

DETAILED ECONOMIC AND FINANCIAL ANALYSIS

A. Introduction

1. The Irrigation Agriculture Inclusive Development Project (the Project) supports agricultural value chains promotion and irrigation system modernization in two districts, Yamethin of Mandalay Region and Magway of Magway Region, of the Central Dry Zone (CDZ) over a seven-year period. Agricultural value chain promotion cover district-level interventions that address limiting factors to agricultural growth, including access to quality inputs, post-harvest operations and output marketing. The Project also supports irrigation infrastructure rehabilitation and improved water resources management in selected irrigation systems, which cover a total of about 90,000 acres or 36,400 hectare (ha) of farmland in the two districts.

2. A series of subprojects will be identified during implementation. The quantitative analysis will focus on two core subprojects, Chaungmagyi irrigation system in Yamethin, and Natmauk irrigation system in Magway, as samples of subprojects to be identified and implemented over the seven-year period.

B. Rationale for Government Involvement

3. Myanmar is one of the largest countries in Southeast Asia both in land area and population.¹ Agriculture accounts for 28% of gross domestic product in 2015, down from 60% in 1999.² Annual sector growth reached 12.1% in 2005 but has slowed below 5.0% since 2010 and to 3.3% in 2014.³ Agriculture accounts for 50% of employment and 20% of exports in 2015. About 30% of the rural population is landless and 37% of rural households have less than 2 ha. Myanmar is one of the poorest countries in Southeast Asia, with estimated per capita income of \$1,270 in 2015, and 25% of the population live below the national poverty line.

4. One of the first acts of the new Government in April 2016 was to merge the former Ministry of Agriculture and Irrigation and Ministry of Livestock, Fisheries and Rural Development into one Ministry of Agriculture, Livestock and Irrigation (MOALI). Inclusion in a single ministry will increase the ability to address cross cutting issues, including: (i) whole farm system development of crops, livestock and fisheries; (ii) on and non-farm rural livelihoods; and (iii) comprehensive promotion of value chains development. New plans are under review and not yet complete but policies of the 5-year crop production plan, to supply agro-based industries and double farmer's income, are to: (i) extend production and use of good quality seeds; (ii) disseminate modern technology; (iii) upgrade vocational education; (iv) enhance research and development activities for sustainable agriculture; (v) encourage mechanized farming, climate smart agriculture, and extend water availability to increase productivity; (vi) change laws and regulations in line with current conditions; and (vii) encourage public-private partnerships and increase local and international investments in agriculture.

5. Cross-cutting developments are guided by two existing strategies. The National Action Plan for Poverty Reduction and Rural Development through Agriculture⁴ has eight priority areas: (i) agriculture production sector; (ii) livestock and fisheries sector; (iii) rural productivity and cottage industries; (iv) micro savings and credit enterprises; (v) rural cooperatives; (vi) rural

¹ This summary is based on ADB. 2016. *Country Partnership Strategy: Myanmar, 2017-2021*. Manila.

² ADB. 2015. *Key Indicators*. Manila.

³ ADB. 2015. *Key Indicators*. Manila.

⁴ <http://www.napamyanmar.org/>

socio-economy; (vii) rural renewable energy; and (viii) environmental conservation. The Rural Development Strategic Framework (March 2014) proposes integrated rural development strategies for poverty reduction to: (i) address inclusive and sustainable rural development; (ii) strengthen community based organizations, building capacity of local communities and nurturing good governance; and (iii) mitigate natural and social disasters and create resilient communities.

C. Goals of the Plan

6. Myanmar has considerable agricultural development potential. While there are 18.2 million ha of arable land, only 13.3 million (73%) ha are cultivated in 2014. 2.1 million ha are irrigated and 11.2 million ha are rainfed. There are abundant water resources with annual per capita water endowment of 24,000 cubic meters but only about 10% of available water resources are withdrawn, of which 90% is for irrigation. Annual rainfall varies considerably, from 4,000–6,000 millimeters (mm) in coastal areas to 500–1,000 mm in the heavily populated CDZ.

7. Although rice is cultivated extensively as a subsistence crop in the Project regions, it has low commercial value but high water irrigation requirement. The amount of rainfall in CDZ is insufficient for extensive rice cultivation, even during the monsoon. The Project helps to conserve water resources by rehabilitating or modernizing irrigation systems and by improving water resources management. Through agricultural value chains promotion, the Project will also encourage diversification to other crops that have a higher commercial value and are less water intensive.

8. **Activity 1: Effective agricultural value chains in oilseeds, pulses, and horticultural crops developed.** Support will be provided to key participants in the agricultural sector in selected townships in Yamethin and Magway. Key interventions include: (i) improved seed supply; (ii) extension of good agricultural practices (GAP); and (iii) improved post-harvest operations assistance. Frontline Centers (FCs) at the district, township and irrigation systems levels will be established to serve as one-stop resource centers that provide information and training to farming communities and support partnerships with local enterprises. Implementation should begin as early as possible as the realization of these benefits does not depend on irrigation infrastructure conditions. For the irrigation systems that will be rehabilitated, the advance work of agricultural development will improve cultivation practices prior to civil construction completion and thus prepare farmers to respond quickly to improved irrigation. The intervention will cover the canal-irrigated areas (2,598 ha in Chaungmagyi, and 9,292 ha in Natmauk), as well as the surrounding, non-canal-irrigated areas of approximately equal size.⁵

9. **Activity 2: Reliability of agricultural water supplies improved and irrigated area increased.** As water is a critical constraint to agricultural production in the CDZ, the Project will support rehabilitation, modernization, and improved management of about ten irrigation systems. It will (i) improve cross drainage, strengthen and protect canal banks and remove a backlog of sediment deposited in the main and distributary canals; (ii) improve water control along the main and distributary canals using cross regulators and gated outlets; (iii) increase drainage capacity to strengthen crop resilience to climate change; and (iv) improve infrastructure within selected tertiary units.⁶ This analysis will focus on the Chaungmagyi and Natmauk irrigation systems.

⁵ This category includes groundwater-irrigated area, rainfed area, and orchard.

⁶ Farm-to-market access roads improvement accounts for about 15% of the investment costs. While the positive impacts in terms of transportation and time cost savings are not quantified in the analysis, about 7,800 households in Chaungmagyi and Natmauk will reap the benefits.

