Development of Climate Smart Mechanization and Irrigation Lending Product

INITIATIVE ON
Diversification in East and Southern Africa

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Introduction

The purpose of this report is to refine and develop the investment case for a mechanization lending product for emergent farmers in Zambia. It builds upon the understanding that among conservation agriculture practices, intercropping holds the promise of providing benefits to smallholders through increased crop yields and income as well as improved resource use[1]. This study examines a number of intercropping cashflows options, with the anchor value chain for small- and medium-sized farmers being maize farming. It also outlines the commercial viability of maize farming in being an anchor value chain, to enable access to financing of irrigation assets that can be deployed across supplementary value chains (i.e. soy-beans and groundnuts). Then further proves the repayment capacity of a small and medium-scale farmer yields sufficient gross margin to service the loan for an irrigation asset.

Intercropping analysis

Modern agricultural practices are criticized for their negative effects on terrestrial ecosystems, use of nonrenewable resources, and contribution to climate change. As a result, there has been a renewed interest in intercropping as a more sustainable alternative to monoculture systems. Intercropping is the simultaneous (or relatively simultaneous) cultivation of crops in the same field[2]. Intercropping can improve crop yields per unit area, income, nutrient, solar radiation, and water use efficiency[3]. It is further reported that intercropping increases crop yields by 23% and gross income by 172 USD/ha, but effects vary significantly depending on management practices and agro-ecological factors.[4] It is also worth noting that there is no evidence that using leguminous intercropping combinations, minimum/reduced tillage, pesticides, or fertilizers increases intercropping yields and gross income. Dual use of herbicides and intercropping practices resulted in 1442 USD/ha more gross income and 1422 kg/ha more yield than conventionally managed fields, demonstrating the positive impact of supplemental inputs on the effects of intercropping[5]. However, for example the push–pull intercropping methodology commonly utilizes the legume Desmodium, which deters stem borer moths from a companion intercrop, suppresses seed germination of Striga, and attracts parasitic wasps, a natural enemy of moths[6]. In addition, intercropping can be an effective approach for decreasing soil erosion, improving available soil nitrogen via intercropped legumes[7]. Overall, well-designed intercropping operations use natural resources efficiently, increase biodiversity, manage pests, and, in many cases, improve crop productivity, quality, and natural soil fertility while using fewer off-farm inputs. To sum up, intercropping is a labor-intensive technique that smallholder farmers employ extensively to raise yield productivity per unit input, manage crop failure and market fluctuations, satisfy cultural and dietary demands, and boost revenue.[8]

Table 1 presents a maize-only cashflow model for small and medium-sized farmers growing maize in Zambia. The results revealed that the overall yield costs of production are ZMK 12660.06, reflecting a ZMK1851.7 gross margin for 1 hectare unit, and ZMK 63303.00 for 5 hectares with a gross margin of ZMK 9258.50. If a farmer grows maize

[1] J. Himmelstein, A. Ares, D. Gallagher & J. Myers (2017) A meta-analysis of intercropping in Africa: impacts on crop yield, farmer income, and integrated pest management effects, International Journal of Agricultural Sustainability, 15:1, 1-10, DOI: 10.1080/14735903.2016.1242332
[2] Smith, H. A., & McSorley, R. (2000). Intercropping and pest management: A review of major concepts. American Entomologist, 46, 154–161.
[3] J. Himmelstein, A. Ares, D. Gallagher & J. Myers (2017) A meta-analysis of intercropping in Africa: impacts on crop yield, farmer income, and integrated pest management effects, International Journal of Agricultural Sustainability, 15:1, 1-10, DOI:10.1080/14735903.2016.1242332
[4] J. Himmelstein, A. Ares, D. Gallagher & J. Myers (2017) A meta-analysis of intercropping in Africa: impacts on crop yield, farmer income, and integrated pest management effects, International Journal of Agricultural Sustainability, 15:1, 1-10, DOI:10.1080/14735903.2016.1242332
[5] J. Himmelstein, A. Ares, D. Gallagher & J. Myers (2017) A meta-analysis of intercropping in Africa: impacts on crop yield, farmer income, and integrated pest management effects, International Journal of Agricultural Sustainability, 15:1, 1-10, DOI:10.1080/14735903.2016.1242332
[6] Hassanali, A., Herren, H., Kahn, Z., Pickett, J., & Woodcock, C.(2008). Integrated pest management: The push-pull approach for controlling insect pests and weeds of cereals, and its potential for other agricultural systems including animal husbandry. Philosophical Transactions of the Royal Society B: Biological Sciences, 363, 611–621
[7] Hauggaard-Nielsen, H., & Jensen, E. S. (2005). Facilitative root interactions in intercrops. Plant and Soil, 274, 237–250
[8] R.W. Brooker et al. 2015, Improving intercropping: a synthesis of research in agronomy, plant physiology and ecology New Phytol.

on only one or five hectares of land and intends to export the produce. According to the model findings, the gross margin for 1 hectare of land is ZMK 8515.60, while for 5 hectares of land it is ZMK42578.00. This comprises the price of seeds, basal dressing, top dressing, fertilizer transportation, herbicides, labor, and machinery rental.

In order to assess the various options and support the intercropping investment case in Zambia, extra cashflow options were created. Legume crops (groundnuts and soybeans) were among those taken into consideration. Therefore, the expenses of labor, renting machinery, and transporting fertilizer will either not be considered at all or will be significantly reduced if soybeans are interplanted with maize. Likewise, expenses like irrigation and land rental will not be factored into the soybean production cost. It is crucial to remember that only the costs associated with producing soybeans, such as labor, herbicides, top dressing, basal dressing, and seed, would be taken into account. Because of this, it is reasonable to say that cultivating maize in intercropping with legumes or vegetables will result in cheaper production costs than growing soybean and maize individually, which would need more space.

Table 2 provides a cash flow model for intercropping maize and soybeans for Zambian small- and medium-sized farmers. The entire yield costs of production, according to the results, are ZMK 7042.04, with a gross margin of ZMK 211.96 for a unit of one hectare and ZMK 35210.20 for five hectares, with a gross margin of ZMK 1059.80. Should the farmer choose to export their maize yield, they are merely intercropping 1 or 5 hectares of land with soybeans and maize. According to the model results, the total agricultural margin for a 1 hectare plot of land would be ZMK 9727.56, and for a 5 hectare plot of land, ZMK 48637.80. This also covers the price of labor, hiring machinery, fertilizer transportation, herbicides, top dressing, basal dressing, and seeds.

Table 3 presents a cash flow model for intercropping maize and groundnuts for Zambian small- and medium-sized farmers. The results showed that the overall yield costs of production are ZMK 12915.50, representing a ZMK1,343.70 gross margin for a 1 hectare unit, and ZMK 64577.50 for 5 hectares, representing a gross margin of ZMK 6718.50. If a farmer intercrops maize and groundnuts on only 1 or 5 hectares of land decides to export their maize production. According to the model findings, the total farming margin for one hectare is ZMK 9,859.30, while for five hectares, it is ZMK 49,296.50. This comprises the price of seeds, basal dressing, top dressing, fertilizer transportation, herbicides, labor, and machinery rental.

A maize-only option on a 5 hectare unit has a total gross margin of ZMK42578.00 if maize is exported and ZMK 9,258.50 if no crop is exported. The overall farming margin for the intercropping maize and soybean model on a 5 hectare unit is ZMK 48637.80, whereas the maize and groundnut model choice yielded a total farming margin of ZMK 49,296.50 if maize was exported.

