ecological conditions as that of the treatment group. Although the selection of the projects for implementation from the master list of projects is non-random, as opposed to just selecting any rain-fed farming households without potential for irrigation, it provides good reasons for selecting comparison groups. First, the pipeline projects are evaluated to have positive economic returns which is a condition for such public investment financing. Secondly, pipeline projects provide real prospects of irrigation investments with a feasible water source as compared to choosing rain-fed cultivation areas with low probability of irrigation investment.

Sample Size and Sampling Strategy

The sample size of the evaluation was 1,800 households, with 900 households equally split between treatment and comparison groups. Power calculations were done to determine the sample size. This ensured that reliable estimates of impact were obtained to address the attribution question. Since agricultural productivity was the key driver of the expected changes in incomes, food security and nutrition in both interventions, the evaluation assumed a 20% increase in agricultural productivity (according to the projects' targets) as the impact size in the power calculation.

A multi-stage sampling approach was used in the identification of study areas and households. In the first stage, all irrigation infrastructure investment sites under SCPMP and AISP as well as all potential irrigation sites from the IMP were identified to form a sampling frame. In the second stage, districts that had both treatment and comparison irrigation schemes were identified and purposively selected. Accordingly,12 districts were selected including Chitipa, Nkhata Bay, Dowa, Ntcheu, Blantyre, Thyolo, Phalombe, Mulanje, Chikwawa, Nsanje, Neno and Rumphi. In the third stage, WUAs were selected in the treatment areas and one enumeration area was randomly selected in comparison areas. In the final state, households were selected using systematic random sampling based on the WUA membership list and a complete household listing of the enumeration areas in comparison sites.

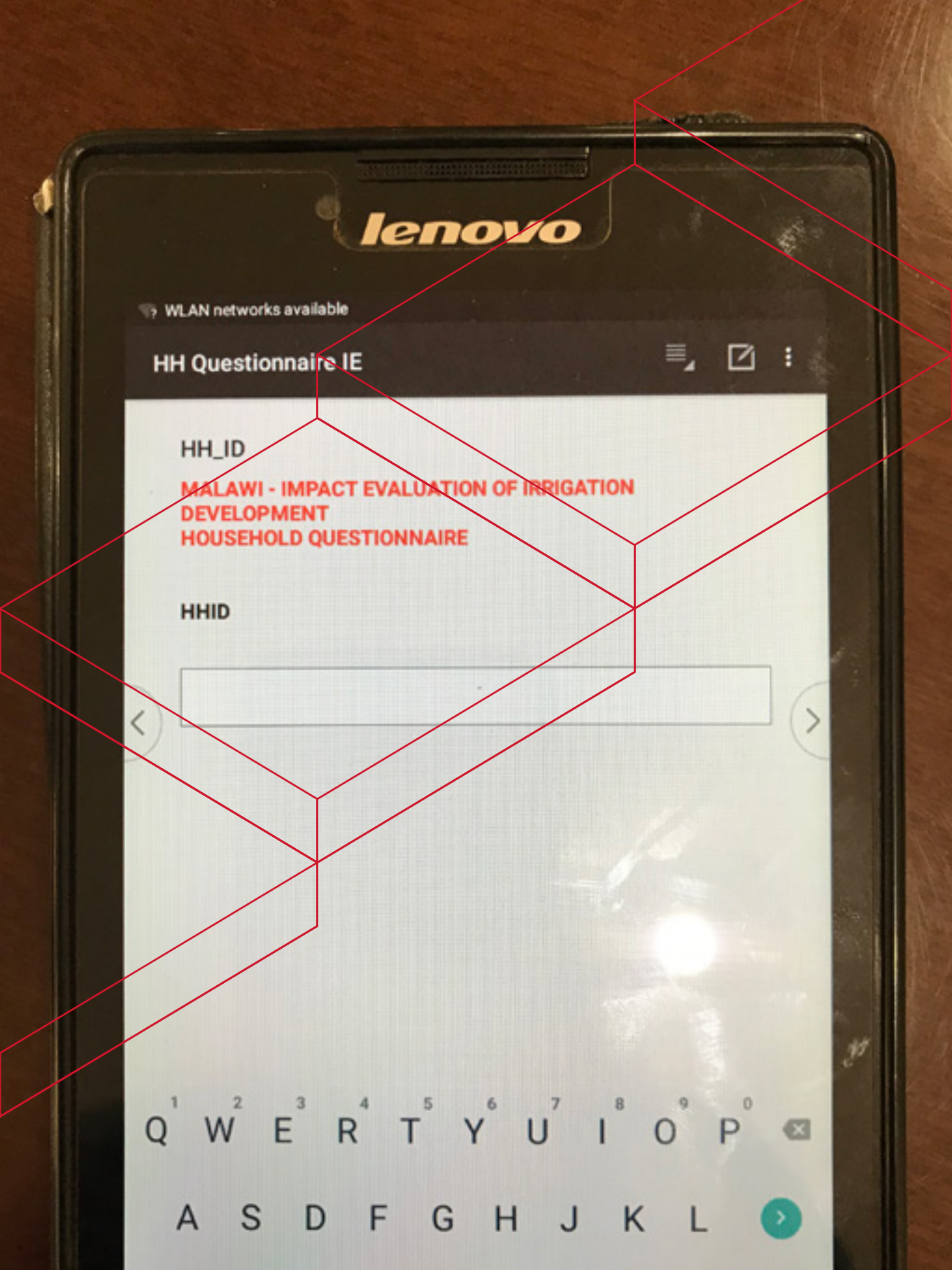
Data Collection

IDEV undertook household and community surveys to generate the required data for the evaluation. The data was collected from selected households and communities in the study areas in 12 districts across Malawi. Data was collected using tablets with the help of enumerators. In addition, the data collection team created a WhatsApp group which helped in sharing experiences and solving problems in real time. The enumerators were trained on the household data collection for this purpose. Pre-test of household questionnaires was done, and lessons were integrated in the final questionnaires. The use of tablets and WhatsApp increased efficiency and quality of data collection. In addition, a qualitative study was undertaken in six schemes to collect information from key informants and focus group discussions.

Impact Estimation Methods

In the absence of baseline experimental data, the evaluation used quasi-experimental methods of evaluation to measure impact of irrigation development interventions. The evaluation used the Inverse Probability Weighting Regression Adjustment (IPWRA) and Endogenous Switching Regression (ESR) models to estimate the level of impact. The IPWRA model generates doubly robust consistent estimates by estimating models of both the propensity score and the conditional mean of the outcome variable; and the ESR model takes into account the endogeneity and selection problem (Paltasingh and Goyari, 2018) by controlling for both observed and unobserved effects. The results are robust across the two methods. The report presents its findings based on estimation results from the ESR model since it controls both for observable and unobservable characteristics that determine participation in irrigation farming. The IPWRA was also used in parallel to show how robust the results were from both models.

The details of both models are presented in Annex 2 the tests for the validity of the models are in Annex 3 and detailed ESR estimation results are in Annex 4.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Did the Bank's Support Make Any Difference to the Farmers' Livelihoods?

In this section, the report presents the main findings of the impact evaluation based on both quantitative and qualitative approaches used during the evaluation process.

Impact on Agricultural Productivity, Income and Crop Diversification, and Crop Intensity

Despite irrigation projects enhancing agricultural productivity and income as well as crop diversification, there was no evidence of improvements in crop intensity. The main constraining factor was the underutilization of irrigation schemes, which in turn was affected by poor scheme governance, faulty scheme designs, lack of markets, and conflicts among beneficiaries.

The Bank supported irrigation-related projects led to improvements in agricultural yield and income. The findings show that the projects led to positive and statistically significant effects on maize yield and revenue, vegetable revenue, and gross crop revenue (Table 4). For example, the estimates indicate an increase of 36% in maize yield, 103% increase in maize revenues, and 120% in total crop revenues. These findings are consistent with other impact evaluations conducted in Malawi, which show that irrigation increased farm incomes and maize output (Jumbe and Nkhata, 2015 and Ng'ong'ola and Associates, 2015).

Farmers growing vegetables had a higher increase in income from irrigated farming than those growing maize. The estimation results show that the average treatment effect of irrigation on revenues from vegetable and maize are 0.95 and 0.71, respectively (Table 4). In other words, farmers who participated in irrigation had increased revenue from vegetables by 159% compared to 103% increase in maize revenue. Thus, the estimated rate of increase in vegetable revenue was higher than the increase in maize revenue. This implies that vegetable production benefits more than maize production in irrigation interventions.

Table 4: Average Treatment Effects of Irrigation on Intermediate Agricultural Outcomes

Outcome Indicator	ESR		IPWRA	
Ln (maize yield)	0.31***	(0.05)	0.32***	(0.05)
Ln (maize revenue)	0.71***	(0.03)	0.37***	(0.06)
Ln (vegetable revenue)	0.95***	(0.09)	0.55***	(0.20)
Ln (Total crop productivity)	0.54***	(0.04)	0.38***	(0.07)
Ln (Total crop revenue)	0.79***	(0.04)	0.37***	(0.06)
Cropping intensity			0.28***	(0.03)
Crop diversification	0.05***	(0.00)	0.05***	(0.01)

Note: Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; Gaps imply that we were unable to generate the endogenous switching regression results because we could not attain convergence in the log likelihood.

Source: Computed from household survey.

The estimation results indicate that the projects under study increased total crop productivity. The impact estimation results reveal that the irrigation projects resulted in statistically significant ATE on total crop productivity. That is, farmers' participation in irrigation projects increased total crop productivity (revenues from all crops) by 72%.

While the projects had positive impact on crop diversification, they did not lead to an increase in crop intensity. The findings show statistically significant positive effects of irrigation on crop diversification (number of crops grown). The estimated indicator for crop diversification, the Simpson diversity index, was 0.05 points higher for households in the treatment group. However, there was no evidence to show that the irrigation projects increased cropping intensity (number of times a piece of land is cultivated). Focus group discussions and interviews with key informants revealed several reasons for this finding including: i) underutilization of irrigation facilities due to weak governance and land conflicts; ii) lack of market access for the agricultural produce (Box 3); iii) weak scheme designs; and iv) conflicts among beneficiaries.

Impact on Food Security, Child Nutrition and Health

Overall, the evaluation findings indicated that beneficiaries of the irrigation projects achieved improved food security status of households where irrigation schemes functioned properly. However, the evaluation found no evidence of impact on child nutrition. In addition, there was also an indication of undesired negative effects on health of the farmer households.

This impact evaluation attempted to capture the impact of the projects on food security, health and child nutrition of the beneficiary households. The impact on food security was estimated using Household Food Insecurity Access Scale (HFIAS) and Household Dietary Diversity Score (HDDS). The impact on household health was estimated using the incidence of illness in the household while the impact on child nutrition was estimated based on anthropometric measures. The anthropometric measures were dichotomized to reflect a child being malnourished as a health indicator or not, i.e., stunting, underweight, and wasting. Table 5 presents the impact estimation results.

Box 3: The Availability of Agricultural Markets is a Vital Signal for Incentivizing the Farmers

According to the evidence from the focus group discussions in the six irrigation schemes, news about the availability of markets for their produce was one of the biggest motivators at the time of establishing the schemes. That is, the farmers had been told that markets were readily available if they joined the schemes. However, when the markets were rare after the schemes were established, some of the beneficiaries were frustrated since they were obliged to sell their produces at low prices due to the absence of markets. This challenge was heavily expressed in Mulanje (Kambenje scheme), Dowa (Chimutu scheme) and in Rumphi (Chigamukire scheme). On the other hand, the irrigation schemes in Blantyre (Mlambe scheme) and in Rumphi (Songoro scheme) have continued to flourish since the beneficiaries were able to find markets. In the case of Mlambe scheme, the beneficiaries are even able to sell their onions and tomatoes in distant markets such as in Zomba and Lilongwe cities.

The findings show that there was positive impact on food security. The ATE of participation in irrigation on HFIAS was statistically significant as expected. That is, the estimate showed that the food insecurity access scale of households that participated in irrigation projects had marginally reduced by 0.79 (on the 27-point scale) compared to the households that did not participate in the projects. This implies that the households achieved improved food security at margin due to their participation in the irrigation activities. The decrease in food insecurity was the result of both an increase in food availability through increased productivity as well as increased food purchases from increased revenues.

The impact on HDDS is also positive and statistically significant implying that participation in irrigation farming increased the diversity of diets. The dietary diversity score for households that participated in irrigation projects increased by 0.55 on the score when compared to households that did not participate. This implies households that participated in irrigation projects diversified their production, which made for the availability of more food types. Households also increased the food types they bought from the market due to an increase in agricultural income. Interviews with key informants and focus group discussions also attested to this finding with beneficiaries reporting improvement in their food security situation, where the schemes worked effectively with help of good leadership and extension service, as was seen in Blantyre (Mlambe scheme) and Rumphi (Songoro scheme).

However, the evaluation found no evidence of effects on child nutrition. The result showed that the treatment effect on child nutrition status was not statistically significant, which suggests that irrigation projects did not improve child nutrition (Table 5). This also suggests that although irrigated farming improved food diversity in the households, it did not translate into improved nutrition for the children. This may imply that other factors such as food safety and hygiene, knowledge of nutrition in food preparation, health situation of child and social factors are critical for improving child nutrition.

In addition, estimation results also showed an unexpected negative effect of irrigation on household health. The result surprisingly shows that the incidence of illness was slightly higher, increasing by 1%, in households that participated in the irrigation projects than in those that did not. This is odd as project expectations were that participation would increase food diversity and nutrition and thereby reduce the incidence of illnesses in the household. This unexpected result was also reported by the PCRs indicating the incidence of waterborne diseases such as malaria and bilharzia increased in the projects areas. Interviews also reported

Table 5: Average Treatment Effects of Irrigation on Food Security, Health and Child Nutrition

Outcome Indicator	ESR		IPWRA	
HFIAS	-0.79***	(0.08)	-0.53*	(0.31)
HDDS	0.55***	(0.04)	0.35**	(0.16)
Incidence of illness	0.01***	(0.00)	-0.01	(0.02)
Height for age	-0.01	(0.01)	-0.02	(0.04)
Weight for age	0.00	(0.00)	-0.00	(0.01)
Weight for height			0.03	(0.02)

Note: t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Gaps imply that we were unable to generate the endogenous switching regression results because we could not attain convergence in the log likelihood.

Source: Computed from the household surveys.

that farmers encountered similar health problems after some irrigation schemes became operational though less common nowadays. Another study (Domenech et al., 2013) also stated that irrigation practices can create conducive environment for vector-borne diseases such as malaria, dengue and schistosomiasis.