10. The former is located in Yamethin and the latter in Magway.

11. With the project, canal-irrigated area in Chaungmagyi will increase by 259 ha, from 2,339 to 2,598 ha. The rehabilitated Natmauk system will serve 9,292 ha of farmland, 567 ha more than the present 8,725 ha.

D. Without-Project and With-Project Scenarios

12. As a part of the project preparatory technical assistance (PPTA), household surveys were undertaken in the two subproject areas. The surveys interviewed 180 households in Chaungmagyi and 181 households in Natmauk, divided into three categories (head, middle and tail) according to their location in the irrigation systems. The survey covered essential information such as cropping pattern cropping intensity by seasons, and crop budgets.

13. In addition, the survey also gathered information on marketing channels, household post-harvest activities, sources and access to extension services and training, and mechanized farm equipment usage. Of particular importance are the main constraints to increasing agricultural production.⁷ These include:

- (i) insufficient seed supply, poor quality and mixed varieties lead to sub-optimal germination and non-uniform quality and sizes that affect prices;
- (ii) fertilizer whose actual nutrient content is below the stated value;
- (iii) inappropriate use of pesticides and lack of effective quality and standards enforcement; and
- (iv) inadequate extension services, poor farm-to-market access roads, limited access to credit, labor shortage, and absence of a supportive regulatory environment.

14. The Project benefits include (i) canal-irrigated area expansion; (ii) increased cropping intensity in existing canal-irrigated areas; (iii) crop diversification; and (iv) improved productivity. The first two benefits are due to irrigation system rehabilitation (Activity 2) and will materialize in the canal-irrigated area. The latter two are due to a combination of irrigation system rehabilitation (Activity 1) and agricultural value chains promotion (Activity 1), and will materialize in both the canal-irrigated and non-canal-irrigated areas.

15. **Canal-irrigated area expansion.** As stated, the project will expand the canal-irrigated area in Chaungmagyi by 259 ha from 2,339 to 2,598 ha, and in Natmauk by 567 ha from 8,725 to 9,292 ha.

16. **Increased cropping Intensity.** Increased water availability during the dry season increases the cultivable farmland in the irrigation systems' command area, thereby increasing the effective cultivation area. While the physical area of canal-irrigated farmland is 2,339 ha in Chaungmagyi, and 8,725 ha in Natmauk, the effective cultivation area are 3,134 and 15,181 ha, respective. This translates to cropping intensities of 134% and 174%. With-project, cropping intensities in canal-irrigated area will increase to 139% and 187%. The effective cultivation area and cropping intensity do not change in non-canal-irrigated areas since they will not receive additional water.

⁷ Survey findings are consistent those of other reports, for instance, ADB's 2014 Country Diagnostic Study "Myanmar: Unlocking the Potential" and the World Bank's "Myanmar: Capitalizing on Rice Export Opportunities" Report No. 85808, Feb 2014.

17. **Diversified cropping pattern.** The PPTA consultants collected per-hectare crop budget and cultivation area for the most commonly grown crop in Chaungmagyi and Natmauk, including rice, cotton, tomato, onion, pulse and sesame. The cropping patterns take into consideration total water availability, the water requirement of each crop, and households' own rice consumption requirement in conjunction with the financial attractiveness of different cropping activities. Rice will continue to be a dominant crop in spite of its lower commercial value.

18. **Yield improvement.** For each common crop, a per-hectare budget was developed for the canal-irrigated and non-canal-irrigated area, based on the household surveys in Chaungmagyi and Natmauk. Representative crop budgets for rice cultivation are presented as in Tables 1 and 2, and those for other crops can be found in the Annex. Note that in the with-project scenarios, all variable agricultural inputs costs are adjusted in proportion to yield growth.

Table 1: Rice Crop Budget in Chaungmagyi at Project Maturity (Year 9)

Item	Without Project			With Project		
	Quantity	Unit price MK/kg	Budget MK'000	Quantity	Unit price MK/kg	Budget MK'000
Crop: Paddy						
Yield	3,046.9	218.4	665.5	3,925.9	218.4	857.5
Inputs						
Seed (kg/acre) ^a	150.2	366.4	55.0	193.5	366.4	70.9
Fertilizer (kg/acre) ^a	294.1	474.9	139.7	379.0	474.9	180.0
Pesticide (MK/acre) ^a	2.5	11,279.8	27.9	3.2	11,279.8	35.9
Draught animal (day/acre)	10.2	2,819.7	28.7	10.2	2,819.7	28.7
Ploughing (day/acre)	2.4	21,489.0	51.5	2.4	21,489.0	51.5
Threshing (kg/acre) ^a	3,046.9	11.0	33.6	3,925.9	11.0	43.3
Family labor (person day)	2.3	3,190.2	7.2	2.9	3,190.2	9.3
Hired labor (person day) ^a	63.8	3,190.2	203.5	82.2	3,190.2	262.2
Other	2.5	10,587.4	26.2	2.5	10,587.4	26.2
Total Cost			573.3			708.0
Net income			92.2			149.5

^a Marked items are variable inputs costs. In the with-project scenario, the input quantities are scaled upward by the yield improvement estimates.

Source: consultant's estimates.

19. In the with-project scenario, the yield in canal-irrigated area is estimated to increase by 2% per annum until project maturity (Year 9) due to increasing water availability and value chains promotion activities. Similarly, the yield in non-canal-irrigated area is estimated to increase by 1% per annum until project maturity due to value chains promotion.

Table 2: Rice Crop Budget in Natmauk at Project Maturity (Year 9)

Item	Without Project			With Project		
	Quantity	Unit price MK/kg	Budget MK'000	Quantity	Unit price MK/kg	Budget MK'000
Crop: Paddy						
Yield	2,522.2	211.9	534.5	3,017.1	211.9	639.4
Inputs						
Seed (kg/acre) ^a	128.0	377.9	48.4	153.1	377.9	57.9
Fertilizer (kg/acre) ^a	151.8	508.3	77.2	181.6	508.3	92.3
Pesticide (MK/acre) ^a	2.5	9,489.9	23.5	3.0	9,489.9	28.1
Draught animal (day/acre)	19.3	2,211.0	42.7	19.3	2,211.0	42.7
Ploughing (day/acre)	2.4	23,661.0	56.0	2.4	23,661.0	56.0
Threshing (kg/acre) ^a	2,522.2	9.4	23.8	3,017.1	9.4	28.4
Family labor (person day)	2.8	0.0	-	3.4	-	-
Hired labor (person day) ^a	56.2	2,109.0	118.5	67.2	2,109.0	141.7
Other	2.5	9,972.0	24.6	2.5	9,972.0	24.6

	Without Project			With Project		
	Quantity	Unit price MK/kg	Budget MK'000	Quantity	Unit price MK/kg	Budget MK'000
Total Cost			414.5			471.6
Net income			120.0			167.7

^a Marked items are variable inputs costs. In the with-project scenario, the input quantities are scaled upward by the yield improvement estimates.

