TIMOR-LESTE: FINANCIAL AND ECONOMIC ANALYSES OF THE SEEDS OF LIFE PROGRAMME

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Front Cover: One of SoL's Commercial Seed Producer Groups sorting peanut seed prior to sale

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Abbreviations and Acronyms

ACIAR	Australian Centre for International Agricultural Research
AR	Adoption Rate - of SoL's improved varieties
AusAID	Australian Agency for International Development - now Australian Aid within DFAT
Ben.	Abbreviation for "Benefit"
CA	Conservation Agriculture
DFAT	(Australian) Department of Foreign Affairs and Trade
DPs	Development Partners
EIRR	Economic Internal Rate of Return
EOP	End of Project/Programme
EU	European Union
FAO	Food and Agriculture Organization
FIRR	Financial Internal Rate of Return
GAFSP	Global Agriculture Food Security Programme
GoTL	Government of Timor-Leste
HH	Household
ICM	Integrated Crop Management
IFAD	International Fund for Agricultural Development
Inc.	Abbreviation for "Incremental"
LDs	Abbreviation for "Labour Days"
LHZ	Livelihood Zone
MAF	Ministry of Agriculture and Fisheries
MCIE	Ministry of Commerce, Industry and Environment
MoF	Ministry of Finance
NSS	National Seed System
OC	Abbreviation for "Opportunity Cost"
OFDTs	On-Farm Demonstrations and Trials - used by SoL
SAPIP	Sustainable Agriculture Productivity Improvement Programme - funded by GAFSP
RDP	EU-funded Rural Development Programme
SoL	Seeds of Life
SER	SoL Economic Report
SRI	System of Rice Intensification
TA	Technical Assistance
TLMSP	IFAD's Timor-Leste Maize Storage Project
TLSDP	Timor-Leste Strategic Development Plan
TLSLS	Timor-Leste Sustainable Livelihoods Survey
TOMAK	DFAT-funded Farming for Prosperity Program in Timor-Leste
ToR	Terms of Reference

1 EXECUTIVE SUMMARY

1.1 Introduction

1. The purpose of this Evaluation of the Seeds of Life Programme (SoL) (SoL Economic Report [SER]) is to: (i) quantify the financial (farm-level) and economic (national-level) benefits generated by improved varieties of food crops grown by Timor-Leste's subsistent farming communities; and (ii) to then determine if this investment has generated sufficient benefits (increased staple food production) to justify combined (Governments of Timor-Leste and Australia) sectoral investment of about US38.60 million (in current dollars) over 16 years.

1.2 Timelines and Costs

1.2.1 Brief History and Expenditure

2. SoL commenced in Timor-Leste in November 2000 with a small Australian Centre for International Agricultural Research (ACIAR) funded adaptive research programme which imported and tested promising food crop varieties. ACIAR provided a small annual budget (US$312,000) and Phase I, with a total expenditure of US$2,443,000 (current dollars, and Australian and Timorese investment) ran from 2000 to 2005.

3. Phase II (2006[1] to 2010) increased the number research stations and introduced the concept of On-Farm Demonstrations and Trials (OFDTs). A feature of the second Phase was increased funding for a national-level Programme from the Australian Agency for International Development (AusAID). The total budget for Phase II was US$9,673,000 (current dollars, and Australian and Timorese investment). Phase III (2011 to mid-2016) built on the adaptive research foundation developed during Phase II, expanded further into contract seed production and seed distribution systems, and commenced activities in community and commercial seed production. By the end of 2015 SoL had released the following improved food crop varieties: (i) three maize; (ii) two rice; (iii) one peanut; (iv) three cassava; (v) five sweet potato; (vi) two kidney bean; and (vii) two mung bean. In addition, new varieties of rice, legumes and beans are in the pipeline. Seed production reached 496 Mt in 2014/15 to support increased variety adoption. Phase III expenditure was US$26,484,000 (current dollars, Australian and Timorese investment). In total, US$38,600,000 has been invested in the three Phases of SoL by the Australian and Timor-Leste Governments.

1.2.2 Ongoing Expenditure

4. Although SoL is coming to an end in June 2016, there is a critical need for ongoing expenditure to support: (i) continued variety importation and testing; (ii) seed multiplication; and (iii) seed purchase and distribution[2]. SoL III established a National Seed System (NSS) which is now managed by MAF. Therefore MAF should be able to continue to support and expand the NSS, and to support increased adoption of improved varieties, but these outcomes will depend on budget availability at a time when MAF's annual budget is only about US$22 million. Therefore "budget support" from other Development Partners (DPs) will be important.

1.3 Analytical Methodology

5. The methodology used to evaluate SoL's impact is a "standard" end of programme methodology based on the following steps:

   (i) demarcating Timor-Leste's food crop production areas into Livelihood Zones (LHZs) based on the current mix of food crops and areas planted to the major food crops;

[1] The MOU was signed on 1st September, 2005.
[2] This includes vegetative planting materials for roots and tubers.

(ii) understanding the current use rates of improved staple food crop varieties released during the three Phases of SoL (the Adoption Rate [AR]);

(iii) preparing; (a) cropping systems, (b) individual crop, (c) farm labour demand and supply, and (d) whole-farm food crop models for two situations - (a) "With" improved varieties, and (b) "Without" improved varieties, referred to in these types of analyses as the "With" Programme and the "Without" Programme situations;

(iv) using the models prepared under (iii) to assess the impact on farmers' food production, farm incomes (Financial Internal Rates of Return [FIRRs]), and returns to family labour inputs;

(v) Scaling-up individual farm models into economic models for each LHZ, depending on each LHZ's specific cropping pattern and the areas of crops planted - Figure 1 is a map of Timor-Leste's LHZs;

(vi) calculating total Programme expenditure over the 16-year life of the Programme, and expressing this figure in current dollar terms;

(vii) using the models prepared in (v) and the costs from (vi) to calculate SoL's Economic Internal Rate of Return [EIRR]); and

(viii) conducting sensitivity analyses to determine which of the main production variables have the greatest impact on SoL's FIRRs and EIRR.

6. The models used to evaluate the impact of SoL are "forward looking", i.e. they are based on: (i) total expenditure to-date (mid-2016) inflated to current value US dollars; and (ii) future projections of how improved varieties might impact on staple food production over the next 20 years. These benefits are also expressed in current (2016) dollar terms. The calculation of SoL's EIRR takes into account the present value of the pre-2016 benefits which were generated as a result of investment in the first two Phases of SoL[3].

7. The intention is that the model of staple food production in Timor-Leste prepared for the analysis of SoL will be used to guide future sectoral investment planning and decision making. The combination of farm models into a national model means that it is possible to ask numerous "what-if" types of questions, and to generate answers by simply changing selected key variables in the excel spread sheets.

1.4 Results and Conclusions

1.4.1 Financial Rates of Return

8. Total and incremental farm gross margins (for 1.0 ha models) are summarized in Table 1 and show that adoption of SoL's improved food crop varieties currently has, and will have in the future, reasonable potential to increase farm incomes. This incremental figure is less than expected because the current and predicted ARs are lower than anticipated.

9. In terms of calculating FIRRs, in a theoretical sense these are very high because Timor-Leste's farmers use few purchased inputs and seed is free. However, a more practical way to express the impact of improved varieties is to focus on returns to incremental family labour inputs. Farmers are more likely to adopt new agriculture production techniques if these interventions result in attractive financial returns to incremental family labour inputs. In Timor-Leste the best "comparator" is the daily cash wage rate which is about $5.00 per day for unskilled labour. However, and as shown in Table 2, farmers who adopt SoL's improved food varieties have the potential to earn substantially more than this daily wage rate. The quite large variations in the

[3] Note that although some example tables in the SER appear to only cover a 10-year period, this is because the tables are too large to fit into the Report. However, figures for years 11 to 20 are included in financial and economic models used for analysis.

returns to incremental family labour inputs are due to different combinations of food crops, and different cropped areas, in the seven LHZ models, not to varying family labour resources.

FIGURE 1: MAP OF TIMOR-LESTE'S LIVELIHOOD ZONES

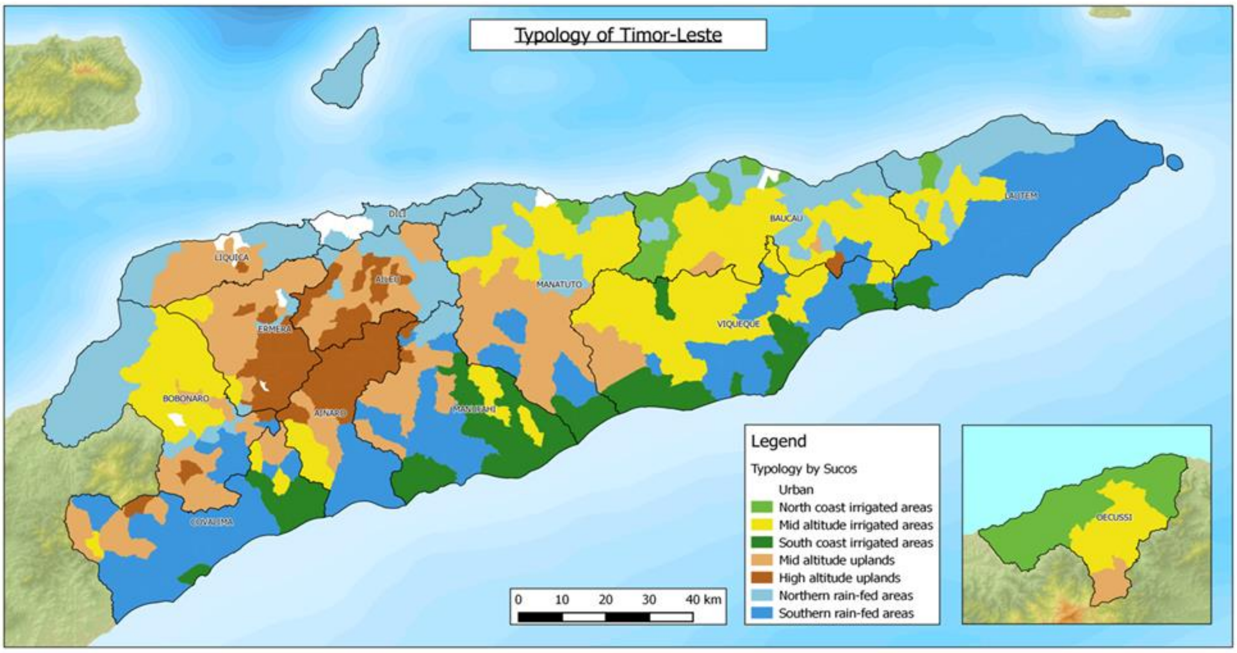


TABLE 1: TOTAL AND INCREMENTAL FARM GROSS MARGINS (FOR 1 HA MODELS)

Total Farm Gross Margins ($) a/ b/		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Scaled over 20 years	WOP	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
		With Project									
1. North Coast Irrigated	$409	$457	$459	$461	$463	$465	$468	$469	$470	$471	$472
2. Mid Altitude Irrigated	$433	$487	$489	$491	$493	$495	$499	$500	$501	$502	$503
3. South Coast Irrigated	$489	$517	$518	$519	$520	$521	$524	$525	$526	$527	$528
4. Mid Elevation Uplands	$191	$223	$224	$225	$226	$227	$230	$231	$232	$233	$234
5. High Elevation Uplands	$110	$137	$138	$139	$140	$141	$144	$145	$146	$147	$148
6. Northern Rainfed Areas	$210	$241	$243	$245	$247	$249	$249	$250	$251	$252	$253
7. Southern Rainfed Areas	$224	$268	$270	$272	$274	$276	$277	$278	$279	$280	$281

a/ From annual food crops only.