Impact on Poverty

Participation in the irrigation schemes showed statistically significant effects on all the poverty indicators used in this evaluation. Thus, households that participated in irrigation could attest to a decline in their poverty level, and the data validated their assessments. In addition, during focus group discussions, beneficiary farmers indicated improvement in their welfare where irrigation schemes were operating effectively.

In this evaluation, poverty was measured through three objectively measured poverty indicators: i) cash expenditure per capita; ii) cash income per capita; and iii) a Multidimensional Poverty Index (MPI). In addition, there were three subjective indicators which included self-reported poverty, well-being change, and satisfaction with life. The self-reported poverty assessment is a six-step ladder that represents a very poor state in the first step of the ladder and rich in the sixth step. For the well-being change, respondents were asked to indicate whether they are better off, the same as, or worse off compared to 12 months before the survey date with the responses presented on a 5-Point Likert Scale where 1 represents much better and 5 represents much worse. Finally, the respondents indicated the extent of their satisfaction with life, which was also presented in a 5-Point Likert Scale with 1 capturing very unsatisfied and 5 capturing very satisfied. The details of the poverty measurement approaches are in Annex 2.

Statistical evidence shows that participation in irrigation projects reduced both income poverty and multidimensional poverty of the participating households. The average treatment effects of participating in irrigation on cash expenditure per capita is 0.36, which translates to an increase of 42% in expenditure per capita (Table 6). Similarly, the average treatment effect for the income per capita is 0.29, reflecting a 34% increase in income per capita. This shows that irrigation interventions reduced income poverty as they led to an increase in expenditure and income. This is also supported by the estimated coefficient of the multidimensional poverty index, which shows that, on average, participation in the irrigation projects led to lower levels of multidimensional poverty.

Table 6: Average Treatment Effects of Irrigation on Poverty and Life Satisfaction

Outcome Indicator	ESR		IPWRA	
Ln (Cash expenditure per capita)	0.36***	(0.03)	0.25***	(0.06)
Ln (Cash income per capita)	0.29***	(0.03)	0.21***	(0.05)
Multidimensional Poverty Index	-0.04***	(0.01)	-0.02	(0.02)
Self-poverty assessment	0.13***	(0.01)	0.08**	(0.03)
Well-being change	-0.10***	(0.01)	-0.14*	(0.08)
Life satisfaction	0.07***	(0.01)	0.04	(0.06)

Note: t statistics in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
Source: Computed from household surveys.

The evaluation gives evidence of desirable effects of irrigation on self-reported poverty and well-being change. The average difference on the self-reported poverty scale is 0.13, which implies that the average score for the treated households is 0.13 higher than households without irrigation. Change in well-being was measured on a 1 to 5 scale, with 5 indicating that the household had become worse off. The negative sign estimate, therefore, means that participation in the projects improved household well-being. In addition, the projects' effect on life satisfaction is positive and statistically significant, implying that life satisfaction has improved for participating households. However, during focus group discussions, beneficiaries expressed mixed views about changes in their welfare (Box 4).

Box 4: Beneficiary Feelings on the Effect of Irrigation

When beneficiaries were asked whether the irrigation schemes improved their welfare or not, mixed feelings emerged from FGDs and KIIs. In some schemes (Chimutu in Dowa, Nyamphembere in Nsanje and Chigamukire in Rumphi), the beneficiaries complained that their participation in the schemes had affected them negatively because the schemes were not functional. Before the schemes, some of the farmers were practicing a form of traditional irrigation, but with participation in schemes, they lost access to their land and water. However, in well-functioning schemes such as the Mlambe scheme in Blantyre and Songoro scheme in Rumphi, the beneficiaries applauded their participation in the schemes because they were able to harvest two to three times per year.

How are the Benefits from Irrigation Distributed Among Households?

Overall, male-headed households have benefited more from irrigation activities than female-headed households. Although male-headed households made more income from the total crop sale, improvement in welfare through expenditure was higher for female-headed households. The evaluation also showed that farmers with relatively smaller land sizes benefited more in terms of maize productivity, but not in welfare improvements. In addition, the finding shows that having a formal education helped to maximize development benefits from irrigation farming.

This evaluation assessed the heterogenous impact of irrigation projects by gender of the head of household, land holding size, and level of education. In the previous sections, the evaluation findings show positive impact, on average, for beneficiary farmers in terms of agricultural productivity, income, food security and poverty. This section explains how those benefits were distributed among farmer households based on their socioeconomic status: gender, farm size, and education level. The details of the impact estimation results are in Annex 3.

Gender

Effects of irrigation interventions varied by the gender of the head of household. The evaluation showed that the effects of irrigation on maize yield and revenue were higher for male-headed households. For instance, irrigation projects increased maize yield for male-headed households by 40% compared to an increase of 22% for female-headed households. Similarly, increases in revenues from maize production were higher for male-headed households with an increase of 105% for male-headed households compared to 101% for female-headed households (Annex 3, Table A3.6).

Total crop revenues increased more for male-headed than for female-headed households. The estimation results indicate that the use of irrigation increased total crop revenues by 127% for male-headed households compared to 118% for female-headed households. This may be explained by the findings that irrigation interventions increased crop diversification more among male-headed households than among female-headed households. The treatment effects on the diversification index was 0.05 for male-headed households compared to 0.04 for female-headed households. The higher revenues may therefore be realized from the diversified number of crops grown by male-headed households. Although statistical results show this income gap between female-headed and male-headed households, focus group discussions indicated that some women benefited from access to land with irrigation technology (Box 5).

Although gender gap exists in productivity and income, female-headed households experienced higher welfare changes and poverty reduction. The findings showed that the irrigation effects on per capita expenditure was higher for female-headed households (38%) than for male-headed households (16%). However, the effects on income per capita was greater for male-headed households (32%) than for female-headed households (26%). This may imply that although male-headed households obtained

more income, it is female-headed households who improved the welfare of the household by spending more to fulfil the household's necessities. This is supported by the results of the irrigation effects on multidimensional poverty, which is positive and statistically significant only in female-headed households (Annex 3, Table A3.7).

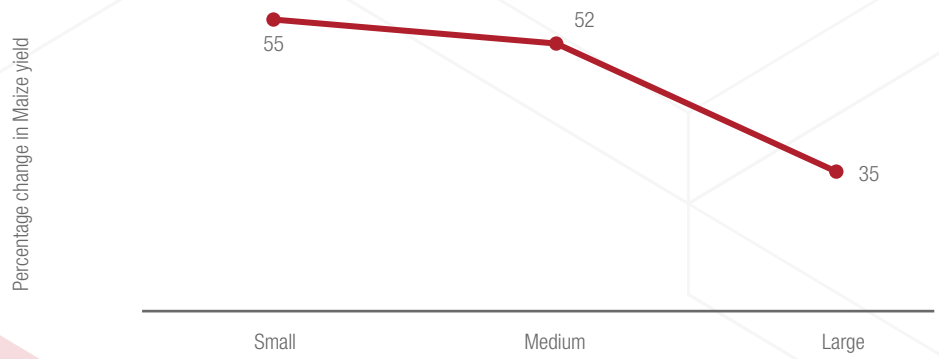
Land Holding Size

Land-constrained households benefited the most in terms of maize yield from the irrigation activities. In other words, the positive effects of irrigation on maize productivity were greater in relatively smaller farms. Maize yield increased for all farms, but less for larger farms with small farms showing a 55% increase versus 35% for larger farms. This pattern is displayed in Figure 1 below. It shows that the impact of participation in irrigation projects on maize yield reduced with relatively larger plot sizes.

Crop diversification increased more in larger farms. The treatment effects on crop diversification was higher for farmers with relatively large landholding sizes. The crop diversification index improved by 0.02 for farmers with medium landholdings and 0.08 for relatively larger ones (Annex 3, Table A3.8). This shows that farmers with relatively larger landholding sizes have more freedom to diversify crop than farmers with less landholding sizes even when participation in irrigation projects provide an opportunity for diversification.

The findings show that irrigation reduced both multidimensional poverty and self-assessed poverty more for households with relatively larger landholding size. That is, the level of multidimensional poverty increased for households with relatively smaller sizes while it decreased for households with relatively larger landholding sizes. In addition, self-assessed poverty reduced more for households with relatively larger landholding sizes. The result showed that the estimated treatment

Figure 1: Maize Yields Increased More in Smaller Farms



Box 5: Views from Focus Group Discussions on Gender

Evidence from FGDs indicates there was not any gender-based segregation on membership or water use practices. In the Mlambe irrigation scheme in Blantyre, for example, some female beneficiaries even challenged the men in their FGD saying they didn't see any differences between them and male farmers.

"…there is no difference between males and females in the scheme, some of us are doing better such that we don't even need to get married in order to get support from the husbands…" (a female participant, Mlambe irrigation scheme)

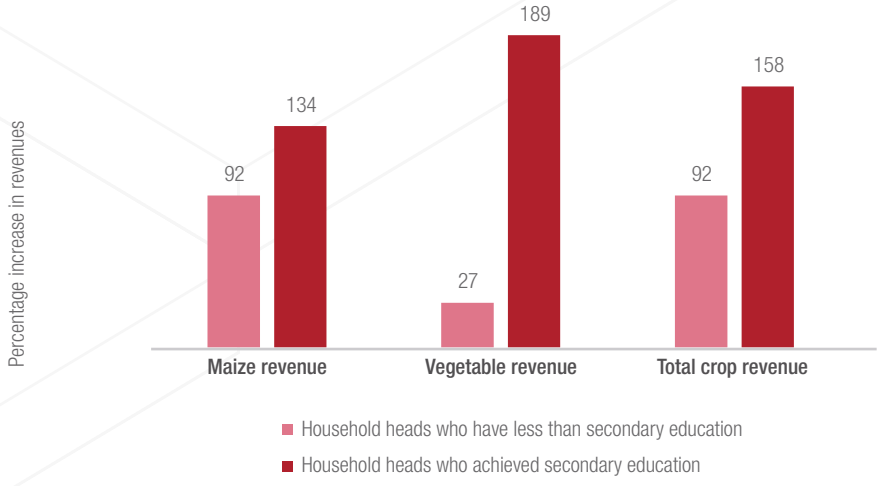
effects were higher for relatively larger landholding sizes – the estimated impact was 0.08 for smaller farms compared to 0.12 for relatively larger farms (Annex 3, Table A3.9). In a nutshell, these findings imply that there should be some minimum landholding sizes for households to fully benefit from participation in irrigation projects. During focus group discussions, participants also indicated that there is marginal welfare change for farmers with small size plots.

Education Level

Formal education of the head of the household enhanced the impact of irrigation projects on development outcomes. The analyses show that household heads with a secondary education had higher treatment effects than household heads with less education (Annex 3, Table A3.10). For instance, the treatment effects on maize, vegetable, and total crop revenues were statistically significant and higher for household heads who had completed secondary education than for those with less education (Figure 2). When comparing treatment effects of less educated household heads to that with more educated ones, maize revenues increased from 92% to 134%, respectively, and vegetables revenues increased from 27% to 189%, respectively.

Crop diversification effects were also higher with formal education. The treatment effects on the crop diversification index was 0.07 for household heads with secondary education compared to 0.03 for those without. This partly explains why households with a secondary education experienced higher increases in revenues than households with less education.

Figure 2: More Educated Household Heads Increased Farming Revenue More with Irrigation



Are the Benefits from Irrigation Development Sustainable?

As shown in the above sections, there is statistical evidence that the projects indeed improved most of the livelihood indicators for beneficiary farmers. But, are these benefits sustainable in the long-term? This section explores the extent of the sustainability of the benefits of irrigation.

Overall, the sustainability of the benefits from the irrigation schemes and marketing infrastructure is highly unlikely due to:

- *Poor scheme design*
- *Weak organizational capacity at the local level, including weak leadership*
- *Lack of markets for agricultural produce*
- *Conflicts among beneficiaries (arising from land disputes and water resource management); and*
- *Beneficiaries' sense of dependency for farm inputs and maintenance of irrigation schemes.*

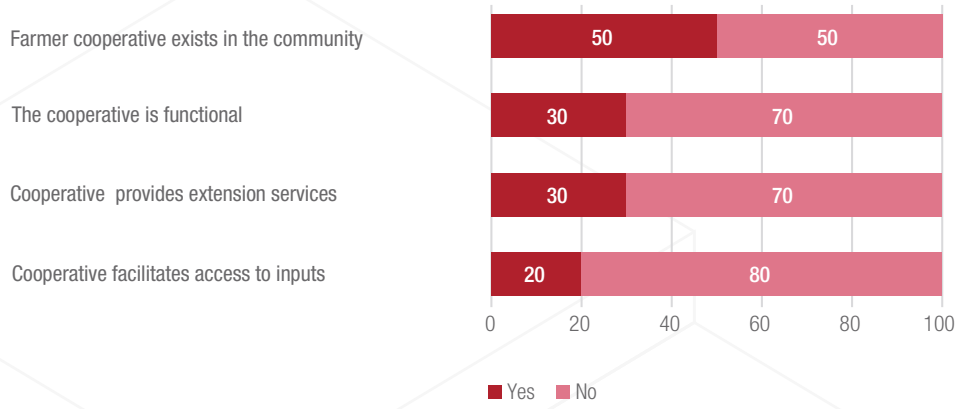
Institutional Sustainability

The capacity and legitimacy of farmers' organizations is vital for the proper use of irrigation schemes. The irrigation schemes are under the management of the WUA or WUG. Many of these organizations did not receive legal status as "association." Interviews with key informants and focus groups revealed that most irrigation schemes had only water user management committees, which were not legally registered. One of the key reasons was a protracted legal process and costs related to establishing the association. As a result, many users prefer to stay as water user committees. This led to poor governance and weak enforcement of rules in operating the irrigation schemes. The survey data show that about 65% of the schemes faced conflicts in water allocation, while about 70% did not punish members for wrongdoing. The absence of legally registered water user associations and cooperatives is one of the factors that limited the proper functioning of the irrigation schemes.

Evidence from the qualitative study also showed that some of the irrigation schemes faced poor leadership and lack of accountability in the management of the schemes. For example, in the Kambenje (Mulanje district) and Chimutu (Dowa district) schemes, members abandoned the scheme due to lack of transparency in financial management. On the other hand, experiences from other schemes showed that good leadership enabled proper functioning of the schemes, as was the case in the Songoro (Rumphi district) and Mlambe (Blantyre) irrigation sites.

In addition, farmers' expectations and motivations at the start of the scheme provided another explanation as identified during interviews with key informants. In five out of the six schemes covered in the qualitative study, some farmers chose to participate in irrigation as they were expecting the government or donor to continue providing free inputs and maintenance of the schemes. For example, in the Kambenje scheme (Mulanje district), farmers used all available irrigable land under the scheme, since inputs were provided for free to the farmer in the initial harvest season. But as the government stopped the free inputs in the second and subsequent seasons, farmers dropped out of using the schemes.