Source: consultant's estimates.

20. Tables 3 and 4 present the with- and without-project estimates on cultivation area, cropping intensity, cropping pattern and crop yields. These were prepared by PPTA consultants during field visits. During data collection, the cultivated areas were estimated separately for the monsoon and non-monsoon seasons, but for reporting purposes were summed in the tables to derive the effective baseline cultivated area. Note that there is no change to the cultivation area and cropping intensity in non-canal-irrigated area.

Table 3: Without- and With-Project Scenarios in Chaungmagyi at Project Maturity (Year 9)

Benefit category	Canal-Irrigated Area			Non-Canal-Irrigated Area		
	Baseline ^a	Without- Project ^b	With- Project ^b	Baseline ^a	Without- Project ^b	With- Project ^b
	2016	2025	2025	2016	2025	2025
Irrigated area expansion						
Expansion (hectare)	0	0	259	0	0	0
Cultivated area (hectare)	2,339	2,339	2,598	2,339	2,339	2,339
Increased cropping intensity (%)	134	134	139	106	106	111
Effective cultivated area (hectare)	3,134	3,134	3,611	2,468	2,468	2,597
Diversified cropping pattern^c						
Paddy						
Effective cultivated area (hectare)	2,550	2,550	2,260	561	561	234
As % of project area	109	109	87	24	24	10
Cotton						
Effective cultivated area (hectare)	585	585	779	281	281	398
As % of project area	25	25	30	12	12	17
Tomato						
Effective cultivated area (hectare)	0	0	1	94	94	199
As % of project area	0	0	0	4	4	9
Onion						
Effective cultivated area (hectare)	0	0	143	187	187	316
As % of project area	0	0	6	8	8	14
Pulse						
Effective cultivated area (hectare)	0	0	143	269	269	187
As % of project area	0	0	6	12	12	8
Sesame						
Effective cultivated area (hectare)	0	0	143	11	1,076	1,263
As % of project area	0	0	6	0	46	54

^a Subproject households survey summary statistics.

^b Consultant's estimates.

^c The sum of all crop areas equals the effective cultivated area.

Source: Consultant's estimates.

Table 4: Without- and With-Project Scenarios in Natmauk at Project Maturity (Year 9)

Benefit category	Canal-Irrigated Area			Non-Canal-Irrigated Area		
	Baseline ^a	Without- Project ^b	With- Project ^b	Baseline ^a	Without- Project ^b	With- Project ^b
	2016	2025	2025	2016	2025	2025
Irrigated area expansion						
Expansion (hectare)	0	0	567	0	0	0
Cultivated area (hectare)	8,725	8,725	9,291	8,725	8,725	8,725
Increased cropping intensity (%)	174	174	187	117	117	117
Effective cultivated area (hectare)	15,181	15,181	17,375	10,165	10,165	10,165
Diversified cropping pattern^c						
Paddy						
Effective cultivated area (hectare)	8,899	8,899	7,433	2,094	2,094	873
As % of project area	102	102	80	24	24	10
Cotton						
Effective cultivated area (hectare)	480	480	1,208	872	872	1,134
As % of project area	6	6	13	10	10	13
Onion						
Effective cultivated area (hectare)	1,832	1,832	3,066	1,309	1,309	1,483
As % of project area	21	21	33	15	15	17
Pulse						
Effective cultivated area (hectare)	1,919	1,919	2,509	1,003	1,003	1,134
As % of project area	22	22	27	12	12	13
Sesame						
Effective cultivated area (hectare)	2,050	2,050	3,159	4,886	4,886	5,540
As % of project area	24	24	34	56	56	64

^a Subproject households survey summary statistics.

^b Consultant's estimates.

^c The sum of all crop areas equals the effective cultivated area.

Source: Consultant's estimates.

21. The cultivated area for each crop was multiplied by the respective per-hectare income to derive the overall income from each particular crop in the subproject areas. The sum of all crop incomes is the total agricultural income in the subproject areas. This procedure was followed to compute the agricultural income in the with- and without-project scenarios, and the difference in income represents the incremental financial benefits. The stream of financial benefits determines the financial net present value (FNPV) and financial internal rate of return (FIRR).

22. Similar procedures were followed for the economic analysis. Tables 5 and 6 present the step-by-step calculations of incremental economic benefits at project maturity (Year 9).

Table 5: Incremental Economic Benefits in Chaungmagyi at Project Maturity^a (Year 9)

	With-Project		Without-Project	
	Canal-Irrigated Area	Non-Canal-Irrigated Area	Canal-Irrigated Area	Non-Canal-Irrigated Area
Paddy				
Effective cultivated area (hectare)	2,335	279	2,550	561
Net income (MK'000/hectare)	161	89	88	88
Paddy Income (MK million)	376	25	224	49
Cotton				
Effective cultivated area (hectare)	751	370	585	281
Net income (MK'000/hectare)	925	773	759	629
Cotton Income (MK million)	695	286	444	176
Tomato				
Effective cultivated area (hectare)	29	170	0	94
Net income (MK'000/hectare)	4,238	3,394	2,593	2,594
Tomato Income (MK million)	124	576	0	243
Onion				
Effective cultivated area (hectare)	29	278	0	187
Net income (MK'000/hectare)	2,085	1,522	1,428	1,233
Onion Income (MK million)	61	423	0	231
Pulse				
Effective cultivated area (hectare)	29	201	0	269
Net income (MK'000/hectare)	389	277	183	182
Pulse Income (MK million)	11	56	0	49
Sesame				
Effective cultivated area (hectare)	29	1,222	0	1,076
Net income (MK'000/hectare)	735	800	492	641
Sesame Income (MK million)	22	978	0	690
Total income in canal-irrigated and non-canal-irrigated areas (MK million)	1,289	2,344	668	1,438
Total crop income (MK million)				
With-Project				3,633
Without-Project				2,105
Project benefit (MK million)				1,527

Source: Consultant's estimates.