Incremental Farm Gross Margins ($) a/ b/	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Scaled over 20 years	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
1. North Coast Irrigated	$48	$50	$52	$54	$56	$59	$60	$61	$62	$63
2. Mid Altitude Irrigated	$54	$56	$58	$60	$62	$66	$67	$68	$69	$70
3. South Coast Irrigated	$28	$29	$30	$31	$32	$35	$36	$37	$38	$39
4. Mid Elevation Uplands	$32	$33	$34	$35	$36	$39	$40	$41	$42	$43
5. High Elevation Uplands	$27	$28	$29	$30	$31	$34	$35	$36	$37	$38
6. Northern Rainfed Areas	$31	$33	$35	$37	$39	$39	$40	$41	$42	$43
7. Southern Rainfed Areas	$44	$46	$48	$50	$52	$53	$54	$55	$56	$57

a/ From annual food crops only.

b/ An average for all rural hhs in the LHZ at current low and slowly increasing adoption rates.

TABLE 2: RETURNS TO INCREMENTAL FARMING HOUSEHOLD LABOUR INPUTS

$/Incremental Family LD a/	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
1. North Coast Irrigated	$7.12	$7.42	$7.72	$8.02	$8.32	$8.64	$8.80	$8.96	$9.12	$9.29
2. Mid Altitude Irrigated	$8.01	$8.33	$8.65	$8.97	$9.30	$9.62	$9.77	$9.92	$10.06	$10.21
3. South Coast Irrigated	$4.21	$4.42	$4.63	$4.83	$5.04	$5.22	$5.36	$5.50	$5.64	$5.79
4. Mid Elevation Uplands	$8.94	$9.28	$9.62	$9.96	$10.30	$10.66	$10.83	$11.00	$11.17	$11.35
5. High Elevation Uplands	$9.20	$9.60	$10.00	$10.41	$10.81	$11.23	$11.36	$11.49	$11.61	$11.74
6. Northern Rainfed Areas	$4.43	$4.64	$4.85	$5.05	$5.26	$5.46	$5.55	$5.64	$5.73	$5.82
7. Southern Rainfed Areas	$8.00	$8.34	$8.68	$9.03	$9.37	$9.70	$9.91	$10.12	$10.33	$10.53

a/ From annual food crops only.

1.4.2 Incremental Food Production

10. SoL's core objective is to increase staple food production. Therefore estimation of how SoL might impact in terms of this objective is a core part of this analysis. Table 3 shows these figures and confirms that SoL has and will have a major impact on staple food production in Timor-Leste. For example, in the Mid-Altitude Irrigated LHZ, incremental staple food production per household is estimated to increase from 140 kg in 2016 to 225 kg in 2035. And at the national level, incremental staple food production is estimated to increase from 14,980 Mt to 19,220 Mt over a period of 10 years. Annual staple food losses are estimated to be 6,420 Mt (2016), valued at about US$4.82 million.

TABLE 3: INCREMENTAL STAPLE FOOD PRODUCTION

Incremental Food Production (Mt) a/ b/		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Scaled over 20 years		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
1. North Coast Irrigated		1,073	1,107	1,141	1,175	1,209	1,243	1,277	1,311	1,345	1,379
2. Mid Altitude Irrigated		4,158	4,291	4,424	4,557	4,690	4,823	4,956	5,089	5,222	5,355
3. South Coast Irrigated		1,364	1,407	1,450	1,493	1,536	1,579	1,622	1,665	1,708	1,751
4. Mid Elevation Uplands		2,604	2,683	2,762	2,841	2,920	2,999	3,078	3,157	3,236	3,315
5. High Elevation Uplands		1,030	1,062	1,094	1,126	1,158	1,190	1,222	1,254	1,286	1,318
6. Northern Rainfed Areas		2,284	2,357	2,430	2,503	2,576	2,649	2,722	2,795	2,868	2,941
7. Southern Rainfed Areas		2,469	2,546	2,623	2,700	2,777	2,854	2,931	3,008	3,085	3,162
Total Mt		**14,982**	**15,453**	**15,924**	**16,395**	**16,866**	**17,337**	**17,808**	**18,279**	**18,750**	**19,221**
Incremental Food per Household - for all Households in the LHZs a/											
1. North Coast Irrigated	8,401	128	132	136	140	144	148	152	156	160	164
2. Mid Altitude Irrigated	29,719	140	144	148	152	156	160	164	168	172	176
3. South Coast Irrigated	9,016	151	156	161	166	171	176	181	186	191	196
4. Mid Elevation Uplands	29,996	87	90	93	96	99	102	105	108	111	114
5. High Elevation Uplands	17,178	60	62	64	66	68	70	72	74	76	78
6. Northern Rainfed Areas	24,685	93	96	99	102	105	108	111	114	117	120
7. Southern Rainfed Areas	27,404	90	93	96	99	102	105	108	111	114	117

a/ After allowing for storage losses and retained seed. b/ Based on rice grain and nuts, not paddy and peanuts nis.

1.4.3 Economic Rates of Return

11. <u>If 100% of SoL's historical and predicted costs are included, SoL's EIRR is a credible 13%</u>; or, 13% is the discount rate at which the present value of SoL's economic costs and benefits are equal. Given that SoL not only focused on variety testing and release, etc. but also on building MAFs institutional and Ministerial staff capacity, an EIRR of 13% is very acceptable.

12. <u>Sensitivity Analyses</u>. The analysis of SoL's impact was based on a number of important key assumptions. These have been setup as key variables in economic tables with the objective of testing the sensitivity of SoL's EIRR to various combinations of these variables. Table 4 summarizes these sensitivity analyses for seven variables. When estimating the EIRRs for one changed variable, all other variables are held constant. For example, when the percentage of Programme costs attributable to benefit generation is reduced from 100% to 85%, the EIRR

increases from 13% to 19% - provided that all other variables are held at their predicted values - see right hand side of Table 4.

13. The following points list the main conclusions in terms SoL's predicted EIRR:

(i) SoL's base case EIRR is 13%, if all other variables are set at conservative values;
(ii) If "attributable" costs are set at 85% of total costs, the EIRR increases to a very strong 19% - and given the wide-spread allocation of SoL's costs over the past 16 years, this is not an unreasonable assumption;
(iii) However, if there has been a further decline in the number of farming households in the target LHZs by (say) 15%, as could be confirmed or denied by the recent 2015 Population and Housing Census, then SoL's EIRR will decline to 11%;
(iv) If the areas cropped to paddy and maize are reduced by 10% - perhaps in response to lack of domestic markets. SoL's EIRR declines to a low 6%;
(v) Similarly, if farm-gate staple food crop prices fall by 20%, SoL's EIRR is 10%, and if these prices increase by 20%, the EIRR increases to 16%;
(vi) If MAF's contributions are treated as non-incremental (or fixed) costs with very low associated opportunity costs, then SoL's EIRR increases to 16%;
(vii) Faster improved food crop variety ARs (say 4% per annum) would increase the EIRR to 16% but if ARs fall to 1.0% per annum, the EIRR declines to 12%; and

Increased rates of growth in food crop yields (from say 2.5% to 5.0% over five years) would increase the EIRR to 17%, and if this rate declined to only 1% over five years, the EIRR would fall to 10%.

TABLE 4: SENSITIVITY TEST RESULTS FOR KEY VARIABLES

Sensitivity Analyses					Constant Values for Sensitivity Analysis of Variables on LHS of table						
1. Percent Programme costs attributable to benefit generation (base 100%)		EIRR-->	13%	19%		2 Value	3 Value	4 Value	5 Value	6 Value	7 Value
			100%	85%		100%	100%	100%	100%	2%	2.5%
2. Further decline in no. farming hhs, from 2010 (base none = 100%)		EIRR-->	13%	11%	1 Value		3 Value	4 Value	5 Value	6 Value	7 Value
			100%	85%	100%	100%	100%	100%	100%	2%	2.5%
3. Areas of maize and paddy reduced (base = 100% - no change)		EIRR-->	13%	6%	1 Value	2 Value		4 Value	5 Value	6 Value	7 Value
			100%	85%	100%	100%		100%	100%	2%	2.5%
4. Farm-gate prices decline/increase (base = 100% = no change)	EIRR-->	16%	13%	10%	1 Value	2 Value	3 Value		5 Value	6 Value	7 Value
		120%	100%	80%	100%	100%	100%		100%	2%	2.5%
5. Ignore MAF's Fixed Costs (base = 100% = no change)		EIRR-->	13%	16%	1 Value	2 Value	3 Value	4 Value		6 Value	7 Value
			100%		100%	100%	100%	100%	100%	2%	2.5%
6. Faster/slower changes in Adoption Rates (base = 2.0 % in five years	EIRR-->	16%	13%	12%	1 Value	2 Value	3 Value	4 Value	5 Value		7 Value
		4.0%	2.0%	1.0%	100%	100%	100%	100%	100%		2.5%
7. Faster/slower inc. in food crop yields (base = 2.5% in five years)	EIRR-->	17%	13%	10%	1 Value	2 Value	3 Value	4 Value	5 Value	6 Value	
		5.0%	2.5%	1.0%	100%	100%	100%	100%	100%	2%	

14. Best Guess EIRR. In analyses such as these it is an accepted practice to identify a "best guess" combination of variables in order to calculate the "most likely" overall Programme EIRR. In the case of SoL: (i) if "attributable" costs are reduced by 15% to reflect that SoL invested considerable funding in areas and topics which did not and will not result in the direct generation of incremental economic benefits; and (ii) MAF's historical costs are excluded from the analyses because they were not incremental - then SoL's EIRR is estimated to be 24%.

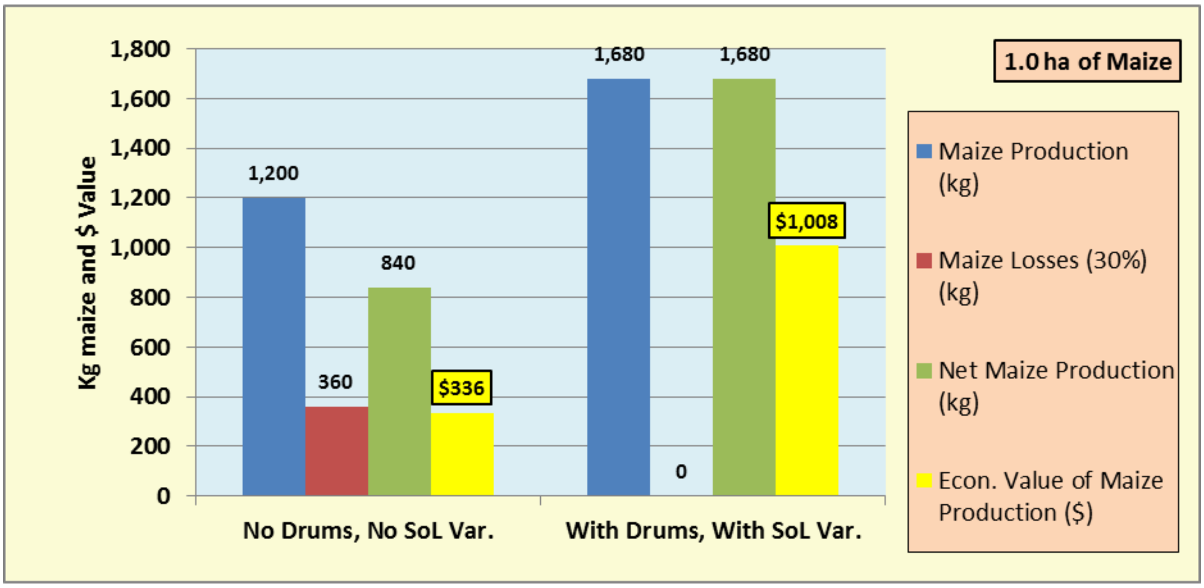
15. Complementarity with Other Projects and Programmes. An important feature of SoL Phase III was the agreement between SoL and the IFAD-funded Timor-Leste Maize Storage Project (TLMSP) which focused on improved post-harvest storage. The memorandum between SoL and TLMSP reflected an agreement for the latter to also distribute small quantities of improved maize seed to drum recipients, with the objective of twinning the complementary benefits from increased production and reduced storage losses. This partnership worked well and resulted in more wide-spread use of Sele and Noi Mutin, and reduced losses of the resultant increased

maize production. Figure 2 shows that if SoL and TLMSP are implemented in partnership, the economic value of maize (grown on 1.0 ha) increases from about US$340 to US$1,000, or by about 200%. This is just one example of the importance of driving complementarity between various DPs' projects and programmes. During its 16-year life, SoL forged many productive partnerships with a wide range of NGOs and other bilateral DPs.