Based on these findings, it is crucial to emphasize that intercropping maize increases a farmer's profit margin since it allows them to harvest more goods per unit hectare of land, such as groundnuts and soybeans, maize and soybeans, or groundnuts and soybeans. In order to repay the loan for an irrigation asset, a farmer can generate greater yields and more earnings by doing this, as it guarantees a larger gross margin than cultivating maize alone.

Table 1 presents the business case for maize farming for both local and export market for different land sizes in Zambia.

Table 1: The Business Case for maize farming for both local and export market for different land sizes

National Small and Medium Scale Farmer Cashflow Model - Maize only							Sources and Assumptions
Farm size (HA)	**1**	**3**	**5**	**8**	**12**	**15**	
Crop	Maize	Maize	Maize	Maize	Maize	Maize	
Yield (KG)	1670	5010	8350	13360	20040	25050	Source: Zambia Statistical Agency(ZSA) Cropforcast survey 2022-2022 - 2023
Bags (50kg)	33.4	100.2	167	267.2	400.8	501	
LOCAL - Market price/Kg (ZMW) *	ZMK 8.69	ZMK 8.69	ZMK 8.69	ZMK 8.69	ZMK 8.69	ZMK 8.69	Sources: Minisitry of Agriculture.,Montly Market Bulletin Commodity Prices as per April 2024
Gross Revenue (ZMW)	**ZMK 14,512.30**	**ZMK 43,536.90**	**ZMK 72,561.50**	**ZMK 116,098.40**	**ZMK 174,147.60**	**ZMK 217,684.50**	
Costs of production Costs of production per HA (ZMW)							
Maize seed - Early Maturing	ZMK 1,172.60	ZMK 3,517.80	ZMK 5,863.00	ZMK 9,380.80	ZMK 14,071.20	ZMK 17,589.00	Assuming that 1 hectare requires 25kg of Maize seed. PRICE (ZMK/10Kg = 469.04

Basal dressing	ZMK 2,628.00	ZMK 7,884.00	ZMK 13,140.00	ZMK 21,024.00	ZMK 31,536.00	ZMK 39,420.00	Number of bags of fertilizer applied. https://nitumezifarms.com/bags-of-fertilizer-per-hectare-in-zambia/ Basal fertilizer: 0 to 3 bags per hectare Top-dressing fertilizer: 2 to 5 bags per hectare
Top dressing	ZMK 4,567.00	ZMK 13,701.00	ZMK 22,835.00	ZMK 36,536.00	ZMK 54,804.00	ZMK 68,505.00	
Fertilizer transport	ZMK 193.00	ZMK 193.00	ZMK 193.00	ZMK 193.00	ZMK 193.00	ZMK 193.00	
Herbicides	ZMK 62.00	ZMK 62.00	ZMK 62.00	ZMK 58.90	ZMK 52.70	ZMK 52.70	
Labor	ZMK 3,438.00	ZMK 10,314.00	ZMK 17,190.00	ZMK 27,504.00	ZMK 41,256.00	ZMK 51,570.00	
Machinery hire	ZMK 600.00	ZMK 1,800.00	ZMK 3,000.00	ZMK 4,800.00	ZMK 7,200.00	ZMK 9,000.00	
Total cost per kg (inc. land cost)	ZMK 7.58	ZMK 7.58	ZMK 7.58	ZMK 7.58	ZMK 7.58	ZMK 7.58	
Total Yield Cost	**ZMK 12,660.60**	**ZMK 37,981.80**	**ZMK 63,303.00**	**ZMK 101,284.80**	**ZMK 151,927.20**	**ZMK 189,909.00**	
Gross margin (ZMW)	**ZMK 1,851.70**	**ZMK 5,555.10**	**ZMK 9,258.50**	**ZMK 14,813.60**	**ZMK 22,220.40**	**ZMK 27,775.50**	
Gross margin (USD)	USD 77.15	USD 231.46	USD 385.77	USD 617.23	USD 925.85	USD 1,157.31	

Farm size (HA)	**1**	**3**	**5**	**8**	**12**	**15**	
Crop	Maize	Maize	Maize	Maize	Maize	Maize	
Yield (KG)	1670	5010	8350	13360	20040	25050	
Bags (50kg)	33.4	100.2	167	267.2	400.8	501	
EXPORT - Market price/ Kg (ZMW)	ZMK 12.68	ZMK 12.68	ZMK 12.68	ZMK 12.68	ZMK 12.68	ZMK 12.68	
Gross Revenue (ZMW)	**ZMK 21,175.60**	**ZMK 63,526.80**	**ZMK 105,878.00**	**ZMK 169,404.80**	**ZMK 254,107.20**	**ZMK 317,634.00**	
Costs of production Costs of production per HA (ZMW)							
Seeds	ZMK 1,172.00	ZMK 3,516.00	ZMK 5,860.00	ZMK 9,376.00	ZMK 14,064.00	ZMK 17,580.00	
Basal dressing	ZMK 2,628.00	ZMK 7,884.00	ZMK 13,140.00	ZMK 21,024.00	ZMK 31,536.00	ZMK 39,420.00	
Top dressing	ZMK 4,567.00	ZMK 13,701.00	ZMK 22,835.00	ZMK 36,536.00	ZMK 54,804.00	ZMK 68,505.00	
Fertilizer transport	ZMK 193.00	ZMK 193.00	ZMK 193.00	ZMK 183.35	ZMK 164.05	ZMK 164.05	
Herbicides	ZMK 62.00	ZMK 62.00	ZMK 62.00	ZMK 58.90	ZMK 52.70	ZMK 52.70	
Labor	ZMK 3,438.00	ZMK 10,314.00	ZMK 17,190.00	ZMK 27,504.00	ZMK 41,256.00	ZMK 51,570.00	
Machinery hire	ZMK 600.00	ZMK 1,800.00	ZMK 3,000.00	ZMK 4,800.00	ZMK 7,200.00	ZMK 9,000.00	

Total cost per kg (inc. land cost)	ZMK 7.58	ZMK 7.58	ZMK 7.58	ZMK 7.58	ZMK 7.58	ZMK 7.58	
Total Yield Cost	**ZMK 12,660.00**	**ZMK 37,980.00**	**ZMK 63,300.00**	**ZMK 101,280.00**	**ZMK 151,920.00**	**ZMK 189,900.00**	
Gross margin (ZMW)	**ZMK 8,515.60**	**ZMK 25,546.80**	**ZMK 42,578.00**	**ZMK 68,124.80**	**ZMK 102,187.20**	**ZMK 127,734.00**	
Gross margin (USD)	USD 354.82	USD 1,064.45	USD 1,774.08	USD 2,838.53	USD 4,257.80	USD 5,322.25	

Strip intercropping of maize with groundnuts or soybeans, for instance, provides a sustainable way to increase crop yields, conserve water, and maximize land utilization. Strategically blending groundnuts or soybeans with maize allows small and medium-sized farmers to maximize resource efficiency and reap financial rewards. For irrigated locations with semi-arid conditions, intercropping maize with other crops is a preferable alternative.[9] In order to boost yields and earnings in a single season, it is crucial to consider the optimal crop mix. One sustainable way to increase crop yields, save water, and maximize land usage is by strip intercropping of maize with soybeans or groundnuts. Small and medium-sized farmers can boost resource efficiency and gain economic benefits by carefully blending groundnuts or soybeans with maize. Under semi-arid circumstances, intercropping maize with other crops is a preferable choice for irrigated regions. [10] . ***Figure 1*** presents a field demonstration of maize/soybean strip intercropping system (A) Intercrops were at the vegetative growth stage, and (B) Intercrops were at the reproductive growth stage.