Table 6: Incremental Economic Benefits in Natmauk at Project Maturity^a (Year 9)

	With-Project		Without-Project	
	Canal-Irrigated Area	Non-Canal-Irrigated Area	Canal-Irrigated Area	Non-Canal-Irrigated Area
Paddy				
Effective cultivated area (hectare)	7,699	1,040	8,899	2,094
Net income (MK'000/hectare)	218	168	144	144
Paddy Income (MK million)	1,675	175	1,282	302
Cotton				
Effective cultivated area (hectare)	1,008	1,073	480	872
Net income (MK'000/hectare)	786	431	622	313
Cotton Income (MK million)	792	463	298	273
Tomato				
Effective cultivated area (hectare)				
Net income (MK'000/hectare)				
Tomato Income (MK million)				
Onion				
Effective cultivated area (hectare)	2,801	1,432	1,832	1,309
Net income (MK'000/hectare)	1,152	1,242	867	1,097
Onion Income (MK million)	3,228	1,778	1,588	1,436
Pulse				
Effective cultivated area (hectare)	2,405	1,104	1,919	1,003
Net income (MK'000/hectare)	189	113	108	77
Pulse Income (MK million)	455	125	207	78
Sesame				
Effective cultivated area (hectare)	2,934	5,364	2,050	4,886
Net income (MK'000/hectare)	594	1,086	460	981
Sesame Income (MK million)	1,742	5,823	943	4,794
Total income in canal-irrigated and non-canal-irrigated areas (MK million)	7,892	8,363	4,318	6,882
Total crop income (MK million)				
With-Project				16,255
Without-Project				11,200
Project benefit (MK million)				1,527

Source: Consultant's estimates.

E. Project Costs

23. Investment costs were based on mid-2015 prices collected by the PPTA consultants for engineering works. All prices are inflation-adjusted to 2016 price level. Table 7 presents the financial costs of the two subprojects by the main project activities, value chains promotion and irrigation infrastructure rehabilitation. The project activities consist of several sub-activities, which in turn consist of different inputs. Each of these inputs is further decomposed into proximate tradable content, non-tradable content and unskilled labor. The summation of the inputs' tradable content gives the total tradable content of sub-activities and project activities. The non-tradable content and unskilled labor are determined in a similar manner. Since the tradable content, non-tradable content and unskilled labor are in financial terms, they are converted to economic values using appropriate conversion factors as outlined in Para.26.

Table 7: Financial Project Costs and Composition by Subprojects and Activities (\$'000)

Item	Chaungmangyi				Natmauk			
	(\$'000)	Tradable (%)	Non-tradable (%)	Unskilled labor (%)	(\$'000)	Tradable (%)	Non-tradable (%)	Unskilled labor (%)
Activity 1: Value Chain Promotion								
Value chain promotion	2,969	26	27	46	6,192	26	30	44
ADU ^b	397	65	31	3	829	26	65	9
Project management	172	63	33	4	359	26	66	7
Subtotal	3,539	33	28	39	7,380	26	36	38
Activity 2: Irrigation Infrastructure Rehabilitation								
Irrigation system rehabilitation	4,611	34	32	33	12,674	35	19	46
Irrigation management improvement	697	26	47	27	1,238	26	37	37
Irrigation design	364	56	39	5	870	26	37	37
Project management	278	63	34	3	725	63	33	4
Subtotal	5,950	36	35	29	15,507	35	22	43
O&M^c								
Primary and secondary canals								
Annual O&M costs (1.5% of Irrigation System Rehabilitation Investment)	69	15	40	45	190	15	40	45
Tertiary canals								
Equivalent annual cost (1.0 day/ha of canal-irrigated farmland)	16.1	0	0	100	57.5	0	0	100

ADU = agricultural development unit; O&M = operation and maintenance.

^a Include physical contingency.

^b This is the share of ADU costs assigned to the two subprojects.

^c Engineering consultant's estimates.

Source: Consultant's estimates.

24. Operation and maintenance (O&M) costs for the (i) primary and secondary canals were estimated by engineering consultants to be 1.5% of total irrigation rehabilitation investment to be borne by the government. O&M costs for the tertiary canals were estimated to be 1.0 labor-day per hectare of irrigated farmland to be borne by the farming households. Although the work will be carried out by farming households, the financial cost of their labor is valued at the prevailing market wage.

F. Methodologies and Assumptions

25. The economic cost and benefit analysis (CBA) has been conducted using the Asian Development Bank's (ADB's) *Guidelines for the Economic Analysis of Projects*,⁸ and *Key Areas of Economic Analysis of Investment Projects: An Overview*.⁹ The major assumptions of the analysis are:

- (i) The project life is taken to be 25 years, including a 7-year implementation period.
- (ii) The economic costs and benefits are valued in Myanmar Kyat (MK) using domestic price level numeraire. The exchange rate is MK1,168 MK/\$.
- (iii) The economic price of rice and cotton at farm gate are estimated using border pricing parity. The initial Cost, Insurance and Freight (CIF) prices are based on the World Bank's Commodity Price Forecasts after adjustment for quality difference.

⁸ ADB. 1997. *Guidelines for Economic Analysis of Projects*. Manila, Philippines.

⁹ ADB. 2014 *Key Areas of Economic Analysis of Investment Projects: An Overview*. Manila, Philippines.

- (iv) The economic costs and benefits for non-tradable agricultural inputs and outputs are derived by excluding taxes and duties. The economic prices of subproject investment and O&M costs are estimated by first removing taxes, and then adjusting the tradable content by the shadow exchange rate factor (SERF) of 1.10, and the unskilled labor content by the opportunity cost of surplus labor (OCSL) of 0.8. No adjustment is required for the non-tradable content.
- (v) The economic opportunity cost of capital is 12.0%.