1.5 Core Lessons

16. SoL's three Phases have generated valuable and ongoing lessons. The first and perhaps the most important lesson is the importance of sustained and focussed support over a prolonged period of time. It is becoming increasingly apparent that five-year projects and programmes are too short, particularly when new projects often achieve very little in terms of development targets in the first two years. SoL and its supporters had the foresight to realize that it would take multiple and progressive Phases to achieve a sustainable impact and to embed systems into an institution such as MAF. An important aspect of this step-by-step approach to rural development was to build on previous results - which in the case of SoL was the progressive release of well-tried and tested improved food crop varieties. In summary, the approach of: (i) identifying and testing new food crop varieties (for yield and taste); followed by (ii) bulking up improved seed and planting materials; and then (iii) establishing farmer-managed seed production and distribution systems - proved to be a "winning formula" for SoL.

FIGURE 2: SUMAMRY OF COMPLEMENTARITY BETWEEN SOL III AND TLMSP



17. A particularly important feature of SoL's three Phases was the deliberate intention to embed the Programme within MAF's organic structure. This approach has resulted in sustained and progressive development of institutional and human resource capacity within MAF. SoL is to be commended for selecting this slower, and sometimes more difficult implementation strategy, but the decision to embed SoL in MAF (and to in fact name Phase III as MAF/SoL) has, according to results from this analysis, increased the chances of real and sustained changes in Timor-Leste's food crop sector.

1.6 Risks

18. Despite these positive conclusions, there are risks which could impact on SoL's ongoing success. The main institutional risk is that MAF is unable to continue to fund SoL's core activities. MAF's annual budget is about US$22.0 million and even though there are signs that MAF accepts its ongoing institutional responsibility for SoL, there is always a risk that a

restructuring of MAF's leadership or a new Government might change priorities. Fortunately there is a good chance that this risk can be managed by using funds from other pipeline projects/ programmes which will rely on ongoing SoL-related activities for support in the form of adequate supplies of seeds and planting materials. In addition, SoL III's team has placed considerable emphasis on ensuring that the importance of ongoing support for SoL is understood throughout MAF. Never-the-less this institutional risk should not be under-estimated - it is the main issue which could not only under-mine SoL's past achievements, but also limit its effectiveness and impact in the future.

19. The technical risks which might impact on SoL's future are not so much "negative risks" but possibly less than optimal outcomes from failures to support SoL's improved varieties with other elements of improved food cropping packages. To some extent this risk has been recognized by the SoL follow-on ACIAR-funded adaptive research programmes. However there are many opportunities to build on improved varieties as key elements in improved food cropping systems, and if these are not factored into the designs of pipeline projects, an opportunity will be missed.

20. Market risks relate mainly to markets for increased paddy production. It seems some-what pointless for SoL to release improved varieties of rice when farmers are reacting to a lack of markets for paddy by reducing the area planted because of low gross margins and returns to household labour inputs. The issue of rice marketing in Timor-Leste is a national one and beyond the remit of a Programme such as SoL - but this negative factor does have an impact on the uptake of improved rice varieties. On a more positive note, markets for other SoL-related products such as maize, legumes and beans are growing. In addition, feeding surplus maize to non-ruminant livestock is likely to increase as the demand for locally-grown poultry and pork increases, and export markets in Indonesia are opening up for legumes.

1.7 Continued Use of Models to Guide Decision Making

1.7.1 Introduction

21. As the SER was progressively compiled and the various models linked together to enable overall Programme assessment, it became obvious that the resultant model of Timor-Leste's staple food cropping sector might be of greater use than just a one-off evaluation of SoL. This realization resulted from the decision to setup the various models to test key assumptions and linkages, so that "what if" type questions could be asked and answered.

1.7.2 Guiding On-going Investment Projects and MAF's Operations

22. Support for TOMAK ("Farming for Prosperity" - to be funded by Australian Aid) in terms of identifying priority products and its target LHZs is the first non-SoL use for these models which is immediately apparent. TOMAK will commence in mid-2016 and therefore this important initial decision - in terms of "on what and where to focus" - could be assisted by manipulation of SoL's food crop models.

23. Even though MAF's current operational budgets are small, use of the SoL models to identify where investments have the greatest impacts in terms of food production and farmers' incomes would result in improved targeting and also improved M&E, as the models would provide some indication of current and future situations.

24. Rural poverty and hunger remain very high in Timor-Leste[4]. Targeting pockets of severe poverty and associated high levels of malnutrition is a high priority for Government and its supporting DPs. SoL's SER models could be useful as a support tool for this exercise as it should be possible to overlay poverty, food deficiency and malnutrition maps over LHZ maps to identify

[4] See HPA agencies El Niño group (CARE, Oxfam, PLAN and World Vision) El Niño assessment report.

priority target areas, and various combinations of food crops which might have the biggest impact on reducing poverty, hunger and nutrition.

25. Using the models to determine where investment in secondary and farm access roads might generate the highest returns would also be appropriate. Road rehabilitation EIRRs are low in Timor-Leste[5] and therefore improved targeting through the use of the SoL SER models could prove useful[6].

26. Adaptive research prioritization and investment planning could also benefit by using SoL's SER models as a decision-making tool. These models would allow decision-makers to test possible outcomes and impacts from improved production systems developed through targeted investment to overcome production constraints. In a similar way it should be possible to use the SoL SER models to predict the impact of events such as continued rural-urban drift, and the effect of El Niño-influenced rainfall patterns.

27. SoL's SER models could also be used by MAF as the basis for improved sectoral policy analysis. There are currently numerous policy topics which warrant further analysis and assessment, followed by clear policy announcements. The models would require some adjustment and fine-tuning, but could form the basis of the modelling required to clarify some of these important policy issues and constraints.

1.7.3 Focusing on ARs and Improved Food Production Systems

28. There is an ongoing need for continued support to farmers with the objective of increasing ARs, some of which are currently lower than expected. Where to focus on this issue could be guided by further use of SoL's evaluation models. The same approach could be used to identify the need for new food crop varieties - once it is understood which are not being adopted and why. Testing the impact of improved food crop production systems on changes in FIRRs, food production, and farm incomes is another potential use for the SoL SER models.

1.7.4 "What Ifs"

29. SoL's SER models have been developed and combined in such a way that they can be used to answer a range of "what-if" questions, such as: (i) what is the impact on household incomes of increased use of farming inputs?; (ii) what is the impact of improved post-harvest food storage?; (iii) what is the impact of rapidly increasing ARs for new legume and bean species?; and (iv) what might happen if the NSS system collapsed?

[5] World Bank and Asian Development Bank pers com with Timor-Leste staff.

[6] The Consultant Agriculture Economist has personal experience with Transport Economists in Timor-Leste who always seem to struggle to identify sufficient incremental benefits to warrant investment in road rehabilitation.

2 INTRODUCTION AND TERMS OF REFERENCE

2.1 Introduction

30. The purpose of this Financial and Economic Evaluation of the Seeds of Life Programme (SoL) (here-in-after referred to as the SoL Economic Report [SER]) is to: (i) quantify the financial (farm-level) and economic (national-level) benefits generated by investment in the identification of improved varieties of food crops for Timor-Leste's subsistence farming communities; and (ii) to then determine if this investment has generated sufficient benefits (increased staple food production) to justify combined (Governments of Timor-Leste and Australia) sectoral investment of about US38.60 million (in current dollars) over 16 years. SoL has been Australia's largest bilaterally-funded rural development Programme in Timor-Leste over a long period of time, and expenditure of this level warrants a thorough analysis and of outcomes and impact, and careful consideration of sustainability. The Terms of Reference (ToR) for the SER are detailed in Annex 1 (Section 6)[7].

2.2 Overview of SoL's Timelines and Expenditure

31. SoL commenced in Timor-Leste in 2000[8] with a small Australian Centre for International Agricultural Research (ACIAR) funded adaptive research programme which imported promising food crop varieties and tested this germ plasm for yield and farmer taste acceptance on a small research centre (known as the Portuguese Garden) near the district centre of Aileu. ACIAR provided a small budget (about US$312,000 per annum - see Table 5 for details) for periodic technical advice, seed importation and operations. Phase I, with a total expenditure of US$2,443,000 (current dollars, and Australian and Timorese investment) ran from 2000 to 2005.

32. Phase II (2006[9] to 2010) increased the number research stations and introduced the concept of On-Farm Demonstrations and Trials (OFDTs) with the objective of increasing farmer acceptance of improved food crop varieties. A feature of the second Phase was increased funding for a national-level Programme from the Australian Agency for International Development (AusAID), now Australian Aid, which is part of the Department of Foreign Affairs and Trade (DFAT). The total budget for Phase II was US$9,673,000 (current dollars, and Australian and Timorese investment).

33. Phase III of SoL (2011 to mid-2016) built on the adaptive research foundation developed during Phase II and expanded further into contract seed production, and seed distribution systems. By the end of April 2016 SoL had released the following improved food crop varieties: (i) three maize; (ii) two rice; (iii) one peanut; (iv) three cassava; (v) five sweet potato; (vi) two kidney bean; and (vii) two mung bean. In addition, new varieties of rice, legumes and beans are in the pipeline. These released and pipeline varieties will form the basis of increased staple food production for many years. By 2014/15 seed production reached 496 Mt to support expansion of variety adoption. Phase III expenditure was US$26,484,000 (current dollars, Australian and Timorese investment).

34. In total, US$38,600,000 has been invested in the three Phases of SoL by the Australian and Timor-Leste Governments. As mentioned above, investment of this magnitude over a period of 16 years warrants thorough End of Programme (EOP) analyses. Therefore the remainder of the SER: (i) outlines the methodology used for the analysis of SoL's impact; (ii) presents the results

[7] The SER was prepared by Mr Philip Young, Consulting Agriculture Economist, with assistance from many of SoL's and MAF's staff who worked on the Programme over its 16 year life. Mr Young would like to acknowledge this excellent and very helpful assistance. He accepts full responsibility for the contents of this report and its findings.

[8] See various Annual Research Reports for more details on SoL's 16-year history.

[9] The MOU was signed on 1st September, 2000.

and conclusions from the detailed analyses; and (iii) concludes with a discussion on future risks to sustainability, and ongoing use of the national-level staple food cropping models used for analytical purposes.