Figure 1: Field demonstration of maize/soybean strip intercropping system (A) Intercrops were at the vegetative growth stage, and (B) Intercrops were at the reproductive growth stage

Source: Raza et al. 2022. (Photos: Muhammad Ali Raza).

With optimal planting configuration and density in maize/soybean strip intercropping, farmers may enhance soybean output without reducing maize production and area, eventually boosting soil fertility and productivity through nitrogen fixation and release of root exudates[11]. Intercropping maize with legumes such as soybeans, groundnuts, and other vegetables can boost production and increase revenue and mitigate drought risk. A comparative examination of maize-soybean strip intercropping systems and maize cultivation exclusively per five hectares was considered.

[9] Raza, M. A., Yasin, H. S., Gul, H., Qin, R., Mohi Ud Din, A., Khalid, M. H. B., Hussain, S., Gitari, H., Saeed, A., Wang, J., Rezaei-Chiyaneh, E., Sabagh, A. E., Manzoor, A., Fatima, A., Ahmad, S., Yang, F., Skalicky, M., & Yang, W. (2022). Maize/soybean strip intercropping produces higher crop yields and saves water under semi-arid conditions. Frontiers in plant science, 13, 1006720. https://doi.org/10.3389/fpls.2022.1006720.

[10] Zhan Xu, Chunjie Li, Chaochun Zhang, Yang Yu, Wopke van der Werf, Fusuo Zhang, (2019), Intercropping maize and soybean increases efficiency of land and fertilizer nitrogen use; A meta-analysis Author links open overlay panel, https://doi.org/10.1016/j.fcr.2019.107661

[11] Chen P., Du Q., Liu X., Zhou L., Hussain S., Lei L., et al.. (2017). Effects of reduced nitrogen inputs on crop yield and nitrogen use efficiency in a long-term maize-soybean relay strip intercropping system. PLoS One 12 (9), e0184503. doi: 10.1371/journal.pone.0184503 [PMC free article] [PubMed] [CrossRef] [Google Scholar] [Ref list]

Table 2: The Business Case for Maize and Soybean Intercropping farming for both local and export market for different land sizes

National Small and Medium Scale Farmer Cashflow Model - Maize and Soybean Intercropping							
							Sources and Assumptions
Farm size (HA)	**1**	**3**	**5**	**8**	**12**	**15**	
Crop	Maize	Maize	Maize	Maize	Maize	Maize	
Yield (KG)	1670	5010	8350	13360	20040	25050	Source: Zambia Statistical Agency(ZSA) Cropforcast survey 2022-2022 - 2023
Bags (50kg)	33.4	100.2	167	267.2	400.8	501	
LOCAL - Market price/Kg (ZMW) *	ZMK 8.69	ZMK 8.69	ZMK 8.69	ZMK 8.69	ZMK 8.69	ZMK 8.69	Sources: Minisitry of Agriculture.,Montly Market Bulletin Commodity Prices as per April 2024
Gross Revenue (ZMW)	**ZMK 14,512.30**	**ZMK 43,536.90**	**ZMK 72,561.50**	**ZMK 116,098.40**	**ZMK 174,147.60**	**ZMK 217,684.50**	
Costs of production Costs of production per HA (ZMW)							
Maize seed - Early Maturing	ZMK 1,172.60	ZMK 3,517.80	ZMK 5,863.00	ZMK 9,380.80	ZMK 14,071.20	ZMK 17,589.00	
Basal dressing	ZMK 2,628.00	ZMK 7,884.00	ZMK 13,140.00	ZMK 21,024.00	ZMK 31,536.00	ZMK 39,420.00	
Top dressing	ZMK 4,567.00	ZMK 13,701.00	ZMK 22,835.00	ZMK 36,536.00	ZMK 54,804.00	ZMK 68,505.00	

Fertilizer transport	ZMK 193.00	ZMK 193.00	ZMK 193.00	ZMK 193.00	ZMK 193.00	ZMK 193.00	
Herbicides	ZMK 62.00	ZMK 62.00	ZMK 62.00	ZMK 58.90	ZMK 52.70	ZMK 52.70	
Labor	ZMK 3,438.00	ZMK 10,314.00	ZMK 17,190.00	ZMK 27,504.00	ZMK 41,256.00	ZMK 51,570.00	
Machinery hire	ZMK 600.00	ZMK 1,800.00	ZMK 3,000.00	ZMK 4,800.00	ZMK 7,200.00	ZMK 9,000.00	
Total cost per kg (inc. land cost)	ZMK 7.58	ZMK 7.58	ZMK 7.58	ZMK 7.58	ZMK 7.58	ZMK 7.58	
Total Yield Cost	**ZMK 12,660.60**	**ZMK 37,981.80**	**ZMK 63,303.00**	**ZMK 101,284.80**	**ZMK 151,927.20**	**ZMK 189,909.00**	
Gross margin (ZMW)	**ZMK 1,851.70**	**ZMK 5,555.10**	**ZMK 9,258.50**	**ZMK 14,813.60**	**ZMK 22,220.40**	**ZMK 27,775.50**	
Gross margin (USD)	USD 77.15	USD 231.46	USD 385.77	USD 617.23	USD 925.85	USD 1,157.31	
Farm size (HA)	**1**	**3**	**5**	**8**	**12**	**15**	
Crop	Soybeans	Soybeans	Soybeans	Soybeans	Soybeans	Soybeans	
Yield (KG)	930	2790	4650	7440	11160	13950	
LOCAL - Market price/Kg (ZMK) *	ZMK 7.80	ZMK 7.80	ZMK 7.80	ZMK 7.80	ZMK 7.80	ZMK 7.80	
Gross Revenue (ZMK)	**ZMK 7,254.00**	**ZMK 21,762.00**	**ZMK 36,270.00**	**ZMK 58,032.00**	**ZMK 87,048.00**	**ZMK 108,810.00**	

Costs of production per HA (ZMK)							
Seeds (100kg/Ha)	ZMK 2,792.04	ZMK 8,376.12	ZMK 13,960.20	ZMK 22,336.32	ZMK 33,504.48	ZMK 41,880.60	PRICE (ZMK/25Kg)
Fertiliser (100kg/Ha)	ZMK 600.00	ZMK 1,800.00	ZMK 3,000.00	ZMK 4,800.00	ZMK 7,200.00	ZMK 9,000.00	
Herbicides (ZMK 400/Ha basic)	ZMK 650.00	ZMK 1,950.00	ZMK 3,250.00	ZMK 5,200.00	ZMK 7,800.00	ZMK 9,750.00	
Labor	ZMK 0.00	ZMK 0.00	ZMK 0.00	ZMK 0.00	ZMK 0.00	ZMK 0.00	
Machinery hire	ZMK 0.00	ZMK 0.00	ZMK 0.00	ZMK 0.00	ZMK 0.00	ZMK 0.00	
Harvesting and Storage	ZMK 2,000.00	ZMK 6,000.00	ZMK 10,000.00	ZMK 16,000.00	ZMK 24,000.00	ZMK 30,000.00	
Total Cost Soy Bean per Kg Ha(ZMK)	**ZMK 6.50**	**ZMK 6.50**	**ZMK 6.50**	**ZMK 6.50**	**ZMK 6.50**	**ZMK 6.50**	the comodity soybean market price is per kg but the model was developed to value price of soybean per 1 kg. PRICE (ZMK/25Kg). Therefore the total cost of soybean per hectare per 1kg is calculated
Total Yield Cost Soy Bean (ZMK)	**ZMK 6,042.04**	**ZMK 18,126.12**	**ZMK 30,210.20**	**ZMK 48,336.32**	**ZMK 72,504.48**	**ZMK 90,630.60**	
Gross margin (ZMK)	**ZMK 1,211.96**	**ZMK 3,635.88**	**ZMK 6,059.80**	**ZMK 9,695.68**	**ZMK 14,543.52**	**ZMK 18,179.40**	
Gross margin (USD)	USD 50.50	USD 151.50	USD 252.49	USD 403.99	USD 605.98	USD 757.48	
			USD 638.26				
Farm size (HA)	**1**	**3**	**5**	**8**	**12**	**15**	