26. **Chaungmagyi subproject.** In present value terms the total investment costs is MK7,481 million, consisting of MK2,975 billion tradable content; MK2,480 million non-tradable content and hired skilled (scarce) labor; and MK2,062 million hired unskilled (surplus) labor. The O&M costs amounts to MK555 million, consisting of MK79 million tradable content; MK192 million non-tradable content and hired skilled labor; and MK294 million unskilled labor inclusive of farmer's labor contribution to the O&M of tertiary canals. At program maturity (Year 9), the combined effect of increased cropping intensity and yield improvement will result in an increase in farm income in the program area above MK1,000 million per year. The overall economic internal rate of return (EIRR) is 13.6%, and the economic net present value (ENPV) at a 12% discount rate is MK1,172 million.

Table 8: Project Statement – Chaungmagyi (MK million)

Project year	Investment	O&M	Total Cost	Farm Benefit	Net Benefit
1	1,123	0	1,123	0	(1,123)
2	2,020	28	2,048	101	(1,947)
3	3,000	57	3,057	219	(2,837)
4	2,993	88	3,080	350	(2,730)
5	668	89	757	509	(248)
6	531	91	621	685	63
7	403	91	494	893	399
8	0	91	91	1,159	1,068
9	0	91	91	1,527	1,436
10-25	0	91	91	1,965	1,874
ENPV	7,481	555	8,035	9,207	1,172
EIRR					13.6%

EIRR = economic internal rate of return; ENPV = economic net present value; O&M = operation and maintenance.

Note: Negative values are in brackets.

Source: Consultant's estimates.

27. **Natmauk subproject.** The total investment costs is MK16,739 million, and the O&M costs amounts to MK1,490 million, also inclusive of farmer's labor contribution to the O&M of tertiary canals. The total project benefit is MK26,158 million. The overall economic internal rate of return (EIRR) is 16.8%, and economic net present value (ENPV) at a 12% discount rate is MK6,970 million.

Table 9: Project Statement – Natmauk (MK million)

Project year	Investment	O&M	Total Cost	Farm Benefit	Net Benefit
1	2,360	0	2,360	0	(2,360)
2	2,500	58	2,557	298	(2,259)
3	4,564	94	4,658	685	(3,973)
4	7,252	176	7,428	1,176	(6,252)
5	6,833	259	7,092	1,773	(5,319)
6	1,071	262	1,334	2,421	1,088
7	801	264	1,065	3,173	2,108
8	0	264	264	4,049	3,785

Project year	Investment	O&M	Total Cost	Farm Benefit	Net Benefit
9	0	264	264	5,055	4,791
10-25	0	264	264	5,863	5,599
ENPV	16,739	1,490	18,229	25,199	6,970
EIRR					16.8%

EIRR = economic internal rate of return; ENPV = economic net present value; O&M = operation and maintenance.

Note: Negative values are in brackets.

Source: Consultant's estimates.

G. Sensitivity analysis

28. Several sensitivity scenarios were tested, including (i) a 10% increase in investment costs; (ii) a 10% decrease in with-project yield improvement; (iii) a 10% reduction in output prices; (iv) a 10% decrease in the non-canal-irrigated area covered by the value chains promotion activity; (v) a 10% increase in variable costs; (vi) a 10% increase in O&M costs; and (vii) a one-year implementation delay. By and large, the Project is robust to adverse changes except for implementation delay which reduces to EIRRs to around 10%.

Table 10: Sensitivity Analysis

Scenario	ENPV (MK million)	EIRR (%)	SI (%)	SV
Chaungmagyi	1,172	13.65		
10% increase in investment cost	380	12.50	-0.8	-1.19
10% decrease in yield improvement	626	12.90	-0.6	-1.8
10% decrease in output price	22	12.03	-1.2	-0.8
10% decrease in VC area coverage	719	13.02	-0.5	-2.2
10% increase in variable costs	943	13.34	-0.2	-4.4
10% increase in O&M costs	1,116	13.57	-0.1	-17.3
1-year implementation delay	(1,564)	10.12		
Natmauk	6,970	16.76		
10% increase in investment cost	5,187	15.30	-0.9	-1.15
10% decrease in yield improvement	5,492	15.82	-0.6	-1.8
10% decrease in output price	3,838	14.72	-1.2	-0.8
10% decrease in VC area coverage	6,235	16.28	1.9	0.5
10% increase in variable costs	6,358	16.38	2.0	0.5
10% increase in O&M costs	6,821	16.65	-0.1	-16.2
1-year implementation delay	(4,858)	9.72		

EIRR = economic internal rate of return; ENPV = economic net present value; O&M = operation and maintenance; SI = sensitivity indicator; SV = switching value; VC = value chain.

Note: Negative values are in brackets.

Source: Consultant's estimates.

H. Distribution Analysis

29. **Chaungmagyi.** The government is responsible for the initial investment costs (MK7,987 million), plus subsequent O&M costs of MK487 billion. The total project costs sums to MK8,474 million. Hired unskilled (surplus) labor will be paid above their opportunity cost of labor. They will earn a total labor surplus of MK550 million. As the Project's direct beneficiaries, farmers in program area will earn an incremental farm income of MK9,207 million, but are expected to contribute labor to the O&M of the tertiary canals, with an imputed economic value of MK111 million. The net benefit accrued to farmers is MK9,097 million.

Table 11: Distribution Analysis – Chaungmagyi Subproject (MK million)

	FNPV	ENPV	Externality	Distribution of Externality			Total
				Government	Labor	Farmers	
Project Benefits							
Incremental Crop Benefits (A)	0	9,207	9,207	0	0	9,207	9,207
Project Costs							
Investment Costs							
Tradable	(2,704)	(2,975)	(270)	(2,975)	0	0	(2,975)
Non-tradable	(2,480)	(2,480)	0	(2,480)	0	0	(2,480)
Unskilled labor	(2,532)	(2,026)	506	(2,532)	506	0	(2,026)
Total Investment Costs (B)	(7,716)	(7,481)	236	(7,987)	506	0	(7,481)
O&M Costs							
Primary & Secondary							
Tradable	(72)	(79)	(7.20)	(79)	0	0	(79)
Non-tradable	(192)	(192)	0	(192)	0	0	(192)
Unskilled labor	(216)	(173)	43.21	(216)	43	0	(173)
Tertiary							
Unskilled labor	0	(111)	(111)	0	0	(111)	(111)
Total O&M Costs (C)	(480)	(555)	(75)	(487)	43	(111)	(555)
Total Project Costs (D=B+C)	(8,197)	(8,035)	161	(8,474)	550	(111)	(8,035)
Project Net Benefits (A-D)	(8,197)	1,172	9,369	(8,474)	550	9,097	1,172

ENPV = economic net present value; FNPV = financial net present value; O&M = operation and maintenance.