TABLE 5: SOL EXPENDITURE OVER THREE PHASES

	Australian Expenditure				Timor-Leste Expenditure				
Year	US$ a/	Index	US$ b/	Phases	US$ a/	US$ b/	Phases	Total	Phases
2000	$312	1.6047	$501		$34	$55		$556	
2001	$312	1.5580	$486		$34	$53		$539	
2002	$312	1.5126	$472		$34	$51		$523	
2003	$312	1.4685	$458		$34	$50		$508	
2004	$79	1.4258	$113		$34	$48		$161	
2005	$79	1.3842	$109	**$2,139**	$34	$47	**$304**	$156	**$2,443**
2006	$79	1.3439	$106		$34	$46		$152	
2007	$1,417	1.3048	$1,849		$82	$107		$1,956	
2008	$1,784	1.2668	$2,259		$82	$104		$2,363	
2009	$1,556	1.2299	$1,914		$82	$101		$2,015	
2010	$2,587	1.1941	$3,089	**$9,217**	$82	$98	**$456**	$3,187	**$9,673**
2011	$4,342	1.1593	$5,034		$381	$442		$5,476	
2012	$4,542	1.1255	$5,112		$381	$429		$5,541	
2013	$5,535	1.0927	$6,049		$381	$416		$6,465	
2014	$2,293	1.0609	$2,432		$381	$404		$2,836	
2015	$3,866	1.0300	$3,866		$381	$392		$4,258	
2016	$1,717	1.0000	$1,717	**$24,210**	$191	$191	**$2,274**	$1,908	**$26,484**
Total	**$31,125**		**$35,566**	**$35,566**	**$2,662**	**$3,034**	**$3,034**	**$38,600**	**$38,600**

a/ Actual US$ expenditure.
b/ US$ expenditure inflated to current values.
Source: Information provided by SoL III's Office Manager.

2.3 Ongoing Expenditure

35. Although the 16-year SoL Programme is coming to an end in June 2016, there is a critical need for ongoing expenditure to support: (i) continued variety importation and testing; (ii) seed multiplication; and (iii) seed purchase and distribution[10]. SoL III assisted MAF in establishing a National Seed System (NSS) which is fully managed by MAF. Therefore MAF should be able to continue to support and expand the NSS, and to support increased adoption of improved varieties, but these outcomes will depend on budget availability at a time when MAF's annual budget is only about US$22 million.

36. In recognition of the importance of ongoing support for SoL's main "legacy" - the NSS - the operational budget for the Sustainable Agriculture Productivity Improvement Project (SAPIP) which is funded by a $21 million grant from the Global Agriculture Food Security Programme (GAFSP) has allocated five years of funding for this important system. In addition, the calculation of SoL's EIRR (see Section 4.7) is based on an assumption that MAF will invest about US$0.8 million per year in perpetuity to maintain the NSS - irrespective of the source of this funding.

[10] This includes vegetative planting materials for roots and tubers.

3 METHODOLOGY

3.1 Summary of Analytical Methodology

37. The methodology used to evaluate SoL's impact is a "standard" end of programme methodology based on the following steps:

(i) demarcating Timor-Leste's food crop production areas into Livelihood Zones (LHZs) based on the current mix of food crops and areas planted to the major food crops;

(ii) understanding the current use rates of improved staple food crop varieties released during the three Phases of SoL (the Adoption Rate [AR]);

(iii) preparing; (a) cropping systems, (b) individual crop, (c) farm labour demand and supply, and (d) whole-farm food crop models for two situations - (a) "With" improved varieties, and (b) "Without" improved varieties, referred to in these types of analyses as the "With Programme" and the "Without Programme" situations;

(iv) using the models prepared under (iii) to assess the impact on farmers' food production, farm incomes (Financial Internal Rates of Return [FIRRs]), and returns to family labour inputs;

(v) Scaling-up individual farm models into economic models for each LHZ, depending on each LHZ's specific cropping pattern and the areas of crops planted;

(vi) calculating total Programme expenditure over the 16-year life of the Programme, and expressing this figure in current dollar terms[11];

(vii) using the models prepared in (v) and the costs from (vi) to calculate SoL's Economic Internal Rate of Return [EIRR]); and

(viii) conducting sensitivity analyses to determine which of the main production variables have the greatest impact on SoL's FIRRs and EIRR.

38. <u>The models used to evaluate the impact of SoL are "forward looking</u>", i.e. they are based on: (i) total expenditure to-date (mid-2016) inflated to current value US dollars (see Section 2.2); and (ii) future projections of how improved varieties might impact on staple food production over the next 20 years. These benefits are expressed in current (2016) dollar terms. The calculation of SoL's EIRR takes into account the present value of the pre-2016 benefits which were generated as a result of investment in the first two Phases of SoL. The calculations also factor in Programme expenditure (funded by Australia and Timor-Leste) during the first two Phases.

39. <u>The intention is that the model of staple food production in Timor-Leste prepared for the analysis of SoL will be used to guide future sectoral investment planning and decision making</u>. The combination of farm models into a national model means that it is possible to ask numerous "what-if" types of questions, and to generate answers by simply changing selected key variables in the excel spread sheets.

40. This is an unexpected outcome from the analytical work, but as the models were progressively compiled it became increasingly apparent that a national model would be of value "post SoL" as a decision-making and investment analysis tool. Some additional work will be required to re-configure some of the basic models, followed by their compilation into a national staple food crop model so that sectoral planners and investors are able to use the resulting model for these purposes. The SER has made a good start in this regard and therefore <u>one of the main recommendations</u> is that further sector modelling be completed to improve the quality of the models and their predictive ability.

[11] Note: all financial figures quoted in this SER are in current (2016 dollars).

3.2 Livelihood Zones

41. As part of the design of TOMAK ("Farming for Prosperity" - to be funded by Australian Aid) SoL assisted with the identification and basic description of the seven main LHZs in Timor-Leste. Therefore it was logical to use this demarcation as the basis of the evaluation of SoL. Table 6: (i) lists the seven LHZs and their key characteristic in terms of the dominant crops grown; (ii) provides information on LHZs' populations and households; and (iii) lists the number and percentage of households growing the main crops[12]. Note that these lists are based on the 2010 Population and Housing Census which reported that between 2004 and 2010, Timor-Leste's farming population declined by 25%. Equivalent data from the 2015 Census are not yet available publically and therefore it was not possible to determine if this downward trend has continued. However SoL's EIRR models have been set up with the number of farming households as a key variable in order to test sensitivity in the case of further downward trends in the number of households who are classified as farmers. Figure 3 is a map which shows Timor-Leste's seven main LHZs.

FIGURE 3: MAP OF TIMOR-LESTE'S LIVELIHOOD ZONES

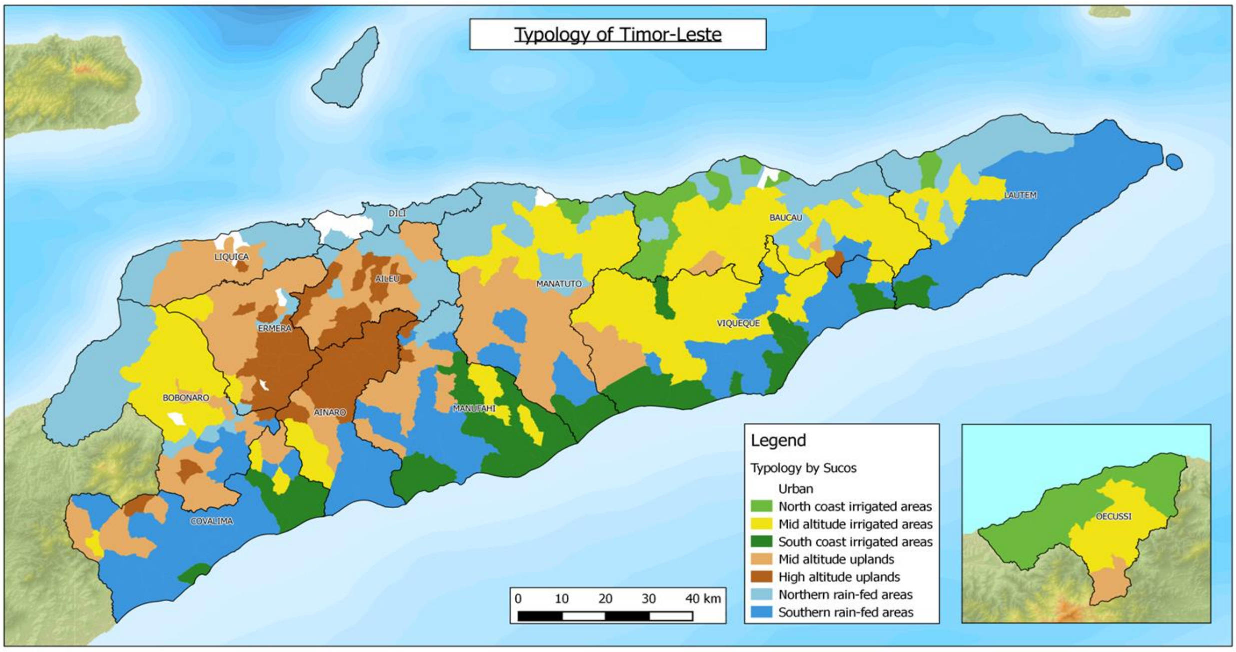


TABLE 6: TIMOR-LESTE'S LIVELIHOOD ZONES

Livelihood Zone	Key Characteristic	Villages a/	Pop'n b/	HHs	Pop'n %	HH %	Rice b/		Maize b/		Cassava b/		Vegies b/	
							% hhs	No hhs	% hhs	No hhs	% hhs	No hhs	% hhs	No hhs
1. North Coast Irrigated	>35% rice	12	42,637	8,401	5.3%	5.7%	61%	5,125	63%	5,293	50%	4,201	50%	4,201
2. Mid Altitude Irrigated	>35% rice	86	150,149	29,719	18.6%	20.3%	62%	18,426	69%	20,506	64%	19,020	53%	15,751
3. South Coast Irrigated	>35% rice	19	47,353	9,016	5.9%	6.2%	61%	5,500	64%	5,770	62%	5,590	57%	5,139
4. Mid Elevation Uplands	>50% coffee	100	176,769	29,996	21.8%	20.5%	23%	6,899	83%	24,897	83%	24,897	69%	20,697
5. High Elevation Uplands	>50% coffee	53	100,840	17,178	12.5%	11.7%	10%	1,718	80%	13,742	71%	12,196	63%	10,822
6. Northern Rainfed Areas	<35% rice, <50% coffee	72	141,269	24,685	17.5%	16.9%	13%	3,209	53%	13,083	45%	11,108	31%	7,652
7. Southern Rainfed Areas	<35% rice, <50% coffee	72	150,207	27,404	18.6%	18.7%	13%	3,563	47%	12,880	47%	12,880	39%	10,688
Totals		**414**	**809,224**	**146,399**	**100.0%**	**100.0%**	**30%**	**44,440**	**66%**	**96,171**	**61%**	**89,892**	**51%**	**74,950**

a/ Same as the number of sucos. b/ From 2010 National Census.

42. Table 6 shows that the importance of rice production varies considerably across Timor-Leste's seven LHZs. For example, only 10% of households in the High Elevation Uplands LHZ grown paddy whereas 62% of the households in the Mid Altitude Irrigated LHZ grow paddy. This

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[12] This information is also available for households and livestock numbers by species.

cropping pattern is not repeated for the non-irrigated crops (maize, cassava and to a lesser extent vegetables) as most farming households grow these important subsistence crops[13].

3.3 Areas of Food Crops Grown

43. Once the seven LHZs had been described, the next step was to estimate the areas of each crop grown by farming households in each LHZ. The results of this exercise, which are based on SoL's EOP survey, and the extensive field experience of SoL's staff over the past 16 years, are listed in Table 7. These crop areas have been designed into the analytical models as key variables. Note that it has been assumed that the areas of the different crops grown by one household will not change over time, i.e. the "With" and "Without" Programme cropped areas are the same, but these figures can be varied in the models to test sensitivities if required.

3.4 Released Varieties - Adoption Rates and Areas Planted

3.4.1 Adoption Rates

44. Table 8 summarises results from past (baseline, mid-term and adoption) and recent (EOP) surveys of the adoption of improved food crop varieties by Timor-Leste's farming communities. The table shows that: (i) the adoption of improved maize varieties is reasonably high and has increased over time - with about 40% of maize farmers using one or more of the three improved varieties; (ii) the adoption of improved rice varieties seems to have "stalled" - not much change since the 2011 baseline survey; and (iii) the ARs of improved varieties of peanut, cassava and sweet potato remain low - varying from 13% to 7%.