Crop	Maize	Maize	Maize	Maize	Maize	Maize	
Yield (KG)	1670	5010	8350	18400	27600	34500	
Bags (50kg)	33.4	100.2	167	368	552	690	
EXPORT - Market price/50 Kg (ZMK)	ZMK 634.00	ZMK 634.00	ZMK 634.00	ZMK 634.00	ZMK 634.00	ZMK 634.00	
Gross Revenue (ZMK)	**ZMK 21,175.60**	**ZMK 63,526.80**	**ZMK 105,878.00**	**ZMK 233,312.00**	**ZMK 349,968.00**	**ZMK 437,460.00**	
Costs of production per HA (ZMK)							
Maize seed - Early Maturing	ZMK 1,172.00	ZMK 1,172.00	ZMK 1,172.00	ZMK 1,172.00	ZMK 1,172.00	ZMK 1,172.00	
Basal dressing	ZMK 2,628.00	ZMK 2,628.00	ZMK 2,628.00	ZMK 2,628.00	ZMK 2,628.00	ZMK 2,628.00	
Top dressing	ZMK 4,567.00	ZMK 4,567.00	ZMK 4,567.00	ZMK 4,567.00	ZMK 4,567.00	ZMK 4,567.00	
Fertilizer transport	ZMK 193.00	ZMK 193.00	ZMK 193.00	ZMK 193.00	ZMK 193.00	ZMK 193.00	
Herbicides	ZMK 62.00	ZMK 62.00	ZMK 62.00	ZMK 62.00	ZMK 62.00	ZMK 62.00	
Labor	ZMK 3,438.00	ZMK 3,438.00	ZMK 3,438.00	ZMK 3,438.00	ZMK 3,438.00	ZMK 3,438.00	
Machinery hire	ZMK 600.00	ZMK 600.00	ZMK 600.00	ZMK 600.00	ZMK 600.00	ZMK 600.00	
Total cost per 50kg bag (inc. land cost)	**ZMK 7.58**	**ZMK 7.58**	**ZMK 7.58**	**ZMK 7.58**	**ZMK 7.58**	**ZMK 7.58**	
Total Yield Cost maize	**ZMK 12,660.00**	**ZMK 37,980.00**	**ZMK 63,300.00**	**ZMK 139,487.43**	**ZMK 209,231.14**	**ZMK 261,538.92**	

Gross margin (ZMK)	**ZMK 8,515.60**	**ZMK 25,546.80**	**ZMK 42,578.00**	**ZMK 93,824.57**	**ZMK 140,736.86**	**ZMK 175,921.08**	
Gross margin (USD)	USD 354.82	USD 1,064.45	USD 1,774.08	USD 3,909.36	USD 5,864.04	USD 7,330.04	
Farm size (HA)	**1**	**3**	**5**	**8**	**12**	**15**	
Crop	Soybeans	Soybeans	Soybeans	Soybeans	Soybeans	Soybeans	
Yield (KG)	930	2790	4650	7440	11160	13950	
LOCAL - Market price/Kg (ZMK) *	ZMK 7.80	ZMK 7.80	ZMK 7.80	ZMK 7.80	ZMK 7.80	ZMK 7.80	
Gross Revenue (ZMK)	**ZMK 7,254.00**	**ZMK 21,762.00**	**ZMK 36,270.00**	**ZMK 58,032.00**	**ZMK 87,048.00**	**ZMK 108,810.00**	
Costs of production per HA (ZMK)							
Seeds (100kg/Ha)	ZMK 2,792.04	ZMK 8,376.12	ZMK 13,960.20	ZMK 22,336.32	ZMK 33,504.48	ZMK 41,880.60	
Fertiliser (100kg/Ha)	ZMK 600.00	ZMK 1,800.00	ZMK 3,000.00	ZMK 4,800.00	ZMK 7,200.00	ZMK 9,000.00	
Herbicides (ZMK 400/Ha basic)	ZMK 650.00	ZMK 1,950.00	ZMK 3,250.00	ZMK 5,200.00	ZMK 7,800.00	ZMK 9,750.00	
Labor	ZMK 0.00	ZMK 0.00	ZMK 0.00	ZMK 0.00	ZMK 0.00	ZMK 0.00	Since the same expense on tilling and labor will be used to gain economics of scale for intercropping maize and soybean, the labour for soybean and machinery hire
Machinery hire	ZMK 0.00	ZMK 0.00	ZMK 0.00	ZMK 0.00	ZMK 0.00	ZMK 0.00	

							is reduced to 400 and 0 respectively
Harvesting and Storage	ZMK 2,000.00	ZMK 6,000.00	ZMK 10,000.00	ZMK 16,000.00	ZMK 24,000.00	ZMK 30,000.00	
Total Cost Soy Bean per Kg Ha(ZMK)	**ZMK 6.50**	**ZMK 6.50**	**ZMK 6.50**	**ZMK 6.50**	**ZMK 6.50**	**ZMK 6.50**	
Total Yield Cost Soy Bean (ZMK)	**ZMK 6,042.04**	**ZMK 18,126.12**	**ZMK 30,210.20**	**ZMK 48,336.32**	**ZMK 72,504.48**	**ZMK 90,630.60**	
Gross margin (ZMK)	**ZMK 1,211.96**	**ZMK 3,635.88**	**ZMK 6,059.80**	**ZMK 9,695.68**	**ZMK 14,543.52**	**ZMK 18,179.40**	
Gross margin (USD)	USD 50.50	USD 151.50	USD 252.49	USD 403.99	USD 605.98	USD 757.48	
Total Farming Margin (ZMK)	**ZMK 9,727.56**	**ZMK 29,182.68**	**ZMK 48,637.80**	**ZMK 103,520.25**	**ZMK 155,280.38**	**ZMK 194,100.48**	
Total Farming Margin (USD)	USD 405.32	USD 1,215.95	USD 2,026.58	USD 4,313.34	USD 6,470.02	USD 8,087.52	

Table 3: The Business Case for Maize and Groundnuts Intercropping farming for both local and export market for different land sizes

National Small and Medium Scale Farmer Cashflow Model - Maize and Groundnuts Intercropping	