Note: Negative values are in brackets.

Source: Consultant's estimates.

30. **Natmauk.** The Natmauk subproject incurs a total cost of MK13,507 million to the government, a labor surplus of MK3,440 million to the hired unskilled (surplus) labor, and a net benefit of MK24,798 million to farmers.

Table 12: Distribution Analysis for the Natmauk Subproject (MK million)

	FNPV	ENPV	Externality	Distribution of Externality			Total
				Government	Labor	Farmers	
Project Benefits							
Incremental Crop Benefits (A)	0	25,199	25,199	0	0	25,199	25,199
Project Costs							
Investment Costs							
Tradable	(2,704)	(6,186)	(3,482)	(6,186)	0	0	(6,186)
Non-tradable	(2,480)	(4,789)	(2,309)	(4,789)	0	0	(4,789)
Unskilled labor	(2,532)	(5,764)	(3,232)	(2,532)	(3,232)	0	(5,764)
Total Investment Costs (B)	(7,716)	(16,739)	(9,023)	(13,507)	(3,232)	0	(16,739)
O&M Costs							
Primary & Secondary							
Tradable	(72)	(194)	(122.26)	(194)	0	0	(194)
Non-tradable	(192)	(471)	(278.92)	(471)	0	0	(471)
Unskilled labor	(216)	(424)	(207.82)	(216)	(208)	0	(424)
Tertiary							
Unskilled labor	0	(401)	(401)	0	0	(401)	(401)
Total O&M Costs (C)	(480)	(1,490)	(1,010)	(881)	(208)	(401)	(1,490)
Total Project Costs (D=B+C)	(8,197)	(18,229)	(10,033)	(14,388)	(3,440)	(401)	(18,229)
Project Net Benefits (A-D)	(8,197)	6,970	15,167	(14,388)	(3,440)	24,798	6,970

ENPV = economic net present value; FNPV = financial net present value; O&M = operation and maintenance.

Note: Negative values are in brackets.

Source: Consultant's estimates.

I. Sustainability analysis

31. **Financial sustainability assessment and management.** The Ministry of Agriculture, Livestock and Irrigation (MOALI) is the executing agency for the project. The Department of Irrigation and the Department of Agriculture are the implementing agencies for the irrigation development component.

32. **Irrigation system O&M requirement.** Historically, the Department of Irrigation has received about 80% of the MOALI budgets. The project requires an additional O&M costs of around \$655,000 per year (1.5% of Activity 2's investment costs, which is \$43.7 million), for the primary and secondary canals. The amount is small compared to the MOALI annual allocations and will not entail excessive fiscal burden. As for the tertiary canals, the project will seek through its irrigation management activities to address ongoing financial needs by developing effective water user groups to undertake the necessary O&M.

33. Apart from the Department of Irrigation, other MOALI departments are not well funded. The initial setup costs of the Frontline Centers (Para.8) will be financed by the project during the implementation period. Upon project maturity, the centers will be self-financing by collecting fees from services provided to farmer groups, private enterprises and commercial associations. If these services are implemented effectively, they can justify service charges. The financial and stakeholder analyses (Para.27-28, 30-31) indicate that the clients can benefit substantially from these services and likely are willing to pay for them.

34. **Institutional sustainability assessment.** One of the first acts of the new Government in April 2016 was to merge the former Ministry of Agriculture and Irrigation and the former Ministry of Livestock, Fisheries and Rural Development into a single ministry, MOALI. Although development of institutional arrangements and plans is ongoing, the merger of all on-farm and non-farm mandates offers a more coherent and comprehensive approach to development that was not possible in the past.

35. Overall effectiveness will continue to be constrained in some departments by an inadequate budget, lack of relevant technical expertise, and poor access to many rural areas. There will continue to be substantial differences between departments in terms of their experience and absorptive capacity. The Project design will engage technical expertise in value chain, agriculture and engineering both to support effective implementation and strengthen institutional capacity.

ANNEX

Annex 1 Pre-Hectare Budget for Commonly Grown Crops in Subproject Areas

Table A.1.1: Rice Crop Budget in Chaungmagyi

Item	Without Project			With Project		
	Quantity	Unit price MK/kg	Budget MK'000	Quantity	Unit price MK/kg	Budget MK'000
Crop: Paddy						
Yield	3,046.9	218.4	665.5	3,925.9	218.4	857.5
Inputs						
Seed (kg/acre) ^a	150.2	366.4	55.0	193.5	366.4	70.9
Fertilizer (kg/acre) ^a	294.1	474.9	139.7	379.0	474.9	180.0
Pesticide (MK/acre) ^a	2.5	11,279.8	27.9	3.2	11,279.8	35.9
Draught animal (day/acre)	10.2	2,819.7	28.7	10.2	2,819.7	28.7
Ploughing (day/acre)	2.4	21,489.0	51.5	2.4	21,489.0	51.5
Threshing (kg/acre) ^a	3,046.9	11.0	33.6	3,925.9	11.0	43.3
Family labor (person day)	2.3	3,190.2	7.2	2.9	3,190.2	9.3
Hired labor (person day) ^a	63.8	3,190.2	203.5	82.2	3,190.2	262.2
Other	2.5	10,587.4	26.2	2.5	10,587.4	26.2
Total Cost			573.3			708.0
Net income			92.2			149.5

^a Marked items are variable inputs costs. In the with-project scenario, the input quantities are scaled upward by the yield improvement estimates.

Source: Consultant's estimates.

Table A.1.2: Rice Crop Budget in Natmauk

	Without Project			With Project		
	Quantity	Unit price MK/kg	Budget MK'000	Quantity	Unit price MK/kg	Budget MK'000
Crop: Paddy						
Yield	2,522.2	211.9	534.5	3,017.1	211.9	639.4
Inputs						
Seed (kg/acre) ^a	128.0	377.9	48.4	153.1	377.9	57.9
Fertilizer (kg/acre) ^a	151.8	508.3	77.2	181.6	508.3	92.3
Pesticide (MK/acre) ^a	2.5	9,489.9	23.5	3.0	9,489.9	28.1
Draught animal (day/acre)	19.3	2,211.0	42.7	19.3	2,211.0	42.7
Ploughing (day/acre)	2.4	23,661.0	56.0	2.4	23,661.0	56.0
Threshing (kg/acre) ^a	2,522.2	9.4	23.8	3,017.1	9.4	28.4
Family labor (person day)	2.8	0.0	-	3.4	-	-
Hired labor (person day) ^a	56.2	2,109.0	118.5	67.2	2,109.0	141.7
Other	2.5	9,972.0	24.6	2.5	9,972.0	24.6
Total Cost			414.5			471.6
Net income			120.0			167.7

^a Marked items are variable inputs costs. In the with-project scenario, the input quantities are scaled upward by the yield improvement estimates.