TABLE 7: ESTIMATED CROP AREAS PER HOUSEHOLD FOR EACH LHZ

With and Without Programme	Crop-->	Paddy	Maize	P/nut	Legs	Beans	Cass.	S/Pot.	Total
Livelihood Zone		ha/hh	ha/hh	ha/hh	ha/hh	ha/hh	ha/hh	ha/hh	ha/hh
1. North Coast Irrigated		0.80	0.66	0.25	0.20		0.29	0.25	**2.45**
2. Mid Altitude Irrigated		0.80	0.66	0.25	0.20		0.29	0.25	**2.45**
3. South Coast Irrigated		1.00	0.66	0.25	0.20		0.36	0.31	**2.78**
4. Mid Elevation Uplands		0.60	0.26	0.12		0.25	0.22	0.19	**1.64**
5. High Elevation Uplands		0.40	0.26	0.12		0.25	0.08	0.13	**1.24**
6. Northern Rainfed Areas		0.80	0.66	0.50	0.10		0.29	0.25	**2.60**
7. Southern Rainfed Areas		0.80	0.66	0.12	0.20		0.29	0.25	**2.32**
Crop Area Adj Factors ---> a/	1.00						0.50		

a/ For sensitivity testing - for: (i) overall decline in cropped areas; and (ii) a reduction in the areas of cassava grown.
The latter factor was used because the "without" Programme estimate of cassava production was unrealistically high.
Therefore these cassava areas were adjusted downwards to more realistic levels.

45. The ARs used in the evaluation's futuristic models are key result-determinant variables and therefore the financial and economic tables have been set up to allow ARs to be varied. However it is somewhat surprising that SoL's overall ARs are not higher for cassava and sweet potato after a five and half year Phase III which focussed on the production and distribution of seed and vegetative planting materials. One explanation of this finding from the EOP survey is that farmers are not able to identify the new varieties.

3.4.2 Areas Planted

46. In contrast to the ARs reported in Table 8, the percentages of the areas planted which are planted with improved varieties are encouragingly high, for example 76% for maize and 83% for paddy. These area figures have been combined with the AR figures to calculate what has been termed an "adjustment factor" to scale back the "With" Programme models so that they are

[13] Note: if households reported they grew vegetables in 2010, this has been interpreted as also growing sweet potato.

representative of the actual situation on the field for an "average" farming family - see Table 17 for an example.

3.5 Key Assumptions

47. Results from EOP analyses are always predicated on a series of assumptions related to key variables. Therefore it is important that these are described early in the SER so that readers are aware of the main assumptions which underlie the financial and economic analyses.

3.5.1 Starting Points - Cropped Areas, Adoption Rates and Crop Yields

48. Estimated current cropped areas for seven individual crops are detailed in Table 7[14]. These figures were sourced from the EOP survey and cross-checked with SoL staff for validity and practicality. Note the assumption that cropped areas per crop will not change significantly in the future because of the constraint imposed by the availability of household labour. Similarly, the current ARs for the seven main food crops were sourced from the EOP survey and then cross-checked. Information on the "Without" Programme crop yields was sourced from various SoL Annual Research Reports - and also cross-checked.

TABLE 8: ADOPTION RATES OF IMPROVED VARIETIES

Variety	Base Survey	MT Survey	AR Survey	EOP Survey	Crop	Total	AR (adj) b/ c/	% Area Planted Impr. Var. d/
Sele	13%	15%	20%	30%	**Maize**	53%	**40%**	**76%**
Noi Mutin		2%	10%	22%				
Nai				1%				
Nakroma a/	11%	15%	14%	8%	**Rice**	15%	**15%**	**82%**
Utamua a/	16%	11%	12%	6%	**P/nut**	13%	**13%**	**86%**
Ai Luka a/	3%	3%	5%	5%	**Cassava**		**7%**	**67%**
Ai Luka 1				3%				
Ai Luka 2				2%				
Ai Luka 4				1%				
Hohrae	7%	7%	9%	10%	**S/Potato**		**10%**	**78%**
Hohrae 1				5%				
Hohrae 2				3%				
Hohrae 3				4%				
Legumes							**0%**	**na**
Beans							**0%**	**na**

a/ Lower than expected at EOP due to late/poor 2016 season, and timing of survey.
b/ Allowance for some farmers who grow more than one improved variety.
c/ Use higher figures than at EOP for rice and peanut - to allow for a/.
d/ From EOP survey - this figure is the area planted to improved varieties as a percent.
of the total area planted, for each crop.

3.5.2 Crop Yields over Time

49. The "With" and "Without" Programme crop yield figures (see Table 9) were extracted from various SoL Annual Research Reports and cross-checked with SoL staff for reality and logic. However, it is expected that crop yields will continue to change over time as ongoing adaptive research and variety testing results in the release of new and improved varieties. Therefore a yield increase variable has been set up for sensitivity testing, with the base increment set at a 2.5% increase every five years, or about 0.5% per year. This is a conservative figure as even with improved varieties, crop yields in Timor-Leste are low by regional standards and therefore it

[14] Note: in para 33, 18 improved varieties are listed as having been released before the end of SoL III. Table 8 only mentions 11 varieties, as the other varieties were only released in April 2016, and are not yet widely available to farmers.

is not unrealistic to postulate that crop productivity could increase at a rate faster than 0.5% per year. However, conservatism has prevailed in this instance.

3.5.3 Changing Variety Adoption Rates

50. The current (2016) variety ARs are listed in Table 8. In terms of changes in variety ARs over time, this variable has been set up in the models for sensitivity testing, with the base case being set at an annual increase in ARs of 2% compound - from the current levels of adoption listed in Table 8. Estimating future ARs is difficult as they are likely to vary from crop to crop as new varieties are released, and as the structure of Timor-Leste's agriculture sector changes over the next 20 years in response to new and changed markets, Government and Development Partner (DP) support programmes, etc. Therefore the models have been set up to allow this variable to be changed for each of the seven main crops, if required.

3.5.4 Numbers of Households Growing Crops

51. The numbers of households growing one or more of the seven food crops targeted by SoL are shown in Table 6. In total about 146,000 households grown rice (paddy), maize, cassava and vegetables in the seven LHZs. This number was sourced from the 2010 Census, and seems reasonable, except when considered against the fact that between 2004 and 2010 Timor-Leste "lost" 25% of its farming households. If this downward trend continues there will be major ramifications for Timor-Leste in terms of the country's ability to feed its population, and the need for off-farm employment generation programmes to absorb an increased rural-urban drift. This scenario is beyond the ToR for this analysis, but should be considered as a key and assumed variable which could change over time.

TABLE 9: "WITH" AND "WITHOUT" SOL CROP YIELDS

1.0 ha Model		Without Programme (2016)							With Programme (2016)						
Farm Inputs	Unit/ha	Trad. Paddy	Trad. Maize	Trad. Peanut	Trad. Legs a/	Trad. Bean b/	Trad. Cassava	Trad. S/ Potato	Impr. Paddy	Impr. Maize	Impr. Peanut	Impr. Legs a/	Impr. Bean b/	Impr. Cassava	Impr. S/Potato
Gross Crop Production (Yield)		Crop Yields (kg/ha)							Crop Yields (kg/ha)						
Base Yields (2016) - WOP	kg	2,500	1,500	1,000	750	750	5,000	3,000							
With Sol Improved Varieties	% inc.								25%	50%	30%	30%	70%	50%	110%
Base Yields (2016) - WP	kg	2,500	1,500	1,000	750	750	5,000	3,000	3,125	2,250	1,300	975	1,275	7,500	6,300
Yields (2021)	kg	2,500	1,500	1,000	750	750	5,000	3,000	3,214	2,314	1,337	1,003	1,311	7,714	6,479
Yields (2026)	kg	2,500	1,500	1,000	750	750	5,000	3,000	3,228	2,324	1,343	1,007	1,317	7,748	6,508
Yields (2031)	kg	2,500	1,500	1,000	750	750	5,000	3,000	3,248	2,338	1,351	1,013	1,325	7,795	6,548

3.5.5 Feeding Maize to Non-Ruminant Livestock

52. As food consumption patterns in Timor-Leste change from maize-based to rice-based diets[15], there will be increased opportunities to use "surplus" maize to feed non-ruminant livestock - poultry and pigs. The demand for locally-produced chicken and pork is growing fast (as evidenced by increased prices in Dili's fresh food markets) and therefore the "With" Programme maize production model is based on an assumption that 50% of the volume of a household's "residual" maize production - after allowing for household consumption requirements - will be feed to back-yard pigs and poultry. This value-adding practice increases the gross margin earned from growing maize by about 50% and is therefore an important variable in the analytical models. Accordingly this variable has also been embedded in the models in order to test sensitivities.

[15] Evidenced by the importation of large tonnages of rice each year from Viet Nam, i.e. 215,000 Mt in 2014/15. Source: Timor-Leste Food Security Bulletin No. 12, July - September, 2015, Table 4.

3.5.6 Use of Yield-Increasing Technologies

53. The analysis of SoL's impact is based on defining staple food production under the "With" and "Without" Programme scenarios. This differential is considered to be directly attributable to the 13 improved varieties released during Phases II and III - see Table 8 for a list of varieties. The current and potential impacts of other proven yield-increasing interventions, such as (i) post-harvest storage to reduce rodent and weevil losses; (ii) use of Conservation Agriculture (CA) farming techniques and weedicides to conserve soil moisture and reduce erosion; and (iii) small-scale mechanization, have not been taken into account. This is because SoL has not invested directly in the promotion and use of these technologies and therefore the incremental benefits from these technologies should not be included in the estimation of SoL's net benefit stream.

54. However, it would be an error to ignore the opportunities represented by these three technical packages, plus others which are either already available or are in the pipeline, e.g. the use of inorganic fertilizer on cash crops. For example, it is estimated that annual post-harvest food losses are about 8,200 Mt valued at about $6.0 million (see Table 23). Therefore it seems illogical to use improved varieties to grow more food and to then not be concerned that 30% of total food production (the increase plus current levels of production) is lost due to poor post-harvest storage. Similarly, it seems logical that CA-adopting farmers use SoL's improved varieties, and (eventually) weedicides and fertilizers to increase yields and gross margins. Section 5.3 contains further analysis of the opportunity to generate complementary incremental benefits by combining improved post-harvest storage techniques and SoL's improved varieties.

3.5.7 Changes in Timor-Leste's Rice Markets

55. This EOP analyses of the impact of three Phases of SoL was completed at a time when Timor-Leste's irrigated rice sector is struggling due to: (i) lack or reliable irrigation water in some areas (due to land degradation in watersheds and the current El Niño event); and (ii) lack of markets for farmers' surplus paddy. Paddy production in 2015 was about 65,586 Mt (39,350 Mt of rice grain) from just 22,000 ha. Furthermore, the area of paddy planted has declined from 46,700 ha in 2012 to only 22,000 ha in 2015, confirming that farmers are losing interest in growing this crop. The main point to be made in this para is that the rice production environment in Timor-Leste is currently not conducive for increased adoption of improved varieties. This could be evidenced by the AR figures in Table 8, which show that fewer farmers are using Nakroma than at the time of the Mid-Term survey (June-July, 2013). If this scenario continues into the future it is not unrealistic to predict that the ARs of improved paddy varieties will at best stall and may decline as paddy farmers abandon the System of Rice Intensification (SRI) and Integrated Crop Management (ICM) (and the use of improved seed) and revert to traditional paddy production methods which require less family labour and often produces what can be termed an "opportunity crop", which is sufficient for immediate family requirements but with no surplus for sale.

56. Note however, that there could be another (at least partial) explanation of the low ARs for improved rice varieties recorded by the EOP survey, as follows. The low AR for Nakroma could be due to the impact of El Niño (lack of irrigation water) and the fact that the survey was conducted in February/March when many rice farmers had not yet started to prepare their paddies or seed plots. There will be a follow-up check with the EOP survey rice farmers in Baucau, Lautem and Viqueque districts in late April/early May, 2016, to further-test this conclusion[16].