Figure 3: Status and Support Received from Farmers' Cooperatives (% of WUA/WUG)



Farmers' cooperatives (where they existed) were mostly inactive. Only about 30% of WUAs/WUGs reported to have functional cooperatives at the time of this evaluation. In addition, these farm cooperatives had not adequately supported the farmers in terms of input supply, marketing and extension services (Figure 3).

Members of the WUAs/WUGs also received useful training which varied from farm practices and schemes' management. This training included WUA/WUG management principles, irrigation technology operations, and marketing practices. About 94% of the respondents found this training useful to their farming activities. However, focus group discussions indicated that some of the training involved only management committees, which limited the participation of other members.

Government's organizational capacities at local level are very limited to provide support to the irrigation schemes and farmers organizations. The Agricultural Extension Agents at community level are responsible for mobilizing and training farmers and for field demonstrations. The District Agricultural and Irrigation Officers provide sporadic support to the irrigation schemes in addition to being instrumental during the construction and commissioning of the schemes. However, interviews with the district officials indicated that they faced shortages of human and budgetary resources to adequately monitor and support the irrigation schemes and farmers.

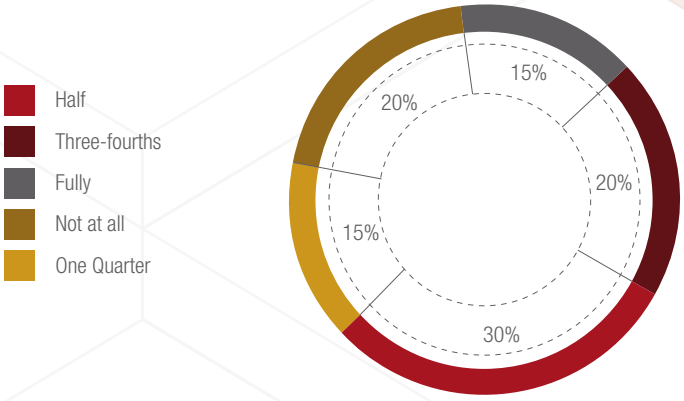
Technical Sustainability

Irrigation schemes' maintenance and operations are under the responsibility of WUAs/WUGs. With the help from district irrigation service, WUAs/WUGs are expected to raise the necessary financial resources to fund maintenance and operation of the schemes.

Most of the irrigation schemes are underutilized. According to the survey data, over 50% of the household respondents expressed dissatisfaction with the performance of the irrigation schemes. In addition, WUAs/WUGs reported that about a quarter of the schemes were unfunctional. Moreover, only 15% of WUAs/WUGs reported using the full capacity of the irrigation schemes (Figure 4).

Poor design of the structure and choice of technologies used are among the key reasons for underutilization. This was identified during interviews with key informants and focus group discussions. For example, four schemes faced poor design and pump installations problems including Mlambe (Blantyre district), Nyamphembere (Nsanje district), Chigamukire (Rumphi district) and

Figure 4: Proportion of the Irrigation Schemes Utilized in 2018 (% WUAs)



Chimutu (Dowa district). Poor design resulted in the schemes not being functional at all, not being used at full capacity, or working only for a short period. For example, at two of the schemes (Nyamphembere and Chigamukire), pipe laying at the water intake was at a higher position such that pumping water was not possible. Since these problems were not corrected for several years, the schemes stopped functioning and the members ceased coming to the scheme. However, the members indicated their continued interest in participating in the schemes if these issues could be rectified. Even in active schemes such as the Mlambe scheme in Blantyre, water could not reach all farmlands under the scheme due to problems in design and construction.

Financial Sustainability

The sources of finance are members' contributions and water use fees. According to household surveys, annual membership fees ranged from 500 to 3,000 Kwacha while water user fees ranged from 500 to 6,000 Kwacha. Information provided by key informants and focus group discussions, however, suggested that the money collected from the fees was too little to cover maintenance of the irrigation systems, particularly if conveyor pipes or water pumps broke down.

During the interviews and the survey, inadequate funds was reported as one of the key challenges encountered in operating the irrigation schemes. Beneficiaries often look to the government or other partners to fund maintenance of the irrigation schemes. Furthermore, lack of adequate financial resource management systems at the scheme level posed great problems in fee collection and expenditure. For example, out of six schemes covered in the qualitative study, only two WUAs/WUGs had proper accounting systems in place, leading to abuse of collected fees. For instance, it was alleged that the chair of the water user's committee in the Kambenje scheme (Mulanje district) used the collected fees for personal purposes, and the scheme's committee, including the local chief, misused the financial resources of the Chimutu scheme (Dowa district).

Conclusion, Lessons and Recommendations

Conclusion

The African Development Bank has been investing in irrigation infrastructure to create enabling conditions for sustainable and productive agriculture throughout Africa. In Malawi, the Bank has funded several irrigation development projects. This evaluation covered only two projects, namely the Smallholder Crop Production and Marketing Project (SCPMP) and Agriculture Infrastructure Services Project (AISP), which were completed in 2014 and 2017, respectively. It was expected that irrigation development would improve agriculture productivity through cropping intensification and crop diversification, which would in turn lead to an improvement in final outcomes: food security, poverty, health and child nutrition. This evaluation aimed to assess the impact of the two projects on these outcomes at the farmer household level.

The evaluation findings show that the Bank-supported projects had positive impacts on many development outcomes. The irrigation development projects increased intermediate agricultural outcomes such as maize yield, revenues (from maize, vegetables, and total crop), and crop diversity. The estimated impact indicated some improvement in food security of the households. The projects have also improved both income poverty and multidimensional poverty of the participating households. However, there was no evidence of effects on cropping intensity and child nutrition.

The evaluation also concluded that irrigation development had higher impact on vegetable revenues than on maize revenues. The statistical evidence showed that the treatment effects for vegetables were higher than those for maize. For example, irrigation projects increased revenue from vegetables by 159% compared to 103% for maize. This shows the importance of integrating high value crops such as vegetables in irrigation projects to maximize development benefits.

While crop diversification has been improved, there was no evidence of increase in crop intensity. The analyses show statistically positive effects of irrigation on crop diversification (number of crops grown). However, there was no evidence to show that the irrigation projects increased cropping intensity (number of times a piece of land is cultivated). The main reasons were: i) underutilization of irrigation facilities due to poor governance; ii) conflicts among beneficiaries; and iii) absence of markets for the agricultural produce.

Furthermore, there is no evidence on the impact of irrigation activities on child nutrition. The result showed the effect on child nutrition was not statistically significant. This may imply that other factors such as food safety and hygiene, knowledge of nutrition in food preparation, the health situation of children and other social factors are vital to improve child nutrition.

Female-headed households improved household welfare and reduced poverty while male-headed households realized higher incomes. The finding showed that male-headed households realized more income gains from irrigation than female-headed households, but the latter experienced statistically significant improvements in welfare and poverty indicators. Thus, any interventions that aim at improving household well-being through promotion of agricultural technologies such as irrigation should focus on empowering women.

The effects of irrigation on maize productivity were higher for relatively smaller land holders, but small farm sizes constrained the desired

effects of irrigation on poverty reduction. The analysis showed that maize productivity increased more for small landholding sizes when compared with relatively larger landholding sizes. However, the effects of irrigation on poverty reduction were more in relatively larger farm sizes. That is, some farm plot sizes would be too small to realize the positive benefits of irrigation in terms of achieving poverty reduction.

Although the irrigation projects generated benefits for the farmers, those benefits are unlikely to be sustainable. The underutilization of irrigation schemes has already jeopardized the desired benefits of irrigation. Moreover, most of the market centers and storage facilities are not being utilized as a result of weak governance systems at the scheme level, inadequate scheme designs, lack of markets, and farmers' unrealistic expectations of continued subsidies.

Lessons

The following are the key lessons from this impact evaluation:

1. **Inadequate attention to the capacity and governance systems of local institutions undermines achievement of sustainable outcomes from irrigation development.** The evaluation found that weak organizational capacity and leadership problems hindered proper functioning of irrigation schemes. The Water User Associations (WUAs) or Water User Groups (WUGs) are the direct beneficiaries of the irrigation schemes and are entrusted with the responsibility to maintain and operate them. Due to the weak capacity and lack of required legal status, these local organizations are unable to enforce rules for operating the schemes requisite for ensuring sustained benefits. In addition, these organizations have the potential to influence the mind-set of farmers towards taking up commercial farming, which is a shift from subsistence farming to farming as business. Thus, Bank's support to enhance the capacity and governance systems of these local institutions will contribute to the effective use of the existing irrigation infrastructures and thereby yield sustainable development benefits.

2. **Building market infrastructure is necessary but not a sufficient condition to create markets for farmers.** The Bank supported construction of irrigation and other infrastructures related to marketing, such as market centers and storage facilities. However, the evaluation found that irrigation did not increase crop intensity, i.e., the frequency of use of a piece of land in a given year. Moreover, most of the market infrastructures remained unused. This is because although the irrigation schemes increased agricultural yield, it was difficult for farmers to find markets for their produce. The farmers lost interest in production as they failed to find a market, leading them to cultivate for subsistence only. It is essential that these infrastructures are adequately integrated into the country's marketing system so that the improved yields lead to sustainable incomes and livelihoods.

3. **Technical quality of the construction designs of irrigation schemes should be ensured to enhance the effectiveness of the projects' outcomes.** The evaluation found that faulty construction designs of irrigation schemes led to the underutilization of such schemes, which in turn led to suboptimal agricultural production. For example, in the Mlambe scheme, which remains very active, the irrigation water can reach only part of the irrigable land due to design issues. Other schemes faced similar issues which reduced their effectiveness, e.g. pipe laying at the water intake was at a higher position which made pumping difficult.

4. **Irrigated farming and resultant improved food security and food diversity may not necessarily lead to improvement in child nutrition.** The evaluation found that child

nutrition did not improve in the project areas despite improvement in food security and food diversity. In order to enhance nutritional status of children, the irrigation project designs would need to provide targeted complementary interventions. Further studies are required to identify such interventions and incorporate them into project design.

5. **Empowering women to participate in irrigated farming can improve ultimate development outcomes, i.e., poverty reduction and household welfare.** The evaluation found that female-headed households spent more to satisfy the household daily needs and the effect of irrigation on their per capita expenditure was statistically significant and higher compared to the male-headed households. Interestingly, the level of poverty reduction was found to be statistically significant only for female-headed households. However, the findings also show that the total income earned was higher for male-headed households compared to female-headed households. It is essential to further explore the underlying causes of this gender gap in the participation in irrigation farming and address them in project designs, to further empower women farmers and maximize their benefit. This includes not only the participation of women in training activities but also their access to irrigation land and finance for the purchase of inputs, which requires policy dialogue with the government and other stakeholders.

Recommendations

The evaluation proposes the following three recommendations aimed at maximizing and sustaining the gains from the Bank's investment in irrigation and market infrastructures:

Recommendation 1. Support capacity and governance systems of local institutions. The Bank should support institutional capacity building including the governance systems of WUAs or WUGs, who are the direct beneficiaries of the irrigation schemes and entrusted with the responsibility of maintaining and operating the irrigation schemes. Capacity building should include: i) training for members of the associations or groups in financial management; ii) procedures for getting legal status; iii) commercial farming, iv) scheme management; and v) agronomic practices. In this approach, the Bank should first ensure the use of existing infrastructures before embarking on similar interventions in Malawi.

Recommendation 2. Enhance agricultural market access. The Bank should support agricultural market access by going beyond building marketing infrastructures to linking them to the wider agricultural market for farm produce. This will require: i) the coordination of actors along value chains; ii) the establishment of a framework to support producers in meeting quality standards; iii) marketing information; and iv) support in establishing fair conditions for contract farming. To benefit from a greater synergy, the Bank should partner with the government and other key actors to support market creation thereby ensuring sustainable income for farmers.

Recommendation 3. Engage in knowledge work and policy dialogue. The Bank should engage quickly in policy dialogue with governments and other stakeholders on sector policy issues including: i) land tenure; ii) knowledge and support services systems in irrigated farming; and iii) gender equality. To engage effectively in policy dialogue, the Bank should invest in analytical and knowledge work to better understand the complexities of the sector policy issues. Land tenure systems would require reforms to embrace poor farmers with relatively small landholdings. Better understanding of the power and social relations in the community would help bridge the existing gender gap. The Bank's dialogue with the government should urgently focus on fixing the design and operational problems of the existing irrigation schemes and provision of support services to maximize and sustain the benefits of irrigated agriculture.