Source: Consultant's estimates.

Table A.2.1: Cotton Crop Budget in Chaungmagyi

	Without Project			With Project		
	Quantity	Unit price MK/kg	Budget MK'000	Quantity	Unit price MK/kg	Budget MK'000
Crop: Cotton						
Yield	1,036.3	624.5	647.2	1,361.8	624.5	850.5
Inputs						
Seed (kg/acre) ^a	6.8	3,468.5	23.6	9.0	3,468.5	31.1
Fertilizer (kg/acre) ^a	119.3	520.3	62.1	156.8	520.3	81.6
Pesticide (MK/acre) ^a	2.5	16,410.8	40.6	3.2	16,410.8	53.3
Draught animal (day/acre)	12.0	2,812.5	33.8	12.0	2,812.5	33.8
Ploughing (day/acre)	2.5	20,575.0	50.8	2.5	20,575.0	50.8
Family labor (person day)	2.7	2,472.1	6.6	3.5	2,472.1	8.6
Hired labor (person day) ^a	79.9	2,472.1	197.6	105.1	2,472.1	259.7
Other	2.5	7,539.7	18.6	2.5	7,539.7	18.6
Total Cost			433.7			537.5
Net income			213.5			313.0

^a Marked items are variable inputs costs. In the with-project scenario, the input quantities are scaled upward by the yield improvement estimates.

Source: Consultant's estimates.

Table A.2.2: Cotton Crop Budget in Natmauk

	Without Project			With Project		
	Quantity	Unit price MK/kg	Budget MK'000	Quantity	Unit price MK/kg	Budget MK'000
Crop: Cotton						
Yield	725.4	528.6	383.5	1,022.2	528.6	540.3
Inputs						
Seed (kg/acre) ^a	5.6	6,656.6	37.6	8.0	6,656.6	52.9
Fertilizer (kg/acre) ^a	44.8	533.3	23.9	63.1	533.3	33.7
Pesticide (MK/acre) ^a	2.5	16,250.0	40.2	3.5	16,250.0	56.6
Draught animal (day/acre)	11.1	3,158.8	35.1	11.1	3,158.8	35.1
Ploughing (day/acre)	2.2	18,000.0	38.9	2.2	18,000.0	38.9
Family labor (person day)	2.0	0.0	-	2.8	-	-
Hired labor (person day) ^a	77.2	1,687.5	130.3	108.8	1,687.5	183.6
Other	2.5	32,500.0	80.3	2.5	32,500.0	80.3
Total Cost			386.3			481.2
Net income			- 2.8			59.1

^a Marked items are variable inputs costs. In the with-project scenario, the input quantities are scaled upward by the yield improvement estimates.

Source: Consultant's estimates.

Table A.3.1: Tomato Crop Budget in Chaungmagyi

	Without Project			With Project		
	Quantity	Unit price MK/kg	Budget MK'000	Quantity	Unit price MK/kg	Budget MK'000
Crop: Tomato						
Yield	10,271.7	291.0	2,988.9	15,994.9	291.0	4,654.3
Inputs						
Seed (kg/acre) ^a	0.6	15,110.8	8.6	0.9	15,110.8	13.4
Fertilizer (kg/acre) ^a	245.6	690.6	169.6	382.5	690.6	264.1
Pesticide (MK/acre) ^a	2.5	74,012.8	182.9	3.8	74,012.8	284.8
Draught animal (day/acre)	27.2	2,500.0	68.1	27.2	2,500.0	68.1
Ploughing (day/acre)	2.5	22,800.0	56.3	2.5	22,800.0	56.3
Family labor (person day)	5.1	2,777.8	14.0	7.9	2,777.8	21.9
Hired labor (person day) ^a	160.3	2,777.8	445.3	249.6	2,777.8	693.4
Other	2.5	30,250.0	74.8	2.5	30,250.0	74.8
Total Cost			1,019.6			1,476.8
Net income			1,969.3			3,177.5

^a Marked items are variable inputs costs. In the with-project scenario, the input quantities are scaled upward by the yield improvement estimates.

Source: Consultant's estimates.

Table A.4.1: Onion Crop Budget in Chaungmagyi

	Without Project			With Project		
	Quantity	Unit price MK/kg	Budget MK'000	Quantity	Unit price MK/kg	Budget MK'000
Crop: Onion						
Yield	10,826.8	189.2	2,048.7	14,897.4	189.2	2,818.9
Inputs						
Seed (kg/acre) ^a	10.7	14,430.3	155.0	14.8	14,430.3	213.2
Fertilizer (kg/acre) ^a	287.3	581.2	167.0	395.3	581.2	229.7
Pesticide (MK/acre) ^a	2.5	55,256.9	136.5	3.4	55,256.9	187.9
Draught animal (day/acre)	2.5	2,600.0	6.4	2.5	2,600.0	6.4
Ploughing (day/acre)	2.5	22,772.7	56.3	2.5	22,772.7	56.3
Family labor (person day)	4.7	2,739.1	12.8	6.4	2,739.1	17.6
Hired labor (person day) ^a	168.9	2,739.1	462.8	232.5	2,739.1	636.7
Other	2.5	10,520.8	26.0	2.5	10,520.8	26.0
Total Cost			1,022.7			1,373.9
Net income			1,026.0			1,445.1

^a Marked items are variable inputs costs. In the with-project scenario, the input quantities are scaled upward by the yield improvement estimates.

Source: Consultant's estimates.