[16] By the time the report was finalized, this follow-up work had been completed and the AR for improved varieties of rice was a little higher than the rate used in the analyses. However, the models were not re-worked because the impact of this change would be minimal.

4 DETAILED RESULTS

4.1 Introduction

57. This section expands on the above-listed analytical steps and key assumptions, and provides examples of the numerous excel-based tables prepared to enable Timor-Leste's staple food crop production scenarios to be modelled and analysed. In summary, the section uses these tables and other unlisted tables to describe and evaluate SoL's impact on staple food production in Timor-Leste. Note that as there are seven LHZs in Timor-Leste, and therefore seven of each of the models listed in para 37, this section only contains sufficient examples to enable the reader to follow the analytical steps, and to understand how the results (impacts) were calculated.

4.2 Programme Costs and Attributable Costs

58. Programme costs were calculated from SoL's expenditure records maintained in SoL's office in Dili and in the University of Western Australia (UWA). As shown in Table 10, these figures were escalated to reflect expenditure in current dollar terms, for both Australian and Timorese contributions. Evaluations such as this are often based on what are termed "attributable costs" - those cost categories which are considered to have resulted in the direct generation of benefits. For example, SoL has invested in the training of 10 Master Degree students and there is one school of thought which says that this cost should be excluded from the benefit cost analyses as it not possible to predict how these graduates might contribute to future sectoral development[17]. The alternative approach is to test SoL's impact and benefit/cost resilience in terms of being able to "withstand" the inclusion of 100% of all costs in the analysis, and to then test the model's sensitivity to a reduction in "attributable costs". The latter approach has been used to analyse SoL, with the percentage of "attributable costs" being included in the models as a key variable.

TABLE 10: SOL EXPENDITURE OVER THREE PHASES

	Australian Expenditure				Timor-Leste Expenditure				
Year	US$ a/	Index	US$ b/	Phases	US$ a/	US$ b/	Phases	Total	Phases
2000	$312	1.6047	$501		$34	$55		$556	
2001	$312	1.5580	$486		$34	$53		$539	
2002	$312	1.5126	$472		$34	$51		$523	
2003	$312	1.4685	$458		$34	$50		$508	
2004	$79	1.4258	$113		$34	$48		$161	
2005	$79	1.3842	$109	**$2,139**	$34	$47	**$304**	$156	**$2,443**
2006	$79	1.3439	$106		$34	$46		$152	
2007	$1,417	1.3048	$1,849		$82	$107		$1,956	
2008	$1,784	1.2668	$2,259		$82	$104		$2,363	
2009	$1,556	1.2299	$1,914		$82	$101		$2,015	
2010	$2,587	1.1941	$3,089	**$9,217**	$82	$98	**$456**	$3,187	**$9,673**
2011	$4,342	1.1593	$5,034		$381	$442		$5,476	
2012	$4,542	1.1255	$5,112		$381	$429		$5,541	
2013	$5,535	1.0927	$6,049		$381	$416		$6,465	
2014	$2,293	1.0609	$2,432		$381	$404		$2,836	
2015	$3,866	1.0300	$3,866		$381	$392		$4,258	
2016	$1,717	1.0000	$1,717	**$24,210**	$191	$191	**$2,274**	$1,908	**$26,484**
Total	**$31,125**		**$35,566**	**$35,566**	**$2,662**	**$3,034**	**$3,034**	**$38,600**	**$38,600**

a/ Actual US$ expenditure.
b/ US$ expenditure inflated to current values.
Source: Information provided by SoL III's Office Manager.

[17] For an excellent "Impact Assessment of Seeds of Life's Capacity Building Programme", see a report under the same name prepared by Robert T. Raab, February 2016

4.3 Phases, and Costs and Benefits

59. Section 2.2 refers to MAF's three Phases in terms of calculating the Programme's total costs and benefits. The historic values of investment expenditure and estimated benefits have been expressed in current dollar terms. Costs have been based on Programme expenditure records (see Table 10). Historical (pre-2016) benefits were defined as a scaled-back 2016 differential between the current estimates of "With" and Without" Programme net economic benefits. Table 11 shows how SoL's historical benefits were calculated and equated to 2016 values, for inclusion in the economic analysis.

TABLE 11: CALCULATION OF PRESENT VALUE OF HISTORICAL BENEFITS

Historical Benefits ($'000)										
Year	2007	2008	2009	2010	2011	2012	3013	2014	2015	**2016 a/**
% 2016 benefit b/	20%	30%	40%	50%	60%	70%	80%	90%	95%	100%
Net benefit in 2016										$2,775
Inflation factor c/	1.3048	1.2668	1.2299	1.1941	1.1593	1.1255	1.0927	1.0609	1.0300	1.0000
Adjusted benefit	$724	$1,055	$1,365	$1,657	$1,930	$2,186	$2,426	$2,650	$2,715	
a/ Estimated net economic benefit in 2016 is US$2.775 million									**Present Value--> d/**	**$16,708**

b/ Percent of 2016 benefit achieved in each year.

c/ Factor to allow for inflation

d/ This figures is equivalent to the accumulated present value of net benefits during SoL I and II.

4.4 Traded and Non-Traded Goods

60. Calculation of EIRRs requires financial prices (at the farm-gate level) to be converted to economic prices (import parity prices, or "how much would an imported product cost at the farm-gate level"?). This conversion is normally completed for what are termed "traded goods". In the case of Timor-Leste the only traded agricultural commodity which is relevant to the analysis of SoL is rice - because such large volumes are imported. Therefore this economic analysis: (i) uses the import parity price for rice (converted to a paddy price); (ii) assumes that maize and all other food crops are non-traded goods and therefore converts financial prices to economic values by multiplying the former by a Standard Conversion Factor (SCF) of 0.95; (iii) and assumes that maize is no longer a direct substitute for rice in people's daily food consumption patterns. Similarly, as none of the crop production inputs are traded, the same conversion from financial prices to economic values applies - multiplication by a SCF. This means that the economic analysis of the impact of SoL is relatively straight forward, with the exception of dealing with the opportunity cost of household and hired farm labour - see Section 4.5 for more details on this point.

4.5 Opportunity Cost of Household and Hired Labour

4.5.1 Financial Cost

61. The farm labour supply and demand models (see Table 13) indicate that one of the main constraints to increased food crop production in Timor-Leste is the availability of household and hired farm labour. This means that most farming families can only crop about 0.7 ha of land in any one season or to any one crop - see Table 7. Many of the crop gross margin models used in this analysis rely on some hired farm labour at a cost of $5.00 per person day. This is an expensive input when compared with yields and commodity prices, and is often the most important limiting factor when rural households consider expanding cropped areas.

62. Note that the farm gross margin models used for this analysis are based on some cash payment for hired labour where required, <u>but no imputed cost for family labour</u>, Instead, the returns to family labour days invested in the production of the various food crops have been calculated to

determine if cropping is as attractive to rural households as working off-farm on road construction, etc. This scenario is confounded by the payment of various types of pensions which allow rural household to buy rather than to grow staple foods[18].

4.5.2 Economic Cost

63. One of the most important additional costs which are factored into an economic analysis of any project or programme is the opportunity cost of farm household and hired labour. This cost should represent the value of production foregone when working on farm. In the case of Timor-Leste, there is a large difference between the financial cost of farm and hired labour and the economic or opportunity cost. This is because of the high un- and under-employment throughout the country. In other words, the economic cost of labour is not as high as the financial price. Recent sectoral analyses of investment in irrigation development in Timor-Leste[19] by the Ministry of Finance and the World Bank used a labour opportunity cost of US2.50 per day and this SoL analysis used the same rate.

4.6 Financial Internal Rates of Return

4.6.1 Step-by-Step Description of Models

64. This Section of the SER use a series of example financial models in tabular form to explain how the financial analysis of SoL was completed. As mentioned above, not all models are included as examples because many are repetitious due to the seven LHZs. These models were then scaled-up to Programme level to estimate SoL's EIRR - see Section 4.7.

4.6.2 Farming Systems

65. Farming systems models were prepared for seven staple food crops, for the "Without" and the "With" Programme situations, with the latter being modelled for years 2016, 2021, 2026 and 2031. This approach enabled the scaling of incremental benefits between these time zones, rather than having to prepare incremental models for all 20 years. Examples are provided in Table 12 for "Without" and "With" Programme (2016). This table shows how the farming systems models reflect incremental yields over time as new varieties are released.

[18] Estimated to be US$160 million in 2012 and growing. Source: Pamela Dale, Lena Lepuschuetz and Nithin Umapathi, Peace, Prosperity and Safety Nets in Timor-Leste: Competing Priorities or Complementary Investments? Asia & the Pacific Policy Studies, doi: 10.1002/app5.25.

[19] See: MoF and WB (World Bank) 2015. Timor-Leste public expenditure review: Infrastructure. A joint Ministry of Finance and World Bank review of the quality of infrastructure spending in Timor-Leste, focusing on roads, irrigation and electricity. Dili and Washington DC: Ministry of Finance, Timor-Leste and World Bank.

TABLE 12: EXAMPLE FARMING SYSTEMS MODELS

1.0 ha Model		Without Programme (2016)								With Programme (2016)							
Farm Inputs	**Unit/ha**	**Trad. Paddy**	**Trad. Maize**	**Trad. Peanut**	**Trad. Legs a/**	**Trad. Bean b/**	**Trad. Cassava**	**Trad. S/ Potato**	**L/Stock Labour**	**Impr. Paddy**	**Impr. Maize**	**Impr. Peanut**	**Impr. Legs a/**	**Impr. Bean b/**	**Impr. Cassava**	**Impr. S/Potato**	**L/Stock Labour**
Gross Crop Production (Yield)		**Crop Yields (kg/ha)**								**Crop Yields (kg/ha)**							
Base Yields (2016) - WOP	kg	2,500	1,500	1,000	750	750	5,000	3,000									
With Sol Improved Varieties	% inc.	---							Inc.	25%	50%	30%	30%	70%	50%	110%	
Base Yields (2016) - WP	kg	2,500	1,500	1,000	750	750	5,000	3,000	Factor	3,125	2,250	1,300	975	1,275	7,500	6,300	
Yields (2021)	kg	2,500	1,500	1,000	750	750	5,000	3,000	2.8467	3,214	2,314	1,337	1,003	1,311	7,714	6,479	
Yields (2026)	kg	2,500	1,500	1,000	750	750	5,000	3,000	3.3031	3,228	2,324	1,343	1,007	1,317	7,748	6,508	
Yields (2031)	kg	2,500	1,500	1,000	750	750	5,000	3,000	3.9300	3,248	2,338	1,351	1,013	1,325	7,795	6,548	
Farm Inputs																	
Losses b/	%	30%	30%	20%	20%	20%	20%	20%		30%	30%	20%	30%	30%	20%	20%	
Losses	kg	750	450	200	150	150	1,000	600		Losses for WP reflected in net production figures below							
Retained seed	kg	40	40	50	30	30	vegetative			MAF-supplied seed and planting materials							
Net Crop Production - 2016 WOP	kg	**1,710**	**1,010**	**750**	**570**	**570**	**4,000**	**2,400**									
Net Crop Production - 2016 WP	kg									**2,188**	**1,575**	**1,040**	**683**	**893**	**6,000**	**5,040**	
Net Crop Production - 2021 WP	kg									**2,250**	**1,620**	**1,070**	**702**	**918**	**6,171**	**5,183**	
Net Crop Production - 2026 WP	kg									**2,260**	**1,627**	**1,074**	**705**	**922**	**6,198**	**5,206**	
Net Crop Production - 2031 WP	kg									**2,273**	**1,637**	**1,081**	**709**	**928**	**6,236**	**5,238**	
Agro-chemicals																	
Weedicide	litre																
Pesticide	kg	2	2	2	2	2				2	2	2	2	2			
Rodenticide	kg	2	2	2	2	2				2	2	2	2	2			
Labour										**2016**							
Clearing grass/burning	pers day	5	5	5	5	5	5	5		5	5	5	5	5	5	5	
Fencing	pers day	5	5	5	5	5	5	5		5	5	5	5	5	5	5	
Preparing nursery	pers day	5						5		5						5	
Ploughing (tractor)	pers day	1	1	1	1	1	1	1		1	1	1	1	1	1	1	
Harrow (tractor)	pers day	1	1	1	1	1	1	1		1	1	1	1	1	1	1	
Pulling weeds & bunding	pers day	5								5							
Planting	pers day	10	5	5	5	5	5	5		10	5	5	5	5	5	5	
Maintaining borders	pers day	5								5							
Irrigating crops	pers day	10								10							
Maintaining irrigation system	pers day	10								10							
Weeding c/	pers day	20	30	20	20	20	20	20		18	27	18	18	18	18	18	
Spraying chemicals	pers day	5	5	5	5	5	5	5		5	5	5	5	5	5	5	
Staking	pers day					5								5			
Harvesting	pers day	25	20	20	20	20	20	20		31	30	26	26	34	30	42	
Carrying to thresher/cleaning	pers day	3	3	3	3	3	3	3		4	5	4	4	5	5	6	
Drying	pers day	3	3	3	3	3	3	3		4	5	4	4	5	5	6	
Bundling/bagging	pers day	3	3	3	3	3	3	3		4	5	4	4	5	5	6	
Marketing	pers day	3	3	3	3	3	3	3		4	5	4	4	5	5	6	
Transporting	pers day	3	3	3	3	3	3	3		4	5	4	4	5	5	6	
Other crop management	pers day	3	3	3	3	3	3	3		4	5	4	4	5	5	6	
Livestock labour	pers day								60								84
Total Labour	**pers day**	**125**	**90**	**80**	**80**	**85**	**80**	**85**	**60**	**135**	**109**	**90**	**90**	**109**	**100**	**123**	**84**
Equipment																	
Tractor	ha	1	1	1	1	1	1	1		1	1	1	1	1	1	1	
Hand weeders	each	2	1	1	1	1	1	1		2	1	1	1	1	1	1	
Grain bags	each	83	50	33	25	25				104	75	43	33	43			
String	rolls/ha	2								3							
Power thrasher	kg	2,500	1,500	1,000	750	750				3,125	2,250	1,300	975	1,275			
Transport	truck	0.8	0.5	0.3	0.3	0.3	1.7	1.0		1.0	0.8	0.4	0.3	0.4	2.5	2.1	