Annexes

Annex 1: Theory of Change for Bank Projects

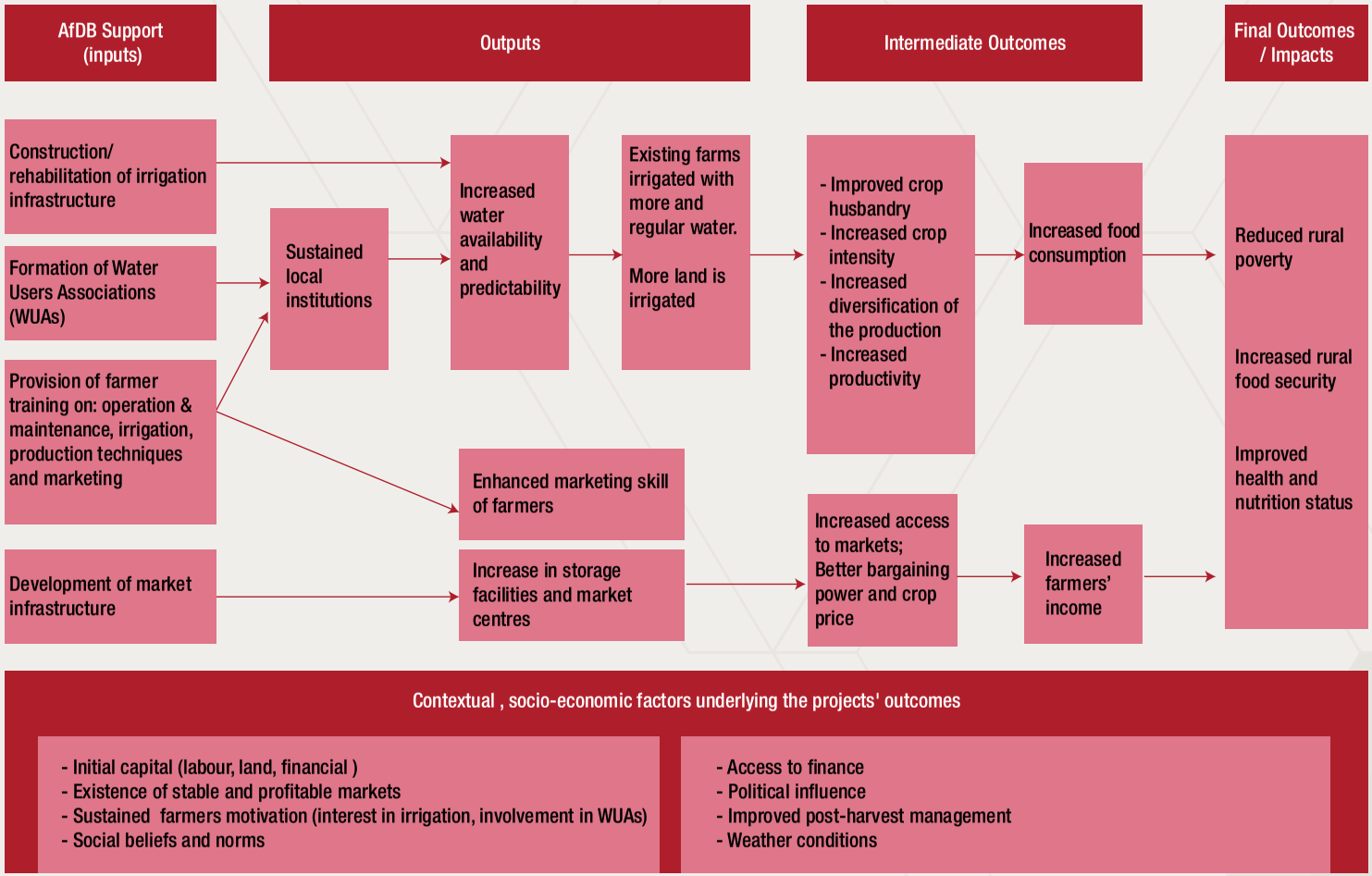
The main interventions, in both the SCPMP and AISP, were the rehabilitation and construction of irrigation infrastructure, construction of storage facilities and market centers, training of farmers in irrigation and crop production, and supporting formation of WUAs. In both projects, increasing agricultural productivity was a key channel through which the interventions were expected to impact outcomes such as revenues, food security, poverty and nutrition. Figure A1.1 below shows the Theory of Change for the SCPMP and AISP resulting from irrigation development interventions to development outcomes. Irrigation infrastructure, with community management of water systems, was expected to lead to more stable and sustainable supply of water for farming practice. This would result into more land under irrigation. Expansion in irrigation, in turn, was expected to lead to an increase in crop intensification, diversification, and agricultural productivity.

In addition, improving agricultural productivity requires better and sustained access to extension services and training in the management of farms as business entities. Furthermore, management of water resources will be key in sustaining the benefits of irrigation infrastructure over time, through training of farmers in the operation and management of water resources.

Irrigation development interventions are also expected to lead to crop diversification, enabling households to produce maize and non-maize high-value crops such as rice, paprika, chilies, cabbages, tomatoes and onions. Increased productivity in the diversity of crops in turn is expected to lead to increased production of maize and other food and cash crops. The key assumption here is that there is better post-harvest management of the crops. Increases in crop production should enable smallholder farmers to consume more nutritious foods. Increased commercialization is expected to lead to increased incomes which will in turn enable smallholder farmers to purchase additional food and contribute to poverty reduction. However, the extent of commercialization will depend on availability of profitable output markets for maize and other crops.

There are several factors that can affect the adoption or utilization of appropriate technologies and good agricultural practices. Studies show that adoption of agricultural technologies and practices are influenced by the level of literacy, road infrastructure, availability of extension services, availability of labor, land sizes and access to financial services (Langyintuo and Mungoma, 2008; Fekele and Zegeye, 2006; Chirwa, 2005). The availability of key inputs into farming activities and farmers' social beliefs/norms are also critical.

Figure A1.1: Theory of Change of SCPMP and AISP



Annex 2: Methodological Approaches

Quantitative approaches

For the quantitative study, the evaluation used an ex-post evaluation approach using a survey of households in treatment and comparison sites because both the SCPMP and AISP did not have baseline data and project sites were not assigned randomly. In such situations, many researchers opt for the Propensity Score Matching (PSM) because of its ability to identify a counterfactual with similar characteristics from the non-treated sample based on the propensity scores. Owing to the shortfalls of the PSM which includes the inconsistency of estimates when the propensity score model mis-specified and the inability to account for unobserved effects, we estimated the impact by using the Inverse-Probability-Weighting-Regression-Adjustment (IPWRA) model (Sloczynski and Wooldridge, 2016) and the Endogenous Switching Regression (ESR) model (Lokshin and Sajaia, 2004).

Sampling strategy

A multi-stage sampling approach was used in the identification of study areas and households for the impact evaluation. In the first stage, all irrigation infrastructure investment sites under SCPMP and AISP and all potential irrigation sites from the IMP were identified to form a sampling frame. In the second stage, districts that have both treatment and comparison irrigation schemes were identified, and sites for the study were purposively selected in the treatment and comparison groups. In the third stage, WUAs were selected in treatment areas and one EA was randomly selected in comparison areas. In the final state, households were selected using systematic random sampling based on WUA membership list and based on a complete household listing in the EAs in comparison sites.

Sample size determination

In order to ensure that reliable estimates of the impact on irrigation development interventions were obtained to address the attribution question, power calculations were undertaken to determine the sample size. Since agricultural productivity was the key driver of the expected changes in incomes, food security and nutrition in both interventions, we assumed a 20% increase in agricultural productivity as the impact size in the power calculation. Our sample takes into account the need to generate reliable estimates of the impact of the interventions that satisfy internal and external validity with the power to detect the assumed effect sizes, at 5% level of significance with 80% statistical power (such as in Palmer-Jones et al., 2012; ADB, 2012) to detect 20% points difference in agricultural productivity and other outcomes between treatment and control households.

Power calculation for two means in Stata (the statistical software package for social research) assuming a two-sided hypothesis test with a 5% significance level, a desired power of 90% - 95%, and that both groups will have the same number of observations and assuming a standard deviation that is midpoint between pre-intervention productivity levels and the expected productivity levels. The project documents provide details of the expected increases in the productivity of specific crops in the project areas. The baseline figures and expected changes were used for power calculations. Under these assumptions, the statistical power of 90% and 95% leads to a sample size of 1,274 households and 1,576 households equally split with 637 households and 788 households in each group, respectively. We also assumed that 5% of the sample would not satisfy common support conditions in

Propensity Score Matching (PSM), hence the need to oversample to 880 and 1,660 households to achieve 80% and 95% statistical power, respectively. In order to increase precision of the estimates, a final sample of 1,800 households was decided, with 900 households in treatment areas and 900 households in comparison areas.

Selection of treatment and comparison groups

In order to inform the selection of treatment and comparison groups, detailed information was obtained on irrigation schemes under SCPMP and AISP and information on pipeline projects of the 2015 IMP. The selection of comparison groups that were deemed to have a higher likelihood to match households in the treatment group was critical for the selection of communities for this impact evaluation. The schemes in the IMP that were in the pipeline, given the information gathered about irrigation development activities in Malawi, were deemed to be appropriate areas to draw comparison groups in the impact evaluation, particularly those schemes with positive economic evaluation ranked between 1 and 42 (SMEC, 2015). The selection of study sites was purposive taking into account factors including irrigation infrastructure investment as a core intervention, number of beneficiaries in treatment schemes, existence of potential irrigation schemes within the district and existence of functional cooperatives in treatment sites. A total of 36 study sites (18 treatment schemes and 18 comparison schemes) were purposively selected in 12 districts (3 districts in the north, 2 districts in the center and 7 districts in the south). Table A2.1 presents the list of treatment irrigation schemes and potential irrigation schemes included in the study.

In each selected site, 50 households were selected using systematic random sampling for the household survey, resulting in a sample size of 1,800 households. In treatment schemes, a list of WUA members was obtained while in the comparison scheme, a full household listing was undertaken with enumeration areas as a household sampling frame. Since participation in irrigation development activities is voluntary and involves monetary contributions in terms of membership fees, plot fees and water use fees, the household listing form in comparison areas contained a screening question on household willingness to become a paid-up member if irrigation development were to take place in the area. The willingness indicated an intention to be treated, although experience has shown greater enthusiasm for smallholder participation in irrigation at the commencement of investments with the actual uptake falling once project activities are completed. In these comparison schemes, only households that expressed willingness to participate in a potential irrigation schemes were included in the study.

Data

Data used in the quantitative study came from household and community surveys conducted in the study areas during the months of April and May 2019. The household questionnaire covered several topics including the socio-economic characteristics of households (household composition, housing characteristics, assets and ownership of livestock), education (attendance and enrolment) and health status of children (incidence of illness), farming characteristics (rain-fed and irrigation farming), food security and nutritional status of children (anthropometric measures), dietary diversity, economic activities and income sources, assets, self-assessment of poverty and well-being, water user groups and cooperatives. For some of the time invariant variables (such as household size, headship of household, education of household head), we used recall questions to capture information prior to 2006. The full questionnaire is annexed to the technical report of the evaluation.

Table A2.1: Selected Study Treatment and Comparison Schemes by District

No.	Treatment Schemes					Comparison Schemes	
	Funding	District	Name of Scheme	Type	No. of households	District	Name of Scheme
1	SCPMP	Chitipa	Ibuluma	Gravity	231	Chitipa	Marko
2	SCPMP	Chitipa	Sekwa	Gravity	115	Chitipa	Ilengo
3	SCPMP	Nkhata Bay	Lilezi	Gravity	175	Chitipa	Namasasa
4	SCPMP	Rumphi	Divwa	Gravity	190	Nkhata bay	Ngazi
5	SCPMP	Rumphi	Msongolo	Motorized	105	Nkhata bay	Mteperera
6	SCPMP	Rumphi	Chagumukile	Motorized	118	Nkhata Bay	Chindevu
7	SCPMP	Rumphi	Jambuko	Motorized	147	Dowa	Dowa Dambo
8	SCPMP	Dowa	Chimutu	Gravity	96	Dowa	Kholongo
9	SCPMP	Dowa	Themba Lipimbi	Gravity	81	Ntcheu/Neno	Lembani
10	SCPMP	Ntcheu	Kamphulusa	Gravity	118	Blantyre	Nkawinda/ Bakasala
11	AISP	Blantyre	Mlambe	Gravity	139	Phalombe	Nkhulambe/ Wowo
12	AISP	Phalombe	Bwanje	Gravity	180	Mulanje	Likabula/ Kholiwe
13	AISP	Mulanje	Kambenje	Gravity	500	Mulanje	Lichenya
14	AISP	Thyolo	Namalowa	Gravity	170	Thyolo	Ruo - Diversion
15	SCPMP	Chikwawa	Nkombedzi	Gravity	765	Chikwawa	Navaya
16	AISP	Nsanje	Nyamphembere	Solar	400	Nsanje	Ruo - Diversion
17	SCPMP	Nsanje	Masenjere	Gravity	658	Nsanje	Nyanthana
18	AISP	Neno	Mtengula	Solar	1,600	Mwanza/ Neno	Zidala

A community level questionnaire was administered to members of the WUAs, WUGs or Cooperatives in treatment sites and to community leaders in comparison sites. The main objective was to understand governance arrangements, constraints and challenges, factors contributing to sustained use of the investments, perceptions on the suitability of the technology, issues of access to markets, utilization of complementary infrastructure (storage and market facilities), the general performance of the schemes and the perceptions on the welfare impact - focusing both on intermediate outcomes and final outcomes such as productivity, crop diversification, poverty, food security, health and child nutrition. The community questionnaire is annexed to the technical report of the evaluation.

Selected Impact Indicators and their Measurement

The impact evaluation therefore focused on both intermediate outcome variables and final outcomes indicators.

Intermediate Outcome Indicators

Four intermediate outcome indicators are tested in this study: agricultural productivity, crop intensity, crop diversification and agricultural revenue. Firstly, we tested the hypothesis that the immediate effect of the use of irrigation farming is to increase agricultural productivity. Agricultural productivity was measured by output per hectare for selected crops grown by both treatment and

comparison households. We tested this hypothesis on maize as maize is grown by large a proportion of farmers. Several studies in the impact evaluation of irrigation interventions used yields as outcome indicators (World Bank, 2008; Dillon, 2011; ADB, 2012; Ring et al., 2018; Nonvide, 2018). We also estimated agriculture productivity using the gross value of output per hectare as is used in many agricultural productivity studies (Aguilar et al., 2015; Ali et al., 2016; de la O Campos et al., 2016; Kilic et al., 2015). We used the value of crop revenue per hectare as an indicator of gross yield in the analysis.

Secondly, we tested whether irrigation interventions led to increases in cropping intensity by providing opportunities to participating farmers to use land intensively over several seasons in a year. Cropping intensity (CI) was calculated as a ratio of the sum of the areas cropped in the main season plus the areas cropped in the second season to net cropped area (the area cropped in the main cropping season) (World Bank, 2008; Binswanger-Mkhize and Savastano, 2014). A number of studies have used this indicator in an impact evaluation of irrigation interventions (Kuwornu and Owusu, 2012; ADB, 2012; Garbero and Songsermsawas, 2018; World Bank, 2008) and find evidence of increased cropping intensity among participants in irrigation schemes compared to comparison households.

Thirdly, we tested the hypothesis that households participating in irrigation farming are also accorded opportunities to grow a diversified portfolio of crops. Crop diversification is measured by the Simpson's Intra-Farm Crop Diversity score. It is calculated as 1 minus the ratio of the sum of squares of land cultivated for each crop to the square of total land under cultivation. The index ranges from 0 to 1 with an index towards zero indicating complete specialization and an index towards 1 indicating high diversity (ADB, 2012).

Finally, we tested the hypothesis that irrigation interventions lead to increases in agricultural incomes. With increased productivity and better access to markets, farmers participating in irrigation farming are likely to witness increased incomes compared to farmers relying on rain-fed cultivation. We used gross revenue from crop sales as a proxy measure of agricultural income. We also used revenues for maize and vegetables to test this hypothesis. Gross crop revenue, maize revenue, and vegetables revenue were expressed in logarithms to improve on the distribution and therefore the model fit mainly in the outcome model of the IPWRA.

Final Outcomes Indicators

With respect to final outcomes - poverty reduction, food security, health and child nutrition, the study used several indicators. In assessing the poverty reduction impact of irrigation interventions, the evaluation used household cash income per capita and cash expenditure per capita, and the multi-dimensional poverty index. Per capita income and consumption expenditure are common proxies of poverty used in irrigation development impact evaluations.