							Sources and Assumptions
Farm size (HA)	**1**	**3**	**5**	**8**	**12**	**15**	
Crop	Maize	Maize	Maize	Maize	Maize	Maize	
Yield (KG)	1670	5010	8350	13360	20040	25050	
Bags (50kg)	33.4	100.2	167	267.2	400.8	501	
LOCAL - Market price/Kg (ZMW) *	ZMK 8.69	ZMK 8.69	ZMK 8.69	ZMK 8.69	ZMK 8.69	ZMK 8.69	
Gross Revenue (ZMW)	**ZMK 14,512.30**	**ZMK 43,536.90**	**ZMK 72,561.50**	**ZMK 116,098.40**	**ZMK 174,147.60**	**ZMK 217,684.50**	
Costs of production Costs of production per HA (ZMW)							
Maize seed - Early Maturing	ZMK 1,172.60	ZMK 1,172.60	ZMK 1,172.60	ZMK 1,172.60	ZMK 1,172.60	ZMK 1,172.60	
Basal dressing	ZMK 2,628.00	ZMK 2,628.00	ZMK 2,628.00	ZMK 2,628.00	ZMK 2,628.00	ZMK 2,628.00	
Top dressing	ZMK 4,567.00	ZMK 4,567.00	ZMK 4,567.00	ZMK 4,567.00	ZMK 4,567.00	ZMK 4,567.00	
Fertilizer transport	ZMK 193.00	ZMK 193.00	ZMK 193.00	ZMK 193.00	ZMK 193.00	ZMK 193.00	
Herbicides	ZMK 62.00	ZMK 62.00	ZMK 62.00	ZMK 62.00	ZMK 62.00	ZMK 62.00	
Labor	ZMK 3,438.00	ZMK 3,438.00	ZMK 3,438.00	ZMK 3,438.00	ZMK 3,438.00	ZMK 3,438.00	

Machinery hire	ZMK 600.00	ZMK 600.00	ZMK 600.00	ZMK 600.00	ZMK 600.00	ZMK 600.00	
Total cost per kg (inc. land cost)	ZMK 7.58	ZMK 7.58	ZMK 7.58	ZMK 7.58	ZMK 7.58	ZMK 7.58	
Total Yield Cost	**ZMK 12,660.60**	**ZMK 37,981.80**	**ZMK 63,303.00**	**ZMK 101,284.80**	**ZMK 151,927.20**	**ZMK 189,909.00**	
Gross margin (ZMW)	**ZMK 1,851.70**	**ZMK 5,555.10**	**ZMK 9,258.50**	**ZMK 14,813.60**	**ZMK 22,220.40**	**ZMK 27,775.50**	
Gross margin (USD)	USD 77.15	USD 231.46	USD 385.77	USD 617.23	USD 925.85	USD 1,157.31	
	1	**3**	**5**	**8**	**12**	**15**	
Crop	Groundnuts	Groundnuts	Groundnuts	Groundnuts	Groundnuts	Groundnuts	
Yield (KG)	640	1920	3200	5120	7680	9600	
LOCAL - Market price/Kg (ZMK) *	ZMK 22.28	ZMK 22.28	ZMK 22.28	ZMK 22.28	ZMK 22.28	ZMK 22.28	
Gross Revenue (ZMK)	**ZMK 14,259.20**	**ZMK 42,777.60**	**ZMK 71,296.00**	**ZMK 114,073.60**	**ZMK 171,110.40**	**ZMK 213,888.00**	
Costs of production per HA (ZMK)							
Seeds(ZMK/100Kg)	ZMK 4,633.70	ZMK 4,633.70	ZMK 4,633.70	ZMK 4,633.70	ZMK 4,633.70	ZMK 4,633.70	

Basal dressing	ZMK 2,628.00	ZMK 2,628.00	ZMK 2,628.00	ZMK 2,628.00	ZMK 2,628.00	ZMK 2,628.00	
Top dressing	ZMK 3,653.80	ZMK 3,653.80	ZMK 3,653.80	ZMK 3,653.80	ZMK 3,653.80	ZMK 3,653.80	
Labor	ZMK 0.00	ZMK 0.00	ZMK 0.00	ZMK 0.00	ZMK 0.00	ZMK 0.00	
Machinery hire	ZMK 0.00	ZMK 0.00	ZMK 0.00	ZMK 0.00	ZMK 0.00	ZMK 0.00	
Harvesting and Storage	ZMK 2,000.00	ZMK 2,000.00	ZMK 2,000.00	ZMK 2,000.00	ZMK 2,000.00	ZMK 2,000.00	
Total Cost groundnuts per kg Ha(ZMK)	**ZMK 20.18**	**ZMK 20.18**	**ZMK 20.18**	**ZMK 20.18**	**ZMK 20.18**	**ZMK 20.18**	
Total Yield Cost Soy Bean (ZMK)	**ZMK 12,915.50**	**ZMK 38,746.50**	**ZMK 64,577.50**	**ZMK 103,324.00**	**ZMK 154,986.00**	**ZMK 193,732.50**	
Gross margin (ZMK)	**ZMK 1,343.70**	**ZMK 4,031.10**	**ZMK 6,718.50**	**ZMK 10,749.60**	**ZMK 16,124.40**	**ZMK 20,155.50**	
Gross margin (USD)	USD 55.99	USD 167.96	USD 279.94	USD 447.90	USD 671.85	USD 839.81	
total margin			USD 665.71				
Farm size (HA)	**1**	**3**	**5**	**8**	**12**	**15**	
Crop	Maize	Maize	Maize	Maize	Maize	Maize	
Yield (KG)	1670	5010	8350	13360	20040	25050	
Bags (50kg)	33.4	100.2	167	267.2	400.8	501	
EXPORT - Market price/50 Kg (ZMW)	ZMK 12.68	ZMK 12.68	ZMK 12.68	ZMK 12.68	ZMK 12.68	ZMK 12.68	

Gross Revenue (ZMW)	**ZMK 21,175.60**	**ZMK 63,526.80**	**ZMK 105,878.00**	**ZMK 169,404.80**	**ZMK 254,107.20**	**ZMK 317,634.00**	
Costs of production Costs of production per HA (ZMW)							
Seeds	ZMK 1,172.00	ZMK 1,172.00	ZMK 1,172.00	ZMK 1,172.00	ZMK 1,172.00	ZMK 1,172.00	
Basal dressing	ZMK 2,628.00	ZMK 2,628.00	ZMK 2,628.00	ZMK 2,628.00	ZMK 2,628.00	ZMK 2,628.00	
Top dressing	ZMK 4,567.00	ZMK 4,567.00	ZMK 4,567.00	ZMK 4,567.00	ZMK 4,567.00	ZMK 4,567.00	
Fertilizer transport	ZMK 193.00	ZMK 193.00	ZMK 193.00	ZMK 193.00	ZMK 193.00	ZMK 193.00	
Herbicides	ZMK 62.00	ZMK 62.00	ZMK 62.00	ZMK 62.00	ZMK 62.00	ZMK 62.00	
Labor	ZMK 3,438.00	ZMK 3,438.00	ZMK 3,438.00	ZMK 3,438.00	ZMK 3,438.00	ZMK 3,438.00	
Machinery hire	ZMK 600.00	ZMK 600.00	ZMK 600.00	ZMK 600.00	ZMK 600.00	ZMK 600.00	
Total cost per kg (inc. land cost)	ZMK 7.58	ZMK 7.58	ZMK 7.58	ZMK 7.58	ZMK 7.58	ZMK 7.58	
Total Yield Cost	**ZMK 12,660.00**	**ZMK 37,980.00**	**ZMK 63,300.00**	**ZMK 101,280.00**	**ZMK 151,920.00**	**ZMK 189,900.00**	