a/ Mix of mung and soybean

b/ Mixed varieties of new beans.

c/ Labour inputs for Items highlighted in light blue vary with crop yields, other inputs are fixed.

4.6.3 Farm Labour Supply and Demand

Two models were prepared to enable the demand for and supply of farm and hired labour for crop production to be calculated. These are: (i) labour timing and demand for food crops (see Table 13); and (ii) LHZ-based labour models (see Table 14 for an example for one LHZ - North Coast Irrigated). These models have been used to calculate the financial (and economic) costs of family-supplied and hired farm labour.

TABLE 13: FARM LABOUR TIMING AND DEMAND FOR ALL FOOD CROPS

LABOUR TIMING AND LABOUR DEMAND FOR ALL CROPS												
Labor Timing (products and seasons)	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Traditional and Improved Paddy				plant	weed	weed	grow	harvest				
				30%	20%	20%		30%				
Traditional and Improved Maize	weed	grow	harvest								plant	weed
	10%	10%	30%								30%	20%
Traditional and Improved Peanuts	weed	grow	harvest								plant	weed
	20%		30%								30%	20%
Traditional and Improved Legumes				plant	weed	grow	harvest					
				30%	30%		40%					
Traditional and Improved Beans				plant	weed	grow	harvest					
				30%	30%		40%					
Traditional and Improved Cassava			plant	weed	weed	grow	grow	grow	grow	grow	harvest	
			30%	20%	10%						40%	
Traditional and Improved Sweet Potato				plant	plant	plant	grow	harvest				
				30%	20%	10%		40%				

Labour Demand (days/month)		**1.0 ha**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Without Programme 2016														
Paddy	Traditional	125				38	25	25		38				
Maize	Traditional	90	9	9	27								27	18
Peanuts	Traditional	80	16		24								24	16
Legumes	Traditional	80				24	24		32					
Beans	Traditional	85				26	26		34					
Cassava	Traditional	80			24	16	8						32	
Sweet Potato	Traditional	85				26	17	9		34				
Non-rum. L/stock	Traditional	60	5	5	5	5	5	5	5	5	5	5	5	5
Total Labour Demand		**1.0 ha**	30	14	80	135	105	39	71	77	5	5	88	39
With Programme 2035														
Paddy	Improved	131				39	26	26		39				
Maize	Improved	103	10	10	31								31	21
Peanuts	Improved	86	17		26								26	17
Legumes	Improved	86				26	26		34					
Beans	Improved	100				30	30		40					
Cassava	Improved	99			30	20	10						40	
Sweet Potato	Improved	139				42	28	14		56				
Non-rum. L/stock	Improved	84	7	7	7	7	7	7	7	7	7	7	7	7
Total Labour Demand			34	17	94	164	127	47	81	102	7	7	104	45

4.6.4 Product and Input Prices (Financial and Economic)

66. Table 15 lists the financial and economic commodity and production input prices used for the Financial and Economic Analyses of SoL's impact. Sections 4.4 and 4.5 discuss how financial prices have been converted to economic prices, and how farm and hired labour inputs have been costed.

TABLE 14: LIVELIHOOD ZONE LABOUR MODELS

Livelihood Zone Labour Models	2.45												
1. North coast irrigated		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1.1 Traditional (ha) - Without Programme (2016)													
0.80 Paddy	100				30	20	20		30				
0.66 Maize	59	6	6	18								18	12
0.25 Peanuts	20	4		6								6	4
0.20 Legumes	16				5	5		6					
Beans													
0.29 Cassava	23			7	5	2						9	
0.25 Sweet Potato	21				6	4	2		8				
Non-rum. L/stock	60	5	5	5	5	5	5	5	5	5	5	5	5
2.45 Total Labour Days	299	15	11	36	51	36	27	11	43	5	5	38	21
1.2 Improved (ha) - With Programme (2035)													
0.80 Paddy	105				32	21	21		32				
0.66 Maize	68	7	7	20								20	14
0.25 Peanuts	22	4		7								7	4
0.20 Legumes	17				5	5		7					
Beans													
0.29 Cassava	28			8	6	3						11	
0.25 Sweet Potato	35				11	7	4		14				
Non-rum. L/stock	84	7	7	7	7	7	7	7	7	7	7	7	7
2.45 Total Labour Days	359	18	14	42	61	43	32	14	53	7	7	45	25
1.3 Incremental Labour Days	**60**	**3**	**3**	**6**	**10**	**7**	**5**	**3**	**10**	**2**	**2**	**7**	**4**
1.4 Hired Labour Days					**11**				**3**				

4.6.5 Financial (and Economic) Crop Budgets

67. The next step in the analysis was the preparation of financial (and economic - the latter for use in Section 4.7) crop budgets (see Table 16 for an example for paddy). These budgets were based on the farming systems and labour models discussed above, and the prices and costs in Table 15. Table 16 shows that, for paddy production (a 1.0 ha WOP model) farmers earn US$456 (value of product consumed and sold). This figure increases to US$652/ha over time as improved varieties are adopted. Financial returns are low, ranging from US$3.65 per family labour day to US$4.86, over time.

TABLE 15: PRODUCT AND INPUT PRICES (FINANCIAL AND ECONOMIC)

Agricultural Outputs		Unit	Financial Price ($)	Economic Price ($)
	Rice - paddy	kg	$0.45	$0.33
	Maize - grain	kg	$0.50	$0.48
	Peanuts (nis)	kg	$1.00	$0.95
	Legumes - grain	kg	$1.00	$0.95
	Beans	kg	$1.00	$0.95
	Cassava	kg	$0.10	$0.10
	Sweet Potato	kg	$0.15	$0.14
Agricultural Inputs				
	Seed			
	- Rice	kg	$0.45	$2.00
	- Maize	kg	$0.50	$2.00
	- Peanuts (nis)	kg	$1.00	$2.00
	- Legumes	kg	$1.50	$3.00
	- Beans	kg	$1.50	$3.00
	- Cassava	100 cuts.	$2.00	$1.90
	- Sweet Potato	100 canes	$2.00	$1.90
	Fertilizer			
	- Urea	kg	$1.00	$0.97
	- TSP/SP-36, or NPK mix	kg	$1.13	$1.10
	- KCL	kg	$1.20	$1.16
	Chemicals			
	Weedicide	litre	$25.00	$23.75
	Pesticide (sevin/dharma bas)	litre	$15.00	$14.25
	Rodenticide	kg	$5.00	$4.75
	Labour	pers-day	$5.00	$2.50
	Hired Equipment			
	- Tractor, plough and harrow	ha	$110	$105
	- Storage drums	drum	$10.00	$120.00
	- Hand weeder	each	$10.00	$9.50
	- Grain bags	each	$0.50	$0.48
	- Power thresher	kg	$0.02	$0.02
	- Transport	load	$50.00	$47.50

4.6.6 Whole-Farm Financial Gross Margins

68. Once the food crop budgets had been prepared, the next step was to calculate crop gross margins - as shown in Table 17 for one LHZ (North Coast Irrigated) and for "Without" Programme and "With" Programme for two example years - 2016 and 2021[20]. The results presented in Table 17 are based on scaled crop areas and ARs to reflect trends in the latter over time as more farmers adopt existing and yet-to-be released improved food crop varieties. The "factors" used to make these adjustments to the whole-farm financial models are shown as purple highlighted cells in Table 17, and indicate that the "factors" are low (for example, from 0.14 for paddy to 0.32 for maize and 0.09 for sweet potato) because the current and predicted ARs are low and conservative, respectively. Note that the results presented in Table 17 are for "average" families in one LHZ. This approach to results presentation has been used so that

[20] These full-sized tables are too large to insert into the SER

these household models can be scaled up to enable SoL's EIRR to be calculated - see Table 27.

TABLE 16: EXAMPLE FINANCIAL AND ECONOMIC CROP BUDGETS

Item (1.0 ha model)	Unit	Unit price ($)		Paddy - WO Prog.			Paddy - W Prog. (2016)			Paddy - W Prog. (2021)		
		Finan.	Econ.	Qty	Amount ($)		Qty	Amount ($)		Qty	Amount ($)	
					Finan.	Econ.		Finan.	Econ.		Finan.	Econ.
Net Production	kg			1,710			2,188			2,250		
Home Consumed a/	kg	$0.45	$0.33	1,056	$475	$346	1,056	$475	$346	1,056	$475	$346
Sold	kg	$0.45	$0.33	654	$294	$215	1,132	$509	$371	1,194	$537	$392
Gross Value of Prod'n	kg			1,710	**$770**	**$561**	2,188	**$984**	**$717**	2,250	**$1,012**	**$738**
Farm Inputs												
Seeds	kg		$2.00				40		$80	40		$80
Chemicals												
Weedicide	ltr	$25.00	$23.75									
Pesticide	ltr	$15.00	$14.25	2	$30	$29	2	$30	$29	2	$30	$29
Rodenticide	kg	$5.00	$4.75	2	$10	$10	2	$10	$10	2	$10	$10
Equipment/labour												
Tractor	ha	$110	$105.00	1	$110	$105	1	$110	$105	1	$110	$105
Hand weeders	ha	$10.00	$9.50	2	$20	$19	2	$20	$19	2	$20	$19
Grain bags	each	$0.50	$0.48	83	$42	$40	104	$52	$49	107	$54	$51
String	ha	$6.00	$5.70	2	$12	$11	3	$18	$17	3	$18	$17
Power thresher	kg	$0.02	$0.02	2,500	$50	$50	3,125	$63	$63	3,214	$64	$64
Transport	truck	$50.00	$47.50	0.8	$40	$38	1.0	$50	$48	1.1	$55	$52
Total Farm Inputs b/					**$314**	**$301**		**$353**	**$419**		**$361**	**$426**
Gross Margin per ha					**$456**	**$260**		**$632**	**$299**		**$652**	**$311**
Net Gross Margin/ha					**$456**			**$632**			**$652**	
No Family Labour Days					125			135			134	
Financial Return per Labour Day					**$3.65**			**$4.68**			**$4.86**	

a/ 100kg/pp, 6 pp/hh, 55% yield.

b/ Excludes hired labour costs - these costs are factored into the whole-farm gross margin budgets.