Another measure of poverty used in the evaluation was the multidimensional poverty index (MPI) (Alkire and Foster, 2007; Alkire and Foster, 2011; Alkire and Santos, 2014). The MPI recognizes that poverty is multidimensional, and it uses several dimensions of poverty to determine the aggregate measure of deprivation. The main features of the MPI are the identification of the dimensions of deprivation and indicators in each dimension with equal weights for each dimension and equal weights for each indicator in each dimension. The sum of the weights for all the indicators should add up to one. The most popularly used index has three dimensions - namely education, health and standard of living, and a total of 10 indicators of deprivations. For each indicator, a dichotomous variable is computed equal to 1 if the condition applies and equal to zero when it is not satisfied. Table A2.2 presents the elements and weighting in the construction of MPI. Several steps are undertaken for the computation of MPI including: i) determining indicators; ii) setting cut-off points of deprivation for each indicator; iii) applying the cut-off

points on every individual or household; iv) selecting the weights; v) creating (weighted) deprivation score for each individual or household; vi) determining poverty cut-off for each individual/household; vii) computing the headcount ratio and the intensity of poverty; and viii) calculating the MPI (Alkire and Santos, 2014).

According to Alkire et al (2013) households are classified as poor if they are deprived in 33% of weighted indicators and classified as ultra-poor if they are deprived in at least 50% of the indicators.

In the area of food security, there are many indicators that have been used to measure food security in the impact evaluation of irrigation interventions including months of food shortage, food expenditures and share of food expenses, dietary intake, dietary diversity scores and food insecurity scores (Domènech, 2015). Two indicators were used in this study as indicators of food security following IFAD (2018). The first measure is the Household Food Insecurity Access Scale (HFIAS) (Coates et al., 2007). It is a continuous measure of the degree of food insecurity in the household in the past four weeks. In order to generate the HFIAS, nine occurrence questions are asked to the households and the responses are summed up. The response codes for the questions range from 0 to 3 (0- no occurrence; 1 – rarely; 2 - sometimes; and 3 often). The maximum value of the HFIAS is 27 indicating a highly food insecure household whose response in every question is 'often.'

The second indicator of food security is the Household Dietary Diversity Score (HDDS) measured as the count of the number of food groups consumed by any member of the household using 24-hour recall (Kennedy et al., 2011). This measure includes the food groups consumed by household members in the home or prepared in the home for consumption by household members outside the home. Foods consumed outside the home that were not prepared in the home are not included. Thus, the HDDS reflects household dietary diversity, on average, among all household members. The twelve food groups that are used to calculate the HDDS are: cereals, root and tubers, vegetables, fruits, meat, poultry and offal, eggs, fish and seafood, pulses/legumes/nuts, milk and milk products, oil/fats, sugar/honey,

Table A2.2: Multidimensional Poverty Index

Dimension	Indicator	Deprived if …	Index Weight
Education	1. Years of schooling	No household member has completed 5 years of schooling	1/6
	2. Children school attendance	Any child aged between 6 and 14 not in primary school	1/6
Health	3. Child mortality	Any child death in the family	1/6
	4. Nutrition	Whether any child is malnourished	1/6
Standard of living	5. Electricity	Household has no electricity	1/18
	6. Sanitation	Household's sanitation facility is not improved	1/18
	7. Safe drinking water	Household does not have access to safe drinking water	1/18
	8. Floor of house	Household has a mud or sand floor	1/18
	9. Cooking fuel	Household cooks with wood or charcoal	1/18
	10. Assets	Household does not own more than one asset (radio, TV, telephone, bike, motorbike, refrigerator), and does not own car or truck	1/18

Source: Adapted from Alkire and Foster (2007)

and miscellaneous. However, Walls et al. (2018) notes that these dietary diversity measures do not adequately account for consumption of processed foods that have low nutritional value, and such processed foods are also more likely to be consumed outside of the home, which the household dietary diversity measure does not address. The HDDS thus falls short of its ability to measure changing diets in the context of a 'nutrition transition.'

Health and nutrition indicators have rarely been used in the impact evaluation of irrigation interventions, possibly due to the data requirements. For instance, out of 28 studies reviewed by Domènech (2015) only 6 studies looked at the impact of irrigation using anthropometrics measuring nutritional status of children, 5 studies used clinical indicators, 8 studies used morbidity indicators (health expenditures or incidence of disease). Some studies have also used expenditure on health to link irrigation to increased investment in health while others use incidence of disease and illness as indicators of health impact (ADB, 2012). In this evaluation, the nutrition and health impact are measured using two indicators: i) the incidence of illness or disease among household members; and ii) the nutritional status of children - measured using three health indicators: stunting, underweight and wasting.

Since several factors influence the outcome indicators, the outcome equations in the models included other key determinants of outcome variables. With respect to total income per capita or poverty, studies in Malawi show that several key factors have to be taken into account, including the age of household head, education, gender, dependency ratio, household size, land size, access to basic services, occupation and access to public works programs (Mukherjee and Todd, 2003). Studies in food security in Malawi, key determinants of food and nutrition security include crop diversity, production diversity, purchase diversity and household characteristics, wealth, market access and market participation (Koppmair et al, 2016; Jones et al., 2014).

Estimation Strategy

In the absence of experimental data, the evaluation used quasi-experimental methods of evaluation to measure treatment effects of irrigation development interventions. It used the IPWRA model which derives consistent estimates even when the model is mis-specified (Sloczynski Wooldridge, 2016) compared to the standard PSM and the ESR which takes into account both observed and unobserved characteristics (as in Nkhata et al., 2014; Ng'ong'ola and Associates, 2015; Palmer-Jones, et al., 2011; Kuwornu and Owusu, 2012; Nonvide 2018).

Inverse Probability Weighting Regression (IPWRA)

The IPWRA model estimates the propensity scores and the conditional mean for the outcome variable consistently even when one of the models is mis-specified (Sloczynski and Wooldridge, 2016). The model has been previously used in impact evaluations by other authors (Ring et al., 2018 and Garbero and Songsermsawas, 2018). The IPWRA is one of the methods that generates doubly robust consistent estimates by estimating models of both the propensity score and the conditional mean of the outcome variable. Following Hirano and Imbens (2001), the model specification and weights for estimating ATE using IPWRA approach is:

1. $Y_i = \beta_o + \tau T_i + \beta_1 Z_i + \beta_2 (Zi\text{-}\bar{Z})\ T_i + \varepsilon_i$

where Y_i is the outcome variable of interest, T_i is the indicator of treatment, Z_i is the vector of covariates in the outcome equation, $\bar{Z}$ is the sample average of Z for the sub-sample of the households that participated in the irrigation programs, and ε_i is the error term. The weights in the model are given as:

2. $\omega(t,x) = {}^{t}/_{\hat{p}(x)} - {}^{1-t}/_{1-\hat{p}(x)}$

where, $\omega(t,x)$ is the weight, t represents $T_i=1$, x is a vector of covariates in the propensity score equation, and $\hat{p}(x)$ is the estimated propensity score. The ATE is obtained using predicted outcomes of treatment and control households as:

3. $ATE = E\left[\hat{Y}_i \middle| T_i=1\right] - E\left[\hat{Y}_i \middle| T_i=0\right]$

The propensity score was obtained from the probability of participation in irrigation farming was given by the following function:

4. $Pr(T_i) = f(HHC, RELC, RFLAND, EXT)$

where Pr (T_i) is the propensity score or probability of participation, HHC is a vector of household characteristics, RELC is a variable representing relationship of any household member to the village chief, RFLAND is the amount of rainfed land owned by the household, while EXT is the existence of government extension worker in the community. HHC includes age of household head and its square, sex of household head, education level of household head measured as a dummy variable for attainment of secondary education, marital status of household head captured by a dummy variable for whether they are married or not, and household size.

IPRWA using the propensity score is only valid if there are no residual systematic differences in observed baseline characteristics between treated and control subjects in the sample weighted by the estimated inverse probability of treatment (Austin & Stuart, 2015). To check if the covariates were balanced, the evaluation used the overidentification test for covariance balance that was derived by Imai and Ratkovic (2014) and is implemented by the *tebalance overid* command in Stata

The IPWRA was then implemented in Stata using the *teffects ipwra* command. Concavity in outcome variables (revenue and yield) in the IPWRA approach was achieved when the variables were log transformed. In this case, the exponent of the ATE from the estimation measured the ratio between the average outcomes for the treated and the average outcome for the control groups.

Endogenous Switching Regression (ESR)

ESR models account for both observable and unobservable characteristics and control for other factors that affect outcome variables (Lokshin and Sajaia, 2004; Nonvide, 2018). The key problem addressed by endogenous switching models is the possibility of participation being influenced by the outcomes, hence there is an interdependence between the equation of participation in irrigation development and the outcome equation. Thus, farmer's participation in irrigation development interventions may be motivated by the expected improvements in productivity and economic welfare. It is therefore important to account for endogeneity of the decision to participate due to the influence of unobservable characteristics of the farmers. This involves estimating three equations including equation (4) and the following two regime equations:

5. $Y_{1i} = \beta_1 Z_{1i} + \varepsilon_{1i}$ *for treatment group* $(T_i=1)$

6. $Y_{2i} = \beta_2 Z_{2i} + \varepsilon_{2i}$ *for comparison group* $(T_i=0)$

Where Y and Z stand for outcome variables and covariates, respectively; β_1 and β_2 are the parameters; ε_{1i} and ε_{2i} are error terms for the first and second regime equations.

The Full Information Maximum Likelihood (FIML) method is used to simultaneously estimate equations (4), (5) and (6) to obtain efficient estimates of the treatment effects (Nonvide, 2018; Asfaw et al., 2012; Di Falco et al., 2011; Carter and Milon, 2005). The *movestay* command in Stata was used to implement the FIML estimations for endogenous switching regression models.

Qualitative approaches

Qualitative study helped to get more insights into contextual (social and cultural) issues; the project processes and implementation challenges; governance and challenges of WUAs and cooperatives; and other factors that enable or constrain the effectiveness and sustainability of the impact of irrigation interventions.

The qualitative study used Key Informant Interviews (KII), Focus Group Discussions (FGDs and observations to collect information in six purposely selected irrigation schemes in five districts: Nyamphebere in Nsanje, Kambenje in Mulanje, Mlambe in Blantyre, Chimutu in Dowa, and Songoro and Chigamukire in Rumphi. These six schemes were selected based on geographic distribution, status of functionality, type of irrigation technology (gravity, motorized, solar, and treadle mill), and presence of active cooperative.

In total, ten FGDs sessions were held in the six schemes. Five of the sessions involved women only while another set of four FGD sessions involved men only and one session had a mix of men and women. The age range of the participants was 24-50 years. In addition to the FGDs sessions, 14 sessions of KII were also held with:

- 7 Field Agricultural Extension Officers responsible for the selected irrigation schemes in Mulanje, Blantyre, Nsanje and Rumphi;
- 10 members of scheme committees in Mulanje, Nsanje and Dowa;
- 1 Agricultural Development Officer in Rumphi; and
- 12 District Irrigation Engineers and/or their Assistants in the five districts.

All the KIIs and FGDs were audio-recorded and transcribed verbatim by a four-member team which comprised a Senior Researcher and three Research Assistants. The team also participated in the 2019 household and community survey. All the transcripts were later translated into English in readiness for analysis.

To ensure data security, the audio recorders and laptops on which the transcripts were stored were kept in sealed envelopes kept by the Senior Researcher. No names of all the participants have been used or mentioned in this report.

Data analysis adapted the 'content analysis' (sometimes also called 'thematic analysis') with the help QDA Miner, a software for uploading, sorting and analyzing qualitative data. Most of the 'themes' and 'sub-themes' that were used to code the data were derived from the study objectives.

Annex 3: Household Socio-Economic Characteristics, Balance test for Covariate, and Estimates for Heterogenous Analysis

Socioeconomic Characteristics of Households

This subsection presents the statistical analysis of the existing conditions of households in treatment and comparison areas based on the sample of 1,800 households. We present socio-economic characteristics including household characteristics, housing conditions, access to services, income and expenditure patterns, and household self-assessed welfare. As noted below, on average, most of the socioeconomic characteristics are in favor of treatment households compared to comparison households.

Household Characteristics

Table A3.1 below presents the characteristics of sample households in treatment areas and comparison areas. The report presents the characteristics of the combined sample as well as the mean differences and their statistical differences by using t-statistics. The results show that households in the treatment and control areas differed in a number of characteristics such as age of the household head, education attainment of the head, household size in 2006 and 2019, number of children, years of residence in the community and relationship with the village head. The findings show that treatment households are older, more educated, and have larger household sizes than comparison households. Treatment households also had lived, on average, five years longer in the village and were more likely to be related to the village head compared to comparison households. The two samples were statistically similar in terms of sex of household head, marital status of household head, and dependency ratio.

With respect to the main occupation of the household head, the findings show that farming is the dominant occupation with 88% of household heads in the treatment areas and 69% of households in comparison areas taking farming as their main occupation. The proportions of households in non-farm businesses, Ganyu (short-term rural labor), and in-salaried employment are higher in comparison households compared to treatment households. The differences are also statistically significant at the 1% level in all occupations.

The finding that many characteristics are statistically different between households in the treatment and control areas suggest that the two samples have systematic differences in observable variables, and thus can bias the treatment effects if they are estimated by finding the mean in outcome indicators between the households in the treated and control groups.

In terms of the characteristics of the overall sample, we found that 76% of the households are male-headed, and the average age of households in the sample was 46 years. The average household size increased from 4.0 in 2006 to 5.2 in 2019. On average, household heads in the study only had a primary education implying that we had a lowly educated sample.

Table A3.1: Household Characteristics of Sample Households

Characteristics	Control	Treated	t- statistic	Total
Head male (1=yes)	0.75	0.77	-1.16	0.76
Head age (Years)	43.1	49.9	-8.70***	46.5
Head married (1=yes)	0.77	0.78	-0.85	0.78
Head education level	1.91	2.23	-5.12***	2.07
Occupation of Head				
Farming (1=yes)	0.69	0.88	-9.81***	0.78
Business(1=yes)	0.14	0.051	6.05***	0.094
Ganyu (1=yes)	0.060	0.015	4.79***	0.038
Employed (1=yes)	0.086	0.042	3.92***	0.064
HH size in 2006 (individuals)	3.24	4.67	-10.2***	3.95
HH size in 2019 (individuals)	4.95	5.56	-5.36***	5.26
Children (number)	3.23	3.64	-5.26***	3.43
Dependency ratio	1.62	1.65	-1.07	1.63
Years in the village (years)	22.1	27.1	-6.01***	24.6
Relation to VH (1=yes)	0.40	0.47	-3.19**	0.43

Note: t-statistics used for mean difference between treatment and control (unmatched), *** statistically significant at 1% level, ** statistically significant at 5% level and * statistically significant at 10% level.

Source: Computed from household survey.