Table A.4.2: Onion Crop Budget in Natmauk

	Without Project			With Project		
	Quantity	Unit price MK/kg	Budget MK'000	Quantity	Unit price MK/kg	Budget MK'000
Crop: Onion						
Yield	11,903.2	185.6	2,209.7	10,561.0	185.6	1,960.5
Inputs						
Seed (kg/acre) ^a	9.3	12,627.1	117.6	8.3	12,627.1	104.3
Fertilizer (kg/acre) ^a	424.3	434.4	184.3	376.5	434.4	163.5
Pesticide (MK/acre) ^a	2.5	63,383.1	156.6	2.2	63,383.1	139.0
Draught animal (day/acre)	49.0	2,100.0	102.9	49.0	2,100.0	102.9
Ploughing (day/acre)	2.5	19,052.6	47.1	2.5	19,052.6	47.1
Family labor (person day)	2.3	0.0	-	2.0	-	-
Hired labor (person day) ^a	138.4	1,875.0	259.5	122.8	1,875.0	230.2
Other	2.5	17,664.0	43.6	2.5	17,664.0	43.6
Total Cost			911.6			830.6
Net income			1,298.1			1,129.9

^a Marked items are variable inputs costs. In the with-project scenario, the input quantities are scaled upward by the yield improvement estimates.

Source: Consultant's estimates.

Table A.5.1: Pulse Crop Budget in Chaungmagyi

	Without Project			With Project		
	Quantity	Unit price MK/kg	Budget MK'000	Quantity	Unit price MK/kg	Budget MK'000
Crop: Pulses						
Yield	563.4	751.5	423.4	865.5	751.5	650.5
Inputs						
Seed (kg/acre) ^a	29.2	2,187.3	63.8	44.8	2,187.3	98.1
Fertilizer (kg/acre) ^a	13.9	560.0	7.8	21.4	560.0	12.0
Pesticide (MK/acre) ^a	2.5	14,703.7	36.3	3.8	14,703.7	55.8
Draught animal (day/acre)	6.8	2,500.0	17.0	6.8	2,500.0	17.0
Ploughing (day/acre)	2.5	23,750.0	58.7	2.5	23,750.0	58.7
Family labor (person day)	8.5	2,777.8	23.7	13.1	2,777.8	36.4
Hired labor (person day) ^a	22.2	2,777.8	61.8	34.2	2,777.8	94.9
Other	2.5	10,000.0	24.7	2.5	10,000.0	24.7
Total Cost			293.8			397.5
Net income			129.6			252.9

^a Marked items are variable inputs costs. In the with-project scenario, the input quantities are scaled upward by the yield improvement estimates.

Source: Consultant's estimates.

Table A.5.2: Pulse Crop Budget in Natmauk

	Without Project			With Project		
	Quantity	Unit price MK/kg	Budget MK'000	Quantity	Unit price MK/kg	Budget MK'000
Crop: Pulses						
Yield	713.3	508.9	363.0	852.1	508.9	433.7
Inputs						
Seed (kg/acre) ^a	65.6	873.1	57.3	78.4	873.1	68.4
Fertilizer (kg/acre) ^a	34.9	457.4	16.0	41.7	457.4	19.1
Pesticide (MK/acre) ^a	2.5	13,690.7	33.8	3.0	13,690.7	40.4
Draught animal (day/acre)	15.8	2,166.7	34.2	15.8	2,166.7	34.2
Ploughing (day/acre)	2.1	29,454.5	62.0	2.1	29,454.5	62.0
Family labor (person day)	2.7	0.0	-	3.2	-	-
Hired labor (person day) ^a	58.1	1,796.3	104.4	69.4	1,796.3	124.7
Other	2.5	17,333.3	42.8	2.5	17,333.3	42.8
Total Cost			350.5			391.7
Net income			12.5			42.0

^a Marked items are variable inputs costs. In the with-project scenario, the input quantities are scaled upward by the yield improvement estimates.

Source: Consultant's estimates.

Table A.6.1: Sesame Crop Budget in Chaungmagyi

	Without Project			With Project		
	Quantity	Unit price MK/kg	Budget MK'000	Quantity	Unit price MK/kg	Budget MK'000
Crop: Sesame						
Yield	510.7	1,296.0	661.9	724.0	1,296.0	938.3
Inputs						
Seed (kg/acre) ^a	8.1	1,967.3	15.9	11.5	1,967.3	22.5
Fertilizer (kg/acre) ^a	63.3	537.6	34.0	89.7	537.6	48.2
Pesticide (MK/acre) ^a	2.5	2,742.4	6.8	3.5	2,742.4	9.6
Draught animal (day/acre)	9.2	2,933.3	26.9	9.2	2,933.3	26.9
Ploughing (day/acre)	2.4	19,375.0	46.2	2.4	19,375.0	46.2
Family labor (person day)	2.0	2,907.0	5.9	2.9	2,907.0	8.3
Hired labor (person day) ^a	42.2	2,907.0	122.7	59.8	2,907.0	173.9
Other	2.5	7,333.3	18.1	2.5	7,333.3	18.1
Total Cost			276.5			353.9
Net income			385.3			584.4

^a Marked items are variable inputs costs. In the with-project scenario, the input quantities are scaled upward by the yield improvement estimates.

Source: Consultant's estimates.

Table A.6.2: Sesame Crop Budget in Natmauk

	Without Project			With Project		
	Quantity	Unit price MK/kg	Budget MK'000	Quantity	Unit price MK/kg	Budget MK'000
Crop: Sesame						
Yield	378.5	1,704.1	644.9	452.1	1,704.1	770.4
Inputs						
Seed (kg/acre) ^a	9.2	2,917.0	26.9	11.0	2,917.0	32.2
Fertilizer (kg/acre) ^a	93.4	495.1	46.3	111.6	495.1	55.3
Pesticide (MK/acre) ^a	2.5	4,387.5	10.8	3.0	4,387.5	13.0
Draught animal (day/acre)	15.0	2,277.8	34.2	15.0	2,277.8	34.2
Ploughing (day/acre)	2.5	19,269.2	47.6	2.5	19,269.2	47.6
Family labor (person day)	2.8	0.0	-	3.4	-	-
Hired labor (person day) ^a	48.8	1,957.4	95.6	58.3	1,957.4	114.2
Other	2.5	6,835.9	16.9	2.5	6,835.9	16.9
Total Cost			278.3			313.3
Net income			366.6			457.1

^a Marked items are variable inputs costs. In the with-project scenario, the input quantities are scaled upward by the yield improvement estimates.

Source: Consultant's estimates.