Gross margin (ZMW)	**ZMK 8,515.60**	**ZMK 25,546.80**	**ZMK 42,578.00**	**ZMK 68,124.80**	**ZMK 102,187.20**	**ZMK 127,734.00**	
Gross margin (USD)	USD 354.82	USD 1,064.45	USD 1,774.08	USD 2,838.53	USD 4,257.80	USD 5,322.25	
Farm size (HA)	**1**	**3**	**5**	**8**	**12**	**15**	
Crop	Groundnuts	Groundnuts	Groundnuts	Groundnuts	Groundnuts	Groundnuts	
Yield (KG)	640	1920	3200	5120	7680	9600	
LOCAL - Market price/Kg (ZMK) *	ZMK 22.28	ZMK 22.28	ZMK 22.28	ZMK 22.28	ZMK 22.28	ZMK 22.28	Source?
Gross Revenue (ZMK)	**ZMK 14,259.20**	**ZMK 42,777.60**	**ZMK 71,296.00**	**ZMK 114,073.60**	**ZMK 171,110.40**	**ZMK 213,888.00**	
Costs of production per HA (ZMK)							
Seeds(ZMK/100Kg)	ZMK 4,633.70	ZMK 4,633.70	ZMK 4,633.70	ZMK 4,633.70	ZMK 4,633.70	ZMK 4,633.70	For intercroping we will need have the seed for full hectare
Basal dressing	ZMK 2,628.00	ZMK 2,628.00	ZMK 2,628.00	ZMK 2,628.00	ZMK 2,628.00	ZMK 2,628.00	For intercropping with maize we may add 2 more bag of basal fertlizer and 2 more bags of top dressing fertilizer to the acquired maize fertiler
Top dressing	ZMK 3,653.80	ZMK 3,653.80	ZMK 3,653.80	ZMK 3,653.80	ZMK 3,653.80	ZMK 3,653.80	Source?
Labor	ZMK 0.00	ZMK 0.00	ZMK 0.00	ZMK 0.00	ZMK 0.00	ZMK 0.00	Since the same expense on tilling and labor will be used to gain economics of

Machinery hire	ZMK 0.00	ZMK 0.00	ZMK 0.00	ZMK 0.00	ZMK 0.00	ZMK 0.00	scale for intercropping maize and groundnuts, the labour for groundnuts and machinery hire is reduced to 0 and 0 respectively
Harvesting and Storage	ZMK 2,000.00	ZMK 2,000.00	ZMK 2,000.00	ZMK 2,000.00	ZMK 2,000.00	ZMK 2,000.00	Source?
Total Cost Soy Bean per kg Ha(ZMK)	**ZMK 20.18**	**ZMK 20.18**	**ZMK 20.18**	**ZMK 20.18**	**ZMK 20.18**	**ZMK 20.18**	
Total Yield Cost Groundnuts (ZMK)	**ZMK 12,915.50**	**ZMK 38,746.50**	**ZMK 64,577.50**	**ZMK 103,324.00**	**ZMK 154,986.00**	**ZMK 193,732.50**	
Gross margin (ZMK)	**ZMK 1,343.70**	**ZMK 4,031.10**	**ZMK 6,718.50**	**ZMK 10,749.60**	**ZMK 16,124.40**	**ZMK 20,155.50**	
Gross margin (USD)	USD 55.99	USD 167.96	USD 279.94	USD 447.90	USD 671.85	USD 839.81	
Total Farming Margin (ZMK)	**ZMK 9,859.30**	**ZMK 29,577.90**	**ZMK 49,296.50**	**ZMK 78,874.40**	**ZMK 118,311.60**	**ZMK 147,889.50**	
Total Farming Margin (USD)	USD 410.80	USD 1,232.41	USD 2,054.02	USD 3,286.43	USD 4,929.65	USD 6,162.06	

Location and competitive environment

Intercropping maize with legumes is prevalent in Zambia, especially in the Eastern, Central, and Southern provinces. These locations offer ideal agroecological characteristics for both crops, including enough rainfall and soil types. Intercropping has several benefits and challenges regarding location. Below are some of the issues to consider about competitive environment regarding intercropping.

- **Enhanced Production and Efficiency of Land Use:** Intercropping maize with legumes such as cowpea, soybean, or groundnut can greatly increase land use efficiency. Studies have demonstrated that intercropping can lead to greater land equivalent ratios (LER), implying more effective use of land than monocropping.[12]
- **Rivalry for Resources:** Intercropping offers numerous advantages, but it also means competing for light, water, and nutrients. Maize, being a taller crop, if not spaced well can overshadow legumes, thus decreasing their growth and yield.
- **Pest and Disease Control**: Diseases and pests can be managed with the use of intercropping. Crop diversification can interrupt pest cycles and minimize disease outbreaks, resulting in better harvests.
- **Complexity of Management:** In order to balance the requirements of both crops, intercropping calls for careful management. This entails choosing suitable crop kinds, maximizing planting densities, and controlling the planting and harvesting schedules.
- **Economic Viability**: Intercropping methods may be more economically feasible for smallholder farmers. Crop combinations can provide more reliable income by diversifying revenue streams and lowering the chance of crop failure. [13]
- **Management of Nutrients:** Legumes may fix atmospheric nitrogen, which enriches the soil and benefits the maize crop. This symbiotic connection decreases the demand for synthetic fertilizers, which is especially useful in locations with limited access to commercial fertilizers[14].

Credit, Market and E&S risk analysis

Market Risks

- **Price Fluctuations**;- Prices for different crops can fluctuate, impacting the income stability of farmers. As a result, farmers must understand and build capacity around early warning systems for market price fluctuations and considerations. This should be correlated with the Kwacha's foreign exchange rate. Farmers must be able to factor prices into their intercropping decisions per season or planting period if they use irrigation systems.
- **Crop Market Demand;-** The success of intercropping depends on the market demand for the crops grown. If one crop has low demand, it can affect overall profitability[15]. As a farmer, you must understand which crops

[12] Fu, Z., Chen, P., Zhang, X. et al. Maize-legume intercropping achieves yield advantages by improving leaf functions and dry matter partition. BMC Plant Biol 23, 438 (2023). https://doi.org/10.1186/s12870-023-04408-3

[13] https://academicjournals.org/journal/JCO/article-full-text-pdf/209A4A064169

[14] Dimande, Paulo, Margarida Arrobas, and Manuel Ângelo Rodrigues. 2024. "Intercropped Maize and Cowpea Increased the Land Equivalent Ratio and Enhanced Crop Access to More Nitrogen and Phosphorus Compared to Cultivation as Sole Crops" Sustainability 16, no. 4: 1440. https://doi.org/10.3390/su16041440

[15] Intercropping improves soil ecosystem multifunctionality through .... https://link.springer.com/article/10.1007/s11104-022-05554-7.

to intercrop. As a result, farmers must build capacity for demand fluctuations at both the local and international levels.

- **Market Access:** Farmers require access to markets for all crops they grow. If market access is limited, intercropping may not be economically viable.