Housing Conditions

Table A3.2 compare housing conditions of households from the treatment and control areas. Overall, 85% of sample households had access to safe drinking water, and there were no statistically significant differences between treatment and control households in terms of access to safe drinking water. This is consistent with the national average of 87% of households having access to safe drinking water (NSO, 2017). The proportion of households with a floor of the main dwelling made of improved materials (cement, tiles and wood) is relatively higher among households in the treatment area compared to households in the comparison area and the differences are statistically significant. Households in the comparison area are better than households in the treatment area in terms of walls of their main dwelling house which is made from improved materials (burnt bricks, concrete). However, a higher proportion of households in the treatment area have roofs of the main dwelling made of improved materials compared to comparison households, with the differences being statistically significant at the 1% level.

Access to electricity is mainly through ownership of solar power, with only 5.6% of households in the study areas connected to the national electricity grid. No statistical differences exist in access to electricity between treatment and comparison households. A statistically significant higher proportion of treatment compared to comparison households have access to improved toilet facilities that are not shared with other households.

Access to Basic Social Services

Table A3.3 compares access to social services between households from the treatment and comparison areas. The findings show that a higher proportion of households from the comparison group (6.7%) had an extension worker living in their community than the households from the treated group (0.04%). This result is statistically significant, but it is strange because we expected a higher presence of extension workers for households in the treated group because of the presence of the irrigation projects. As expected, all households in the treated group had an irrigation scheme in their community compared to 40% of households from the comparison group. Access to electricity is also higher in the control households (26%) than in the treated households (1%). The findings further show that households in the comparison group lived in communities that had better access to financial services such as banks and microfinancing services while households in the treatment group had better access to health facilities, schools and markets as measured by distance to those facilities compared to households from the comparison group. All these comparisons are statistically significant at 1% level of significance.

Table A3.2: Household Conditions of Sample Households

Housing characteristics	Control	Treated	t-ratio	Total
Access safe drinking water	0.84	0.87	-1.47	0.85
Improved floor material (1=yes)	0.22	0.27	-2.24*	0.25
Improved roof material (1=yes)	0.54	0.64	-4.26***	0.59
Improved wall material (1=yes)	0.79	0.74	2.34*	0.77
Access to electricity 1=solar/grid)	0.19	0.18	0.36	0.19
Access to electricity (grid)	0.054	0.057	-0.21	0.056
Access to improved toilet (1=yes)	0.65	0.74	-4.27***	0.70

Note: t-statistics for mean difference between treatment and control (unmatched),
*** statistically significant at 1% level, ** statistically significant at 5% level and * statistically significant at 10% level.
Source: Computed from household survey.

Table A3.3: Access to Services by Sampled Households

Services	Control	Treated	t-statistics	Total
Extension worker available (1=yes)	0.066	0.0045	6.66***	0.033
Irrigation scheme (1=yes)	0.41	1.00	-35.7***	0.73
Access to electricity in 2019 (1=yes)	0.26	0.011	15.2***	0.13
Access to electricity in 2006 (1=yes)	0.13	0.0056	10.4***	0.063
Distance to bank (km)	36.3	58.9	-40.6***	48.6
Distance microfinance institution (km)	37.3	58.9	-34.2***	49.0
Distance to health facility (km)	17.2	0.89	10.1***	8.37
Distance to school (km)	0.56	0.029	14.1***	0.27
Distance to market (km)	8.80	6.05	7.80***	7.31

Note: t-statistics for mean difference between treatment and control (unmatched), *** statistically significant at 1% level, ** statistically significant at 5% level and * statistically significant at 10% level.
Source: computed from household survey.

Balance test for the covariates

A balance test was done to check on the validity of the estimates obtained from the IPWRA. To check if the covariates were balanced, the evaluation used the overidentification test for covariance balance that was derived by Imai and Ratkovic (2014). The chi square statistics for the balance test was 6.30 (Prob > chi^2 = 0.70). For the child level impact, the chi-square for the balance test was 9.74 (Prob > chi^2 = 0.46). These results show that we failed to reject the null hypothesis that the covariates are balanced in both the household level impact model and the child level model. We further tested individual covariates for both the household level model (Table A3.4) and the child level model (Table A3.5). The tests are based on standardized mean differences and variance ratios. Covariates with the standardized mean difference that are equal to zero or the variance ratio that are said to be balanced. The results confirm the summary findings by showing that all the covariates in the weighted samples in the two models are balanced which means that we can continue to use the inverse probability weighted regression adjustment to obtain valid treatment effects.

Table A3.4: Covariance Balance Test in the Household Level Model

Covariate	Standardized differences		Variance ratio	
	Raw	Weighted	Raw	Weighted
Age Head	0.390	-0.004	0.962	1.000
Age Head squared	0.348	-0.003	1.100	1.027
Male Head	0.041	-0.005	0.951	1.006
Married Head	0.026	-0.006	0.965	1.008
Secondary education	0.254	0.007	1.244	1.006
Rainfed land	0.057	0.008	0.950	0.959
Relative to Village head	0.134	0.002	1.031	1.000
Access to extension	0.453	-0.003	0.609	1.003

Table A3.5: Covariance Balance Test in the Child Level Model

Covariate	Standardized differences		Variance ratio	
	Raw	Weighted	Raw	Weighted
Sex child	0.014	0.013	0.999	0.999
Age child	0.213	-0.006	1.016	1.044
Male head	0.003	-0.024	0.996	1.036
Married Head	-0.025	0.001	1.046	0.998
Secondary education	0.392	0.004	1.358	1.003
Dependency ratio	0.115	-0.006	1.128	1.048
Rainfed land	0.156	0.012	1.608	1.179
Relative to Village head	0.131	0.006	1.040	1.002
Access to extension	0.454	0.003	0.536	0.997

Results of Heterogeneity analysis

Gender

Households were categorized into male headed households and female headed households and we measured the ATE of the two population groups of households separately. The estimation results are presented in Table A3.6 and A3.7.

Landholding size

On land, the hypothesis is that impact of irrigation projects will be greater for farmers who have larger land holding sizes. We evaluated the differential impact of irrigation among farmers with different land holding sizes by categorizing farmers into three categories based on their land holding size. The first category had an average landholding size of 0.38 hectares (less than or equal to 0.61 ha), while the

Table A3.6: Effects of Gender of Household Head on the Treatment Effects of Participation in Irrigation Projects on Intermediate Agricultural Outcomes

Outcome indicator	Female (N=411)			Male (N=1,307)		
	ESR	IPWRA		ESR	IPWRA	
Ln(Maize yield)	0.20(0.12)*	0.20**	(0.10)	0.34(0.05)***	0.35***	(0.05)
Ln(Maize revenue)	0.70(0.07)***	0.36***	(0.13)	0.72(0.04)***	0.43***	(0.07)
Ln(Vegetable revenue)	---	0.44	(0.34)	---	---	---
Ln(Total crop productivity)	0.41(0.09)***	0.39***	(0.13)	0.60(0.04)***	0.39***	(0.09)
Ln(Total crop revenue)	0.78(0.06)***	0.41***	(0.13)	0.82(0.04)***	0.39***	(0.08)
Cropping intensity	---	0.27***	(0.04)	---	-0.11	(0.41)
Crop diversification	0.04(0.00)***	0.04	(0.03)	0.05(0.00)***	0.05***	(0.02)

Note: t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Gaps imply that we were unable to generate the endogenous switching regression results because we could not attain convergence in the log likelihood.

Table A.3.7: Heterogeneous Effects of Gender of Household Head on Food Security, Health and Poverty

Outcome indicator	Female (N=411)			Male (N=1307)		
	ESR	IPWRA		ESR	IPWRA	
HFIAS	-0.21(0.20)	0.21	(0.65)	---	-0.69**	(0.33)
HDDS	0.21(0.10)**	0.21	(0.30)	0.92(0.04)***	0.49***	(0.18)
Incidence of illness	-0.05(0.01)***	0.46**	(0.23)	0.02(0.00)***	0.01	(0.03)
Expenditure per capita (MK)	0.32(0.05)***	0.38**	(0.15)	0.15(0.03)***	0.25***	(0.06)
Income per capita (MK)	0.23(0.04)***	0.26***	(0.10)	0.28(0.03)***	0.21***	(0.06)
Multidimensional Poverty Index	-0.06(0.02)***	-0.05	(0.05)	0.09(0.81)	0.00	(0.03)
Self-poverty assessment	-0.03(0.01)***	-0.03	(0.06)	0.17(0.1)	0.11***	(0.03)
Well-being change	-1.81(0.03)***	-0.10	(0.17)	-0.12(0.02)**	-0.10	(0.09)
Life satisfaction	-0.98(0.01)***	0.04	(0.11)	0.08(0.01)	0.07	(0.06)

Note: t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Gaps imply that we were unable to generate the endogenous switching regression results because we could not attain convergence in the log likelihood.

second category had an average land holding size of 0.89 hectares (between 0.61 and 1.12 ha), and the last category average land holding size was 1.86 hectares (more than 1.12 ha). The results for the treatment effects on intermediate outcomes and final outcomes are presented in Table A3.8 and A3.9, respectively.

Table A3.8: Effects of Irrigation Projects on Intermediate Agricultural Outcomes by Land Holding Size

Outcome indicator	Small landholding			Medium landholding			Large landholding		
	ESR	IPWRA		ESR	IPWRA		ESR	IPWRA	
Ln(Maize yield)	0.44(0.12)***	0.31***	(0.08)	0.42(0.06)***	0.43***	(0.08)	0.30(0.05)***	0.16**	(0.08)
Ln(Maize revenue)	0.50(0.05)***	0.30***	(0.10)	0.85(0.04)***	0.66***	(0.12)	0.53(0.05)***	0.27**	(0.11)
Ln(Vegetable revenue)	01.47(0.10)***	0.64**	(0.27)	0.26(0.04)***	0.73**	(0.30)	-0.06(0.04)	0.41	(0.33)
Ln(Total crop productivity)	0.62(0.10)***	0.43***	(0.13)	0.56(0.03)***	0.35***	(0.12)	0.59(0.04)***	0.30***	(0.11)
Ln(Gross crop revenue)	0.65(0.04)***	0.40***	(0.13)	0.58(0.04)***	0.35***	(0.12)	0.65(0.05)***	0.30***	(0.11)
Cropping intensity	---	-1.29	(1.48)	0.31(0.05)***	0.14***	(0.05)	---	0.20***	(0.05)
Crop diversification	---	0.02	(0.02)	0.02(0.00)***	0.02	(0.03)	0.08(0.01)***	0.09***	(0.02)

Note: t statistics in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Gaps imply that we were unable to generate the endogenous switching regression results because we could not attain convergence in the log likelihood.

Table A3.9: Effects of Irrigation Projects on Food Security, Health and Poverty by Land Holding Size

Outcome indicator	Small landholding			Medium landholding			Large landholding		
	ESR	IPWRA		ESR	IPWRA		ESR	IPWRA	
HFIAS	---	-0.89	(0.59)	---	0.30	(0.58)	----	-0.25	(0.53)
HDDS	0.49(0.06)***	0.20	(0.30)	0.56(0.09)***	0.35	(0.29)	0.37(0.10)***	0.05***	(0.27)
Incidence of illness	0.03(0.007)***	0.02	(0.04)	0.00(0.00)	-0.01	(0.05)	----	-0.19***	(0.20)
Ln(Expenditure per capita)	0.15(0.04)**	0.15	(0.14)	0.43(0.05)***	0.41***	(0.12)	0.31(0.05)***	0.11***	(0.10)
Ln(Income per capita)	0.10(0.04)***	-0.01	(0.09)	0.29(0.05)***	0.29**	(0.09)	0.31(0.05)***	0.17*	(0.08)
Multidimensional Poverty Index	0.04(0.02)***	0.03	(0.04)	-0.04(0.01)***	0.02	(0.05)	----	-0.03	(0.04)
Self-assessed poverty	0.08(0.02)***	0.06	(0.06)	0.09(0.03)***	0.16***	(0.05)	0.12(0.02)***	0.04	(0.06)
Well-being change	0.29(0.03)***	-0.19	(0.14)	-0.10(0.3)***	-0.29*	(0.17)	0.18(0.03)***	0.10	(0.13)
Life satisfaction	0.14(0.02)***	0.12	(0.11)	-0.18(0.03)***	-0.12	(0.11)	0.11(0.02)***	0.07	(0.10)

Note: t statistics in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Gaps imply that we were unable to generate the endogenous switching regression results because we could not attain convergence in the log likelihood.

Education

To assess, the heterogeneous effects of level of education of the household head, the evaluation categorized the heads based on whether they attained secondary school education or not. The results of the heterogenous effects of education are presented in Table A3.10 and A3.11.

Table A3.10: Effects of Irrigation Projects on Intermediate Agricultural Outcomes by Level of Education of Household Head

Outcome indicator	Head with no secondary education (n=-632)			Head with secondary education (n=402)		
	ESR	IPWRA		ESR	IPWRA	
Ln(Maize yield)	0.33(0.06)***	0.36***	(0.06)	0.23(0.08)***	0.27***	(0.08)
Ln(Maize revenue)	0.65(0.04)***	0.32***	(0.08)	0.85(0.06)***	0.49***	(0.11)
Ln(Vegetable revenue)	0.24(0.03)***	0.37	(0.24)	1.06(0.05)***	1.04***	(0.30)
Ln(Total crop productivity)	0.46(0.04)***	0.33***	(0.09)	0.60(0.07)***	0.53***	(0.12)
Ln(Gross crop revenue)	0.65(0.04)***	0.33***	(0.09)	0.95(0.07)***	0.54***	(0.12)
Cropping intensity	---	-0.19	(0.51)	---	0.17***	(0.03)
Crop diversification	0.02(0.00)***	0.03**	(0.17)	---	0.07**	(0.03)

Note: t statistics in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Gaps imply that we were unable to generate the endogenous switching regression results because we could not attain convergence in the log likelihood.

Table A3.11: Effects of Irrigation Projects on Household Food Security, Health and Poverty by Level of Education of Household Head

Outcome indicator	Head with no secondary education (n=632)			Head with secondary education (n=402)		
	ESR	IPWRA		ESR	IPWRA	
HFIAS	---	-1.04**	(0.38)	-	0.09**	(0.51)
HDDS	---	0.54*	(0.20)	0.13(0.07)	0.02*	(0.29)
Incidence of illness	0.01(0.00)***	0.01	(0.02)	0.01(0.01)	0.76	(0.56)
Expenditure per capita (MK)	0.36(0.03)***	0.32***	(0.07)	0.04(0.05)	0.09	(0.12)
Income per capita (MK)	---	0.25***	(0.06)	0.03(0.05)	0.13	(0.09)
Multidimensional Poverty Index	---	0.01	(0.21)	---	-0.02	(0.06)
Self-poverty assessment	0.11(0.01)***	0.10**	(0.04)	0.02(0.02)	-0.01	(0.05)
Well-being change	-0.16(0.01)***	-0.18**	(0.10)	-0.03(0.04)	0.06	(0.14)
Life satisfaction	0.08(0.01)	0.09	(0.07)	-0.02(0.02)	-0.04	(0.10)

Note: t statistics in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Gaps imply that we were unable to generate the endogenous switching regression results because we could not attain convergence in the log likelihood.