Credit Risks

- **Initial Investment**;- Farmers may require additional funds for seeds, fertilizers, and training, resulting in higher initial credit requirements.
- **Yield Variability;-** Intercropping can result in variable yields due to factors such as pest infestations or weather conditions, which may impact the farmer's ability to repay loans.[16]
- **Securing Credit:** Farmers may have difficulty obtaining credit for intercropping due to perceived risks by financial institutions. Lenders may be reluctant to provide loans without clear evidence of the economic viability of the intercropping system. [17]

Environmental & Social (E&S) Risks

- **Environmental Benefits:-** There are numerous risks associated with monocropping in Zambia. However, intercropping provides many environmental benefits to farmers. It can improve soil health, decrease pest outbreaks, and increase biodiversity. It is also important to note that intercropping requires careful management to avoid negative environmental risks such as soil nutrient depletion.[18]
- **Labour Intensity:**- Intercropping often requires more labor for planting, managing, and harvesting multiple crops. This can be a burden for smallholder farmers who may already be labor-constrained. [19]As a result, it can increase labor requirements especially for women[20], which might be challenging for smallholder farmers without adequate support.
- **Soil Degradation:** While intercropping can improve soil health by increasing biodiversity and reducing erosion, poor management can cause soil degradation. For example, certain crop combinations may deplete specific nutrients from the soil if not properly managed. [21]
- **Pest and Disease Management:** Intercropping can reduce pest and disease incidence by disrupting pest cycles. However, if not carefully planned, it can also lead to increased pest and disease pressure, particularly if one crop serves as a host for pests that affect the other.[22]
- **Resource Competition:** In an intercropping system, crops could compete with one another for resources like sunlight, nutrients, and water. If this competition is not properly managed, yields may be decreased. For instance, the amount of water required for various crops varies. Water scarcity issues in Zambia, exacerbated by climate variability and change, may worsen if intercropping is not properly managed, as it can lead to inefficient water use. . [23]
- **Knowledge and Training:** It takes understanding of the best crop combinations and management techniques to achieve successful intercropping. Lack of access to this information may result in subpar execution and lower yields.

[16] Benefits and Risks of Intercropping for Crop Resilience and Pest .... https://academic.oup.com/jee/article/115/5/1350/6572575.
[17] Benefits and Risks of Intercropping for Crop Resilience and Pest .... https://academic.oup.com/jee/article/115/5/1350/6572575.
[18] Research on intercropping from 1995 to 2021: a worldwide ... - Springer. https://link.springer.com/article/10.1007/s11104-024-06542-9.
[19] Sauer, C.M., Mason, N.M., Maredia, M.K. et al. Does adopting legume-based cropping practices improve the food security of small-scale farm households? Panel survey evidence from Zambia. Food Sec. 10, 1463–1478 (2018). https://doi.org/10.1007/s12571-018-0859-3
[20] Lai, C., Chan, C., Halbrendt, J., Shariq, L., Roul, P., Idol, T., …Evensen, C. (2012). Comparative economic and gender, labor analysis of conservation agriculture practices in tribal villages in India. International Food and Agribusiness Management Review, 15, 73–86
[21] Sauer, C.M., Mason, N.M., Maredia, M.K. et al. Does adopting legume-based cropping practices improve the food security of small-scale farm households? Panel survey evidence from Zambia. Food Sec. 10, 1463–1478 (2018). https://doi.org/10.1007/s12571-018-0859-3
[22] M. Chijikwa, P.O. Y Nkunika & B Siamasonta, 2009ASSESSMENT ON THE EFFECTS OF INTERCROPPING PATTERNS ON INCIDENCE AND DAMAGE TO COTTON BY DIAPAROPSIS CASTANEA: HAMPSON (LEPIDOPTERA: NOCTUIDAE) IN MAGOYE, MAZABUKA DISTRICT OF ZAMBIA, University of Zambia, P.o Box 32379, Lusaka, Zambia; Cotton Development Trust, P.O. Box 670057, Mazabuka, Zambia, https://education.unza.zm/index.php/JONAS/article/download/355/321/
[23] Sauer, C.M., Mason, N.M., Maredia, M.K. et al. Does adopting legume-based cropping practices improve the food security of small-scale farm households? Panel survey evidence from Zambia. Food Sec. 10, 1463–1478 (2018). https://doi.org/10.1007/s12571-018-0859-3

- **Risk of Adopting Intercropping:** There is always the risk of small-scale farmers being unwilling to adopt intercropping based on indigenous knowledge or cultural practices.
- **Complex Management:** Farmers accustomed to monocropping may find it difficult to carefully plan and manage intercropping.
- **Climate Variability:** Zambia's erratic climate may influence how well intercropping systems work. It is crucial to select crops that are compatible with one another and modify management strategies in accordance with the unpredictable weather patterns that can impact crop growth and yields. [24]

Proposed Mitigation measures

To reduce these risks, it is necessary to:

- Provide farmers with training and extension services on the best intercropping practices.
- Create and promote market access for various crops.
- Implement policies that promote sustainable agriculture and resource management.
- Provide small and medium-sized farmers with irrigation systems through a climate smart mechanization and irrigation lending product so they can intercrop sustainably and become resilient to climate variability.

Long-term and short-term financing needs

Similar to other farming practices, intercropping in Zambia requires certain funding in both the short and long terms. Therefore below are some of the short and long term financial needs:

Short-term Financing Needs

- **Initial Setup Costs**: This includes purchasing seeds, fertilizers, and other inputs for multiple crops.
- **Labor Costs**: Intercropping often requires more labor for planting, managing, and harvesting different crops.
- **Training and Technical Support**: Farmers may need training on best practices for intercropping, which can incur costs.
- **Pest and Disease Management**: Additional resources may be needed to manage pests and diseases that affect different crops.

Long-term Financing Needs

- **Infrastructure Development**: Investments in irrigation systems, storage facilities, and transportation are crucial for long-term success.
- **Research and Development**: Continuous research is needed to optimize crop combinations and improve yields.
- **Sustainability Practices**: Implementing sustainable practices such as soil health management and biodiversity conservation can require ongoing investment.

[24] https://repository.cimmyt.org/bitstream/handle/10883/21741/64591.pdf?sequence=1

- **Market Development**: Developing markets for diverse crops can help ensure economic viability and stability for farmers.

Financial Support and Incentives

- **Government Grants and Subsidies:** Financial assistance for the initial setup and ongoing costs. E.g. Mechanize 360 Ulimi Okwana Scheme
- **Microfinance and agricultural loans:** provide affordable credit tailored to the needs of smallholder farmers.
- **Public-Private Partnerships:** Collaborations that offer technical and financial assistance.
- **Training Programs: Funded initiatives** to educate farmers on intercropping techniques and sustainable practices.

Investment Needs and Business Case

1. **Initial Investment**:
    - **Land Preparation**: Plowing, harrowing, and levelling.
    - **Seeds and Seedlings**: Depending on the crop mix.
    - **Fertilizers and Pesticides**: For optimal crop growth.
    - **Irrigation Systems**: Drip or sprinkler systems.
    - **Labor Costs**: For planting, maintenance, and harvesting.
    - **Equipment**: Basic farming tools and pivot for irrigation.
2. **Grant Amount**: Farmer should be able to afford cost of production independently to qualify for irrigation grant or that farmer receives grant for cost of production.
3. **Repayment Capacity for irrigation equipment**:
    - Assuming a loan with a 3-year repayment period at an interest rate of 15%.
    - Annual repayment per farmer: Calculate based on the total loan amount divided by the repayment period. Total Monthly loan repayment of USD 182 and total Annual Loan Repayment of USD 2,187.02.
    - Revenue from crops: Estimate based on the optimal crop mix and market prices.

Business Case for Intercropping Small and Medium Scale Farmers in Zambia					
Return on Investment Analysis for Irrigation equipment					
				Discount Rate	3%
		Intervention Year			**Total**
	Pre-implementation	**1**	**2**	**3**	**(All Years)**
Investment in QEI					
Initial Investment Costs	$ 5,000.00	$ -	$ -	$ -	

Operating Costs		-	-	-	
Total Annual Investment Costs	5,000.00	-	-	-	
x Present Value Factors	1.00	0.97	0.94	0.92	
Total Discounted Annual Investment Costs	$ 5,000.00	$ -	$ -	$ -	$ 5,000.00
Loan repayment from each farmer for 5 hectares					
Total Monthly loan repayment		182	182	182	
Total Annual Loan Repayment		2,187.02	2,187.02	2,187.02	
x Present Value Factors		0.97	0.94	0.92	
Total Discounted Annual Savings (Increases)		$ 2,123.32	$ 2,061.47	$ 2,001.43	$ 6,186.22
Return on Investment Summary					
Undiscounted Annual Net Cash Flows	$ (5,000)	$ 2,187	$ 2,187	$ 2,187	$ 1,561
Cumulative ROI		0.42	0.84	1.24	1.24
Net Present Value					1,186.22
Internal Rate of Return					15%

4. **Optimal Crop Mix**:
    - **Maize**: High demand and relatively easy to grow.
    - **Soybeans**: Good for soil health and market value.
    - **Groundnuts**: High nutritional value and market demand.
    - **Vegetables**: Tomatoes, onions, and leafy greens for local markets.

Example Worksheet for Zambian Farmers

Table 4: ***Example of a worksheet for 100 to 200 farmers:***

Item	Cost per Hectare (ZMK)	Total Cost for 5 Hectares (ZMK)	Total Cost for 100 Farmers (ZMK)	Total Cost for 200 Farmers (ZMK)

Maize seed - Early Maturing	1172	5,860	586,000	1,172,000
Basal dressing	2628	13,140	1,314,000	2,628,000
Top dressing	4567	22,835	2,283,500	4,567,000
Fertilizer transport	193	965	96,500	193,000
Herbicides	62	310	31,000	62,000
Labor	3438	17,190	1,719,000	3,438,000
Machinery hire	600	3,000	300,000	600,000
Total Investment (ZMK)		**60,300**	**6,030,000**	**12,060,000**
Total Investment (USD)		**2512.5**	**251250**	**502500**

Table 5: Revenue and Repayment

Crop	Yield per Hectare (Kg)	Price per kg (USD)	Revenue per Hectare (ZMK)	Revenue for 5 Hectares (ZMK)	Revenue for 5 Hectares (USD)
Maize	**1,670**	**9**	**14,512**	**72,562**	**3023.395833**
Soybeans	**930**	**8**	**7,254**	**36,270**	**1511.25**
Groundnuts	**640**	**23**	**14,592**	**72,960**	**3040**

Conclusion

Based on these findings, it is crucial to note that the cost of production for intercropping maize generates higher returns for farmers since they would be able to harvest more goods from the same unit of land. This research demonstrates that a small and medium scale farmer in Zambia earns a greater gross margin than merely growing maize, allowing them to create bigger yields and more profits to cover the loan for irrigation equipment. To summarize, while intercropping provides benefits such as improved soil health and increased revenue, it also has hazards. These must be controlled with meticulous planning, market research, and support mechanisms. As a result, small and medium-sized farmers in Zambia require substantial technical and financial assistance. This includes training for optimal techniques, availability to excellent seeds, and financial incentives to offset the initial expense. Intercropping may be a sustainable and lucrative agricultural strategy, but in a developing country like Zambia, it requires careful planning and sufficient financial assistance to satisfy both short- and long-term needs.

Appendices

Appendix B

Mechanise 360 Ulimi Okwana

The National Agricultural Mechanization Strategy was established in conjunction with the 'Mechanise 360 Ulimi Okwana,' a smallholder farmer's mechanization promotion campaign. (FAO, 2024). It is being executed by the Ministry of Agriculture, with the goal of mechanizing 500,000 hectares of smallholder farmer land by 2027. This scheme aims to improve knowledge exchange about agricultural equipment and sustainable practices by strengthening ties between the public and private sectors. The level of mechanization should effectively and efficiently meet the needs of smallholder farmers, so the EU, through the Sustainable Intensification of Smallholder Farming System (SIFAZ) project in Zambia, promotes small and medium-scale mechanization technologies that are well adapted to local conditions and needs. "Mechanization reduces manual labor, empowers you, and lowers production costs while increasing your income and food security (FAO, 2024).

Mechanize 360 Ulimi Okwana is a government scheme that aims to strengthen the recently established sustainable agricultural financing facility and credit window by providing funding for equipment, livestock, and fisheries. This will be supported by business supporters and investors. (GRZ, 2024).

Specific Objectives of the 'Mechanise 360 Ulimi Okwana

The Mechanise 360 Ulimi Okwana Operational Guidelines For Mechanization Centers Of Excellence And Service Centres have the following specific objectives:

- Enhance equitable access to mechanization services, ensuring that smallholder farmers have access to efficient agricultural production and processing technologies.
- Promote the sustainable management and utilization of machinery, implements and equipment, emphasizing practices that minimize environmental impact and maximize long-term viability.
- Provide a structured framework for the effective utilization of machinery, implements and equipment offering rules and procedures to optimize their use in agricultural activities.

These guidelines are intended for use by all stakeholders involved in the management and application of mechanization in Zambia. This includes:

- Ministry of Agriculture (MOA);
- Ministry of Fisheries and Livestock (MoFL);
- Ministry of Local Government and Rural Development (MoLRD);
- Cooperating Partners (CPs);
- Non-Governmental Organizations (NGOs);
- Community Based Organization (CBOs);
- Equipment Suppliers;
- Financial Institutions;
- Farmer Organizations (FO); and
- Individual farmers.

Farmers, as individuals or groups engaged in agricultural activities, will ultimately benefit from mechanization services. (GRZ, 2024). Therefore, the rationale behind the guidelines is to provide a tool for the implementation of some strategic interventions outlined in the National Agricultural Mechanization Strategy. The guidelines stems from the recognition of various critical factors for promotion of sustainable mechanization to smallholder farmers. The factors considered are:

- **Equitable Access and Empowerment**;- aims to reduce disparities in access to agricultural mechanization services, especially among smallholder farmers, women, and youth.
- **Enhanced Productivity and Economic Growth**;- Promoting appropriate business models and establishing public and private sector-led mechanization service centers will result in increased agricultural efficiency, higher yields, and higher farmer incomes.
- **Sustainability and Equitability;-** Recognizing the high cost associated with mechanization technologies, foster public-private partnerships, and promote agro-value chains with market potential to spur investment in mechanization technologies.
- **Job Creation and Labor Productivity**;- The guidelines aim to create employment opportunities in the agricultural sector while also improving overall efficiency and competitiveness by promoting labor-saving technologies and increasing labor productivity.
- **Need for Guidelines** - Guidelines will provide a framework for the long-term development and operationalization of agricultural mechanization, ensuring that interventions are effectively implemented and in line with the overall goals of the mechanization strategy.

Guiding Principles

The following are the guiding principles of the 'Mechanise 360 Ulimi Okwana';

- **Commodity Value Chain Approach:** - This system should include production costs and ensure a reasonable profit margin for both the service provider and the farmers who use the service. As a result, the provision and acquisition of mechanization services is intended to fill specific gaps within specific commodity value chains, ranging from production to value addition, processing, and marketing.
- **Ownership And Stewardship;** Small and medium-sized farmers should own this scheme.
- **Beneficiary Co-Investment;-** Beneficiary farmer organizations or small and medium-sized enterprises (SMEs) are expected to participate by mobilizing resources for co-investment, which may include funds, ancillary infrastructure, or equipment.
- **Equity And Social Inclusion;-**Support will be provided in all regions and agro-ecological zones of the country where relevant agricultural value chains exist or are being developed.
- **Capacity Building;-** Engage all stakeholders, including farmers, agricultural officers, extension staff, technicians, tractor operators, and other value chain actors, to ensure effective operation, maintenance, management, and sustainability.

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