Annex 4: Endogenous Switching Regression Results & Descriptive Statistics for Outcome Variables

Table A4.1 Endogenous Switching Regression Results for Intermediate Outcomes

Variable	Log (Maize Yield)		Log (Maize Revenue)		Log (Veg Revenue)		Log (Gross Yield)		Log (Total Revenue)		Crop Diversity Index	
Regime 0												
Age of Head	-0.00	(0.00)	0.00	(0.00)	-0.00	(0.01)	-0.00	(0.00)	-0.00	(0.00)	0.00	(0.00)
Age of Head squared											-0.00	(0.00)
Head male	0.16*	(0.09)	0.29**	(0.11)	0.49*	(0.29)	0.41***	(0.10)	0.40***	(0.10)	0.01	(0.05)
Head married											-0.02	(0.05)
Secondary education											-0.07***	(0.03)
Log (fertilizer)a	0.09***	(0.01)	0.06***	(0.01)	0.07**	(0.03)		0.07***	(0.01)	0.07***	(0.01)	
Log (seed)a	0.20***	(0.03)	0.08**	(0.03)	0.08**	(0.04)	0.12***	(0.02)	0.11***	(0.02)		
Log (land)a	-0.79***	(0.03)	0.17***	(0.03)	0.09*	(0.05)	-0.68***	(0.04)	0.36***	(0.04)	0.02**	(0.01)
Extension	-0.37***	(0.09)	-0.21*	(0.11)			-0.32***	(0.11)	-0.31***	(0.11)		
Age of Head squared												
Constant	5.37***	(0.18)	10.03***	(0.21)	11.10***	(0.59)	10.77***	(0.18)	10.81***	(0.18)	0.33***	(0.10)
Regime 1												
Age of Head	-0.01***	(0.00)	-0.01***	(0.00)	-0.02***	(0.01)	-0.01***	(0.00)	-0.01***	(0.00)	0.00	(0.00)
Head male	0.26***	(0.09)	0.27**	(0.11)	0.43	(0.33)	0.40***	(0.10)	0.39***	(0.10)	-0.00	(0.00)
Log (fertilizer)a	0.07***	(0.01)	0.07***	(0.01)	0.14***	(0.03)	0.07***	(0.02)	0.07***	(0.02)	-0.01	(0.04)

Variable	Log (Maize Yield)		Log (Maize Revenue)		Log (Veg Revenue)		Log (Gross Yield)		Log (Total Revenue)		Crop Diversity Index	
Log (seed)a	0.24***	(0.03)	0.21***	(0.03)	-0.02	(0.03)	-0.55***	(0.04)	0.47***	(0.04)	0.01	(0.04)
Log (land)a	-0.83***	(0.03)	0.15***	(0.04)	0.19***	(0.05)	0.08***	(0.01)	0.08***	(0.01)	0.01	(0.02)
Extension	-0.51***	(0.09)	-0.36***	(0.12)			0.07	(0.13)	0.07	(0.13)	0.07***	(0.01)
Constant	7.41***	(0.21)	12.55***	(0.25)		(0.66)	12.53***	(0.31)	12.52***	(0.31)	0.25**	(0.13)
Select												
Age of Head	0.04***	(0.01)	0.04***	(0.01)	0.04**	(0.02)	0.05***	(0.01)	0.05***	(0.01)	0.06***	(0.01)
Age of Head squared	-0.00***	(0.00)	-0.00***	(0.00)	-0.00*	(0.00)	-0.00***	(0.00)	-0.00***	(0.00)	-0.00***	(0.00)
Head male	-0.08	(0.12)	0.01	(0.12)	0.12	(0.27)	0.02	(0.13)	0.02	(0.13)	0.11	(0.13)
Head married	0.09	(0.11)	0.02	(0.11)	-0.02	(0.27)	0.04	(0.13)	0.04	(0.13)	0.01	(0.14)
Secondary education	0.26***	(0.06)	0.25***	(0.06)	0.33***	(0.11)	0.30***	(0.07)	0.30***	(0.07)	0.28***	(0.07)
Rainfed land	0.11***	(0.04)	0.11***	(0.04)	-0.03	(0.08)	0.04	(0.05)	0.02	(0.05)	-0.07	(0.05)
Relation with VH	0.25***	(0.05)	0.23***	(0.05)	0.35***	(0.10)	0.23***	(0.06)	0.23***	(0.06)	0.17***	(0.06)
Extension	0.51***	(0.08)	0.51***	(0.08)	0.47***	(0.12)	0.55***	(0.07)	0.55***	(0.07)	0.55***	(0.07)
Constant	-1.81***	(0.26)	-1.86***	(0.26)	-1.68***	(0.48)	-2.15***	(0.29)	-2.16***	(0.29)	-2.20***	(0.30)
lns0												
_cons	0.11**	(0.05)	0.24***	(0.04)	0.49***	(0.05)	0.23***	(0.05)	0.21***	(0.05)	-1.18***	(0.03)
lns1												
_cons	0.12***	(0.04)	0.41***	(0.04)	0.88***	(0.07)	0.26***	(0.04)	0.25***	(0.04)	-1.41***	(0.04)
r0												
_cons	-0.88***	(0.11)	-0.44***	(0.13)	-0.04	(0.33)	-0.53***	(0.16)	-0.48***	(0.16)	0.06	(0.18)
r1												
_cons	-1.30***	(0.12)	-1.39***	(0.09)	-1.09***	(0.19)	-0.52***	(0.13)	-0.51***	(0.13)	0.33	(0.20)
N	1486		1512		517		1673		1673		1719	

Table A4.2: Endogenous Switching Regression Results for Food Security and Health

Variable	Household Food Insecurity Assessment Score		Household Dietary Diversity Score		Incidence of Illness	
Regime 0						
Age of Head			-0.06***	(0.01)	0.00	(0.00)
Head male	-1.67***	(0.52)	-0.11	(0.31)	-0.04	(0.04)
Secondary education	-0.86***	(0.18)	0.22**	(0.09)	0.00	(0.01)
Dependency ratio	0.16	(0.37)				
Total land holding	-0.81***	(0.19)	0.23**	(0.10)		
Crop diversification	0.64	(0.70)	0.30	(0.29)	0.03	(0.05)
Under five Children					0.03***	(0.01)
Distance health facility					-0.00**	(0.00)
Constant	8.30***	(1.12)	5.32***	(0.54)	0.20***	(0.07)
Regime 1						
Head male	-2.86***	(0.49)	-0.02**	(0.01)	0.00	(0.00)
Secondary education	-0.55***	(0.16)	0.61**	(0.26)	0.05	(0.04)
Dependency ratio	-0.21	(0.30)	0.53***	(0.09)	0.02*	(0.01)
Total land holding	-0.43**	(0.21)	0.14	(0.11)	-0.01	(0.01)
Crop diversification	1.79**	(0.85)	-0.04	(0.44)	-0.04	(0.06)
Under five Children	9.70***	(1.05)	6.68***	(0.94)	-0.00	(0.00)
select					0.18	(0.16)
Age of Head	0.06***	(0.01)	0.04***	(0.01)	0.06***	(0.01)
Age of Head squared	-0.00***	(0.00)	-0.00***	(0.00)	-0.00***	(0.00)
Head male	0.10	(0.13)	0.07	(0.10)	0.11	(0.13)
Head married	0.03	(0.14)	0.00	(0.08)	0.04	(0.14)
Secondary school education	0.27***	(0.07)	0.20***	(0.06)	0.25***	(0.07)
Extension	0.54***	(0.07)	0.26***	(0.05)	0.54***	(0.07)
Rainfed land	-0.07	(0.05)	0.00	(0.04)	-0.06	(0.05)
Relation with VH	0.16**	(0.06)	0.09**	(0.04)	0.17***	(0.07)
Constant	-2.20***	(0.30)	-1.52***	(0.22)	-2.17***	(0.31)
lns0						
_cons	1.83***	(0.03)	1.51***	(0.03)	-0.81***	(0.03)
lns1						
_cons	1.79***	(0.03)	1.14***	(0.03)	-0.80***	(0.02)
r0						
_cons	-0.06	(0.17)	-1.95***	(0.12)	0.14	(0.15)
r1						
_cons	-0.20*	(0.12)	-0.08	(0.20)	0.01	(0.24)
N	1719		1719		1659	

Table A4.3: Endogenous Switching Regression Results for Child Nutrition Status

Variable	Stunting		Underweight	
Regime 0				
Sex child	0.09**	(0.04)	0.03	(0.03)
Age child	0.00	(0.00)	0.00	(0.00)
Head secondary education	0.11*	(0.06)	0.07**	(0.03)
Multidimensional Poverty Index	0.46***	(0.04)	0.12***	(0.03)
Incidence of illness	-0.01	(0.05)	-0.03	(0.03)
_cons	0.03	(0.08)	-0.00	(0.04)
Regime 1				
Sex child	-0.06	(0.04)	-0.01	(0.03)
Age child	0.00	(0.00)	0.00	(0.00)
Head secondary education	0.06	(0.05)	0.01	(0.05)
Multidimensional Poverty Index	0.47***	(0.05)	0.13***	(0.03)
Incidence of illness	-0.03	(0.05)	0.04	(0.04)
_cons	0.22**	(0.10)	-0.02	(0.10)
select				
Age head	0.02***	(0.00)	0.02***	(0.00)
Head secondary education	0.39***	(0.10)	0.39***	(0.10)
Rainfed land	0.05	(0.07)	0.05	(0.07)
Relation to VH	0.16*	(0.10)	0.18*	(0.09)
Access to extension	0.56***	(0.12)	0.56***	(0.12)
Multidimensional Poverty Index	0.04	(0.10)	0.04	(0.10)
Incidence of illness	-0.07	(0.10)	-0.07	(0.10)
Head male	0.14	(0.12)	0.12	(0.12)
_cons	-1.65***	(0.22)	-1.65***	(0.22)
lns0				
_cons	-0.83***	(0.04)	-1.33***	(0.04)
lns1				
_cons	-0.81***	(0.05)	-1.15***	(0.04)
r0				
_cons	-0.20	(0.16)	0.03	(0.15)
r1				
_cons	-0.30	(0.19)	0.16	(0.32)
N	784		784	

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A4.4: Endogenous Switching Regression Results for Poverty

Variable	Expenditure		Income		MPI		Poverty		Wellbeing		Life Satisfaction	
Regime 0												
Age of Head	0.05***	(0.02)	0.05***	(0.01)	-0.01	(0.01)	0.01	(0.01)	-0.00	(0.00)	0.01	(0.02)
Age of Head squared	-0.00***	(0.00)	-0.00***	(0.00)	0.00*	(0.00)	-0.00	(0.00)			-0.00	(0.00)
Male head	0.58***	(0.11)	0.46***	(0.08)	-0.12***	(0.04)	0.10**	(0.05)	0.02	(0.14)	0.12	(0.10)
Secondary education	0.29***	(0.04)	0.27***	(0.03)	-0.09***	(0.01)	0.15***	(0.02)	-0.00	(0.05)	0.05	(0.03)
Dependency ratio	-0.02	(0.08)	-0.14**	(0.06)	0.05*	(0.03)	-0.04	(0.04)	-0.13	(0.10)	-0.04	(0.07)
Household size	-0.15***	(0.02)	-0.17***	(0.02)	0.02**	(0.01)	-0.02*	(0.01)	0.01	(0.03)	-0.05**	(0.02)
Total land	0.20***	(0.04)	0.15***	(0.03)	-0.00	(0.02)	0.06***	(0.02)	-0.01	(0.05)	0.04	(0.04)
north	0.18	(0.15)	-0.04	(0.11)	-0.22***	(0.06)	0.32***	(0.08)	0.16	(0.19)	0.08	(0.14)
south	0.09	(0.14)	-0.06	(0.11)	-0.02	(0.05)	0.09	(0.07)	0.16	(0.18)	0.07	(0.13)
_cons	8.74***	(0.41)	9.70***	(0.32)	0.80***	(0.16)	1.35***	(0.21)	2.27***	(0.32)	2.53***	(0.39)
Regime 1												
Age of Head	-0.04*	(0.02)	-0.02	(0.02)	0.00	(0.01)	0.00	(0.01)	-0.00	(0.01)	-0.03*	(0.02)
Age of Head squared	0.00	(0.00)	0.00	(0.00)	-0.00	(0.00)	-0.00	(0.00)			0.00	(0.00)
Male head	0.32***	(0.11)	0.26***	(0.09)	-0.08*	(0.04)	0.22***	(0.05)	-0.18	(0.14)	0.07	(0.10)
Secondary education	0.19***	(0.04)	0.20***	(0.03)	-0.09***	(0.01)	0.15***	(0.02)	0.09*	(0.05)	-0.00	(0.03)
Dependency ratio	-0.04	(0.06)	-0.07	(0.05)	0.06**	(0.02)	-0.02	(0.03)	-0.36***	(0.08)	-0.03	(0.06)
Household size	-0.14***	(0.02)	-0.15***	(0.02)	0.02**	(0.01)	-0.01	(0.01)	-0.01	(0.02)	0.01	(0.02)
Total land	0.17***	(0.04)	0.22***	(0.04)	-0.03	(0.02)	0.05**	(0.02)	0.04	(0.06)	-0.00	(0.04)
north	-0.36***	(0.12)	-0.48***	(0.11)	-0.10*	(0.05)	0.05	(0.07)	-0.03	(0.19)	0.10	(0.12)
south	-0.54***	(0.11)	-0.45***	(0.10)	0.07	(0.05)	-0.03	(0.07)	0.10	(0.17)	-0.19	(0.12)
_cons	13.26***	(0.49)	13.06***	(0.46)	0.54*	(0.30)	1.66***	(0.42)	3.06***	(0.75)	4.25***	(0.60)
select												
Age of Head	0.05***	(0.01)	0.05***	(0.01)	0.06***	(0.01)	0.06***	(0.01)	0.05***	(0.01)	0.05***	(0.01)

Variable	Expenditure		Income		MPI		Poverty		Wellbeing		Life Satisfaction	
Age of Head squared	-0.00***	(0.00)	-0.00***	(0.00)	-0.00***	(0.00)	-0.00***	(0.00)	-0.00***	(0.00)	-0.00***	(0.00)
Male Head	0.11	(0.11)	0.10	(0.12)	0.12	(0.13)	0.13	(0.13)	0.10	(0.13)	0.06	(0.13)
Head married	-0.13	(0.10)	-0.02	(0.12)	0.00	(0.14)	-0.00	(0.14)	0.04	(0.14)	0.08	(0.13)
Secondary education	0.21***	(0.06)	0.24***	(0.07)	0.28***	(0.07)	0.28***	(0.07)	0.27***	(0.07)	0.26***	(0.07)
Rainfed land	0.08*	(0.04)	0.03	(0.05)	-0.06	(0.05)	-0.07	(0.05)	-0.06	(0.05)	-0.03	(0.05)
Relation with VH	0.13**	(0.05)	0.16**	(0.06)	0.18***	(0.06)	0.18***	(0.06)	0.17***	(0.06)	0.19***	(0.06)
Extension	0.51***	(0.06)	0.57***	(0.07)	0.55***	(0.07)	0.54***	(0.08)	0.56***	(0.07)	0.56***	(0.07)
_cons	-1.92***	(0.30)	-2.09***	(0.30)	-2.17***	(0.30)	-2.18***	(0.30)	-2.15***	(0.30)	-2.20***	(0.30)
lns0												
_cons	0.18***	(0.03)	-0.08**	(0.03)	-0.76***	(0.03)	-0.49***	(0.04)	0.48***	(0.03)	0.13***	(0.03)
lns1												
_cons	0.42***	(0.04)	0.12**	(0.06)	-0.76***	(0.02)	-0.50***	(0.03)	0.43***	(0.03)	0.17***	(0.05)
r0												
_cons	-0.15	(0.13)	0.18	(0.23)	-0.19	(0.19)	0.22	(0.22)	-0.26	(0.16)	-0.20	(0.21)
r1												
_cons	-1.36***	(0.10)	-0.79***	(0.17)	0.02	(0.25)	0.10	(0.28)	-0.13	(0.30)	-0.46**	(0.19)
N	1649		1707		1719		1719		1719		1719	

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A4.5: Descriptive Statistics - Outcome Indicators (Averages)

Outcome indicator	Control	Treated	Total
Maize yield (kg/ha)	6,885.3	5,585.7	6,199.8
Maize revenue (MK)	66,019.1	155,042.4	110,530.7
Vegetable revenue (MK)	49,483.4	620,848.3	335,165.9
Total crop yield (MK/ha)	1,048,741.4	2,152,279.9	1,614,154.2
Total revenue (MK)	240,141.8	1,197,201.0	718,671.4
Cropping intensity	1.352	1.392	1.372
Crop Diversity Index	0.281	0.332	0.307
Household Food Insecurity Access Scale	6.448	5.749	6.098
Household Dietary Diversity Score	6.554	7.032	6.793
Incidence of illness	0.282	0.288	0.285
Expend per capita (MK)	52,052.6	64,378.8	58,215.7
Income per capita (MK)	72,419.8	95,740.7	84,080.2
Multidimensional Poverty Index	0.533	0.499	0.516
Self-poverty assessment	1.921	2.042	1.982
Change in economic wellbeing	2.377	2.264	2.321
Overall satisfaction with life	2.819	2.879	2.849

Table A4.6: Descriptive Statistics- Outcome Indicators for Male-Headed Households (Averages)

Outcome indicator	Control	Treated	Total
Maize yield (kg/ha)	6,866.5	5,575.0	6,183.9
Maize revenue (MK)	73,382.7	171,773.2	123,334.8
Vegetable revenue (MK)	64,302.2	796,137.3	435,849.2
Total crop yield (MK/ha)	1,112,898.4	2,398,412.9	1,778,958.0
Total revenue (MK)	283,355.0	1,193,470.4	745,413.6
Cropping intensity	1.441	1.409	1.425
Crop Diversity Index	0.283	0.336	0.310
Household Food Insecurity Access scale	5.954	5.053	5.497
Household Dietary Diversity Score	6.685	7.247	6.970
Incidence of illness	0.271	0.300	0.286
Expend per capita (MK)	58,848.8	70,665.8	64,848.2
Income per capita (MK)	79,304.4	104,450.5	92,070.9
Multidimensional Poverty Index	0.497	0.470	0.484
Self-poverty assessment	1.960	2.114	2.038
Change in economic wellbeing	2.382	2.263	2.322
Overall satisfaction with life	2.856	2.916	2.886

Table A4.7: Descriptive Statistics- Outcome Indicators for Female-headed Households (Averages)

Outcome indicator	Control	Treated	Total
Maize yield (kg/ha)	6,948.2	5,622.5	6,253.8
Maize revenue (MK)	44,315.6	99,030.4	70,352.3
Vegetable revenue (MK)	5,807.0	34,011.5	19,228.5
Total crop yield (MK/ha)	853,826.3	1,328,634.9	1,088,370.3
Total revenue (MK)	112,776.4	1,209,690.4	634,756.2
Cropping intensity	1.080	1.334	1.206
Crop Diversity Index	0.274	0.316	0.295
Household Food Insecurity Access Scale	7.904	8.077	7.986
Household Dietary Diversity Score	6.171	6.314	6.239
Incidence of illness	0.316	0.246	0.283
Expend per capita (MK)	32021.9	43,331.2	37,403.6
Income per capita (MK)	52128.3	66,582.0	59,006.3
Multidimensional Poverty Index	0.640	0.594	0.618
Self-poverty assessment	1.807	1.802	1.805
Change in economic wellbeing	2.360	2.271	2.317
Overall satisfaction with life	2.711	2.754	2.731

Table A4.8: Descriptive Statistics - Outcome Indicators for Households with Small Land Holding Sizes (<=0.61 ha) (Average)

Outcome indicator	Control	Treated	Total
Maize yield (kg/ha)	11,274.4	12,709.9	11,886.3
Maize revenue (MK)	35,671.0	72,727.4	51,082.8
Vegetable revenue (MK)	11,916.9	81,328.9	40,785.5
Total crop yield (MK/ha)	1,993,106.2	4,625,407.8	3,087,886.1
Total revenue (MK)	89,617.4	268,786.5	164,134.2
Cropping intensity	1.597	1.343	1.491
Crop Diversity Index	0.229	0.233	0.231
Household Food Insecurity Access Scale	7.686	6.702	7.277
Household Dietary Diversity Score	5.997	6.500	6.206
Incidence of illness	0.272	0.298	0.283
Expend per capita (MK)	35,920.6	40,643.5	37,884.9
Income per capita (MK)	62,165.8	69,635.4	65,272.4
Multidimensional Poverty Index	0.571	0.603	0.584
Self-poverty assessment	1.814	1.897	1.849
Change in economic wellbeing	2.524	2.235	2.404
Overall satisfaction with life	2.654	2.809	2.719

Table A4.9: Descriptive Statistics - Outcome Indicators for Households with Medium Land Holding Sizes (0.61 to 1.12 ha) (Averages)

Outcome indicator	Control	Treated	Total
Maize yield (kg/ha)	5,393.3	2,833.1	3926.4
Maize revenue (MK)	59,371.2	135,947.3	10,1863.4
Vegetable revenue (MK)	96,770.4	113,507.0	106,057.6
Total crop yield (MK/ha)	268,470.7	396,983.8	339,782.9
Total revenue (MK)	243,227.5	359,296.4	307,634.3
Cropping intensity	1.143	1.452	1.315
Crop Diversity Index	0.319	0.334	0.327
Household Food Insecurity Access Scale	6.123	6.060	6.088
Household Dietary Diversity Score	6.357	6.887	6.651
Incidence of illness	0.273	0.261	0.267
Expend per capita (MK)	33,101.5	57,155.4	46,449.0
Income per capita (MK)	57,916.9	76,344.0	68,142.1
Multidimensional Poverty Index	0.542	0.502	0.520
Self-poverty assessment	1.916	2.007	1.967
Change in economic wellbeing	2.396	2.300	2.343
Overall satisfaction with life	2.974	2.802	2.878

Table A4.10: Descriptive Statistics - Outcome Indicators for Households with Larger Land Holding Sizes (>1.12 ha) (Averages)

Outcome indicator	Control	Treated	Total
Maize yield (kg/ha)	1,915.9	2,624.6	2,335.4
Maize revenue (MK)	135,203.2	241,914.3	197,559.6
Vegetable revenue (MK)	75,380.6	1,501,546.3	908,757.4
Total crop yield (MK/ha)	280,432.1	1,628,643.0	1,068,256.2
Total revenue (MK)	530,046.5	2,686,577.6	1,790,210.7
Cropping intensity	1.158	1.381	1.289
Crop Diversity Index	0.327	0.409	0.375
Household Food Insecurity Access Scale	5.142	4.759	4.918
Household Dietary Diversity Score	7.322	7.637	7.506
Incidence of illness	0.314	0.304	0.308
Expend per capita (MK)	69,740.0	90,886.7	82,097.0
Income per capita (MK)	92,687.6	134,367.8	117,043.3
Multidimensional Poverty Index	0.494	0.414	0.447
Self-poverty assessment	2.075	2.196	2.146
Change in economic wellbeing	2.126	2.283	2.217
Overall satisfaction with life	2.900	3.012	2.965

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Endnotes

1. Source: IDEV Report on Impact Evaluation of small-scale irrigation projects in Malawi (page v).
2. Source: IDEV Report on Impact Evaluation of small-scale irrigation projects in Malawi (page vi)
3. The designs of the recent projects including the on-going such as SIVAP,AIYAP and SVTP-1 have incorporated activities on training and awareness on water related diseases such as Malaria and bilharzia and other diseases likely to be increased by the project such as HIV/AIDs.
4. Total crop productivity is measured by dividing total crop revenue (the monetary value of all crops grown) by the total land holding size.
5. In addition to maize and vegetable, the other crops are: rice, cassava, sorghum, millet, potatoes, bean, groundnuts, ground bean, pigeon peas, soya, cotton, tobacco, etc.
6. It includes education, health and standard of living in measuring poverty.
7. See section 5.3 for detail on subjective poverty measurements.
8. The evaluation also assessed the heterogenous impact of irrigation projects by gender of the head of the household, land holding size, and level of education of head of households.
9. The actual was 92% of the revised target. The irrigation development component was scaled down from the appraisal target of 3,055 ha to 1,671 ha at mid-term review due to budget underestimation at design and increased construction costs during implementation.
10. The actual was 71% from the revised target. The initial target of 2320 ha was reduced to 1601 ha at mid-term review due to land disputes and high cost of solar technology.
11. The exponent of average treatment effect (ATE) that is in logarithm form can be expressed as follows: exp\left(ATE\ right)=exp\left(lnO_T-lnO_C\right)=\exp{\left(ln\frac{O_T}{OC}\right)}=\ \frac{O_T}{O_C}\ , where OT is the outcome in the treatment group, OC is the outcome in the control group.
12. In addition to maize and vegetable, the other crops are: rice, cassava, sorghum, millet, potatoes, bean, groundnuts, ground bean, pigeon peas, soya, cotton, tobacco, etc.
13. For crop intensity, IPWRA results were not used, as it did not control both observable and unobservable characteristics in reducing biases, compared with ESR model (see Annex B for details).
14. Total crop productivity is measured by dividing total crop revenue (the monetary value of all crops grown) to the total land holding size.
15. Crop diversification as measured by Simpson index ranges from 0 (complete specialization) to 1 (highly diversified).
16. The details of the measurements are provided in Annex B.
17. HFIAS ranges from 0 (food secure) to 27 (food unsecure).
18. HDDS ranges from 1 (less diversified food) to 12 (most diversified food).

19. Project completion report of SCPMP (2013) and AISP (2017)

20. To assess the differential impact of irrigation among farmers with different land holding sizes, farmers were categorized into three based on their land holding sizes: small (less than or equal to 0.61 ha), medium (between 0.61 and 1.12 ha), and large (greater than 1.12 ha).

21. Crop diversification index ranges from 0 (complete specialization) to 1 (highly diversified).

22. One USD was exchanged for 730 Kwacha.

23. National household survey data such as Household Integrated Surveys are not adequate for assessing the impacts of irrigation given the national spread of the sample and the small proportion of farming agricultural land under irrigation by smallholder farmers. SCPMP and AISP are location specific projects, and there is no guarantee that the random sampling in national surveys would capture adequate numbers of households in such areas.

24. World Bank (2008) reports differences of between 20–50% increases in yields in India following irrigation development.

25. This was done for all the six crops promoted under irrigation: maize with initial productivity of 1.13 tons per hectare, rice (1.17 tons/ha), cabbage (16.7 tons/ha), onions (20 tons/ha), paprika (0.29 tons/ha) and chilies (0.45 tons/ha).

26. IMP potential irrigation schemes were deemed comparable to SCPMP and AISP investments due to their economic viability to attract government and development partners funding and the geographic and ecological spread across the country.

27. However, in the context of Malawi, some of the crops may be grown by few households and the impact analysis may be constrained by the number of observations. Only crops with reasonable sample balance between treatment and comparison areas will be selected for analysis of yield per hectare.

28. Literature suggest several ways of measuring poverty. See Chirwa et al (2018) for a review some of the indicators of poverty.

29. The exponent of average treatment effect (ATE) that is in logarithm form can be expressed as follows: exp\ left(ATE\right)=exp\left(lnO_T-lnO_C\right)=\exp{\left(ln\frac{O_T}{OC}\right)}=\ \frac{O_T}{O_C}\ \ \ \ \ where\ O_T\ is\ the\ outcome\ in\ the\ treatment\ group\ and\ O_C\ is\ the\ outcome\ in\ the\ control\ group

30. Education was measured in an ordinal with 1 for no formal education; 2 for primary education; 3 for junior secondary education; and 4 for tertiary education.

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About this Evaluation

This report summarizes the findings, lessons and recommendations from an impact evaluation of the African Development Bank's (AfDB) support to the Smallholder Crop Production and Marketing Project (SCPMP) and the Agriculture Infrastructure Services Project (AISP) in Malawi. Worth UA 15 million each and completed in 2014 and 2017 respectively, both projects covered irrigation infrastructure and other complementary interventions.

The evaluation estimated that the projects led to positive and statistically significant increases in maize yields and total crop productivity, including substantial revenue increase of participating farmers. Statistical evidence showed that with irrigation development projects, expenditure per capita increased by about 42% and income per capita by 34%, indicating that both income poverty and multidimensional poverty of the farmers' households were reduced. The sustainability of the development outcomes of the two interventions was however highly unlikely, due to shortcomings including weak organizational capacity of farmers and poor irrigation schemes design.

Five main lessons were identified, which could help improve ongoing and future irrigation development interventions. Three recommendations were made, including: i) support capacity and governance systems of local institutions; ii) enhance agricultural market access; and iii) engage in knowledge work and policy dialogue.

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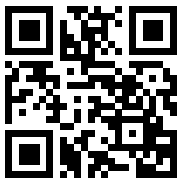

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