4.6.7 Total and Incremental Farm Gross Margins

69. These figures are detailed in Table 18 and show that adoption of SoL's improved food crop varieties currently has, and will have in the future, reasonable potential to increase farm incomes. For example it is estimated for the North Coast Irrigated LHZ, that current farm incomes are about $410 per year - including the value of produce consumed by farming families. Over time this figure could be increased to about $470 per year (by 2021) through the use of improved crop varieties. This incremental figure is less than expected because the current and predicted ARs are lower than anticipated. Note too that if all households used these varieties, average household incomes would be much higher - see Table 19 and Table 20.

TABLE 17: WHOLE-FARM FINANCIAL GROSS MARGINS - "AVERAGE" HOUSEHOLD

1. North Coast Irrigated													Factor			Factor
				Fin GM	Farm GM	Hired LDs	Net Farm				Area	ARs	2016	Area	ARs	2021
WOP	ha/hh	% hhs	Adj ha	($/ha)	($)	($)	GM ($)						(WP)			(WP)
Paddy	0.80	61%	0.49	$456	$223		$223				82%	15%	0.12	82%	17%	0.14
Maize	0.66	63%	0.42	$265	$111		$111				76%	40%	0.30	76%	45%	0.34
Peanut	0.25	10%	0.03	$538	$16		$16				86%	13%	0.11	86%	14%	0.12
Legumes	0.20	10%	0.02	$368	$7		$7				86%	5%	0.04	86%	6%	0.05
Beans				$368							86%	1%	0.01	86%	1%	0.01
Cassava	0.29	50%	0.14	$195	$27		$27				67%	7%	0.05	67%	8%	0.05
S/Potato	0.25	50%	0.13	$190	$25		$25				78%	10%	0.08	78%	11%	0.09
	2.45		1.23		$409	WOP GM	$409									
				2016 ($) (WP)							2021 ($) (WP)					
				Fin GM	Farm GM	Inc Farm	Adj Inc	Hired LDs	Adj Hired	Net Inc	Fin GM	Farm GM	Hired LDs		Inc Farm	Adj Inc
WP	ha/hh	% hhs	Adj ha	($/ha)	($)	Inc ($)	GM ($)	($)	LDs ($)	GM ($)	($/ha)	($)	($)		Inc ($)	GM ($)
Paddy	0.80	61%	0.49	$632	$310	$87	$10	$20	$2	$8	$652	$319	$3		$96	$11
Maize	0.66	63%	0.42	$646	$271	$160	$48	$46	$14	$34	$673	$283	$16		$172	$42
Peanut	0.25	10%	0.03	$758	$23	$7	$1			$1	$840	$25			$9	$1
Legumes	0.20	10%	0.02	$472	$9	$2					$490	$10			$3	
Beans				$666							$690					
Cassava	0.29	50%	0.14	$355	$50	$23	$1			$1	$367	$51			$24	$1
S/Potato	0.25	50%	0.13	$531	$69	$44	$4			$4	$548	$71			$46	$4
	2.45		1.23		$732	$323	$64	$66	$16	$48		$759	$19		$350	$59
								WP GM--->		$457				WP GM--->		$468

TABLE 18: TOTAL AND INCREMENTAL FARM GROSS MARGINS - "AVERAGE" HOUSEHOLD

Total Farm Gross Margins ($) a/ b/		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Scaled over 20 years	WOP	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
		With Programme									
1. North Coast Irrigated	$409	$457	$459	$461	$463	$465	$468	$469	$470	$471	$472
2. Mid Altitude Irrigated	$433	$487	$489	$491	$493	$495	$499	$500	$501	$502	$503
3. South Coast Irrigated	$489	$517	$518	$519	$520	$521	$524	$525	$526	$527	$528
4. Mid Elevation Uplands	$191	$223	$224	$225	$226	$227	$230	$231	$232	$233	$234
5. High Elevation Uplands	$110	$137	$138	$139	$140	$141	$144	$145	$146	$147	$148
6. Northern Rainfed Areas	$210	$241	$243	$245	$247	$249	$249	$250	$251	$252	$253
7. Southern Rainfed Areas	$224	$268	$270	$272	$274	$276	$277	$278	$279	$280	$281

a/ From annual food crops only.

Incremental Farm Gross Margins ($) a/ b/	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Scaled over 20 years	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
1. North Coast Irrigated	$48	$50	$52	$54	$56	$59	$60	$61	$62	$63
2. Mid Altitude Irrigated	$54	$56	$58	$60	$62	$66	$67	$68	$69	$70
3. South Coast Irrigated	$28	$29	$30	$31	$32	$35	$36	$37	$38	$39
4. Mid Elevation Uplands	$32	$33	$34	$35	$36	$39	$40	$41	$42	$43
5. High Elevation Uplands	$27	$28	$29	$30	$31	$34	$35	$36	$37	$38
6. Northern Rainfed Areas	$31	$33	$35	$37	$39	$39	$40	$41	$42	$43
7. Southern Rainfed Areas	$44	$46	$48	$50	$52	$53	$54	$55	$56	$57

a/ From annual food crops only.

b/ An average for all rural hhs in the LHZ at current low and slowly increasing adoption rates.

4.6.8 Whole-Farm Financial Models - 100 Percent Adopting Households

70. If households adopted all seven improved varieties of food crop, their annual farm incomes would increase substantially, as shown in Table 19 and Table 20. For example, by 2025, 100% adopting households would generate incremental farm incomes ranging from US$107 to US$252 depending on the LHZ. This result may seem rather low, but it must be remembered that it only reflects benefits which are directly generated by improved crop varieties, and not improved technologies such as the use of weedicides and inorganic fertilizer, and improved on-farm post-harvest storage.

4.6.9 Incremental Staple Food Production

71. SoL's core objective is to increase staple food production through the identification, bulking-up, release and promotion of improved food crop varieties which appeal to small subsistent farmers in Timor-Leste. Therefore estimation of how SoL might impact in terms of this objective is a core part of this post-Programme analysis. Table 21 and Table 22 show these figures and confirm that SoL has and will have a major impact on staple food production in Timor-Leste. For example, in the Mid-Altitude Irrigated LHZ, incremental staple food production per household is estimated to increase from 140 kg in 2016 to 225 by 2035 - without any other changes to current production and storage practices. And at the national level, incremental staple food production is estimated to increase from 14,980 Mt to 19,220 Mt over a period of 10 years.

TABLE 19: WHOLE-FARM FINANCIAL GROSS MARGINS - 100% ADOPTING HOUSEHOLDS

1. North Coast Irrigated												Factor			Factor
				Fin GM	Farm GM	Less Hire	Net Farm			Area	ARs	2016	Area	ARs	2021
WOP	ha/hh	% hhs	Adj ha	($/ha)	($)	LDs ($)	GM ($)			Fixed		(WP)	Fixed		(WP)
Paddy	0.80	61%	0.49	$456	$223		$223			82%	100%	0.82	82%	100%	0.82
Maize	0.66	63%	0.42	$265	$111		$111			76%	100%	0.76	76%	100%	0.76
Peanut	0.25	10%	0.03	$538	$16		$16			86%	100%	0.86	86%	100%	0.86
Legumes	0.20	10%	0.02	$368	$7		$7			86%	100%	0.86	86%	100%	0.86
Beans				$368						86%	100%	0.86	86%	100%	0.86
Cassava	0.29	50%	0.14	$195	$27		$27			67%	100%	0.67	67%	100%	0.67
S/Potato	0.25	50%	0.13	$190	$25		$25			78%	100%	0.78	78%	100%	0.78
	2.45		1.23		$409		$409								
				2016 ($) (WP)						2021 ($) (WP)					
				Fin GM	Farm GM	Less Hire	Net Farm	Inc Farm	Adj Inc	Fin GM	Farm GM	Less Hire	Net Farm	Inc Farm	Adj Inc
WP	ha/hh	% hhs	Adj ha	($/ha)	($)	LDs ($)	GM ($)	Inc ($)	GM ($)	($/ha)	($)	LDs ($)	GM ($)	Inc ($)	GM ($)
Paddy	0.80	61%	0.49	$632	$310	$16	$294	$71	$58	$652	$319	$17	$302	$79	$65
Maize	0.66	63%	0.42	$646	$271	$35	$236	$125	$95	$673	$283	$37	$246	$135	$103
Peanut	0.25	10%	0.03	$758	$23		$23	$7	$6	$840	$25		$25	$9	$8
Legumes	0.20	10%	0.02	$472	$9		$9	$2	$2	$490	$10		$10	$3	$3
Beans				$666						$690					
Cassava	0.29	50%	0.14	$355	$50		$50	$23	$15	$367	$51		$51	$24	$16
S/Potato	0.25	50%	0.13	$531	$69		$69	$44	$34	$548	$71		$71	$46	$36
	2.45		1.23		$732	$51	$681	$272	$210		$759	$54	$705	$296	$230
							WP GM--->		$619				WP GM--->		$639

TABLE 20: TOTAL AND INCREMENTAL FARM GROSS MARGINS - 100% ADOPTING HOUSEHOLDS

Total Farm Gross Margins ($) a/		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Scaled over 20 years	WOP	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
		With Programme									
1. North Coast Irrigated	$409	$619	$623	$627	$631	$635	$639	$639	$639	$640	$640
2. Mid Altitude Irrigated	$433	$659	$663	$667	$671	$675	$681	$682	$683	$684	$685
3. South Coast Irrigated	$489	$677	$681	$685	$689	$693	$699	$699	$699	$700	$700
4. Mid Elevation Uplands	$191	$330	$332	$334	$336	$338	$339	$340	$341	$341	$342
5. High Elevation Uplands	$110	$210	$211	$212	$213	$214	$216	$216	$216	$217	$217
6. Northern Rainfed Areas	$210	$332	$335	$338	$341	$344	$347	$347	$347	$347	$347
7. Southern Rainfed Areas	$224	$379	$381	$383	$385	$387	$390	$390	$390	$391	$391

a/ From annual food crops only.

Incremental Farm Gross Margins ($) a/	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Scaled over 20 years	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
	With Programme									
1. North Coast Irrigated	$210	$214	$218	$222	$226	$230	$230	$230	$231	$231
2. Mid Altitude Irrigated	$226	$230	$234	$238	$242	$248	$249	$250	$251	$252
3. South Coast Irrigated	$188	$192	$196	$200	$204	$210	$210	$210	$211	$211
4. Mid Elevation Uplands	$139	$141	$143	$145	$147	$148	$149	$150	$150	$151
5. High Elevation Uplands	$100	$101	$102	$103	$104	$106	$106	$106	$107	$107
6. Northern Rainfed Areas	$122	$125	$128	$131	$134	$137	$137	$137	$137	$137
7. Southern Rainfed Areas	$155	$157	$159	$161	$163	$166	$166	$166	$167	$167

a/ From annual food crops only.

TABLE 21: INCREMENTAL STAPLE FOOD PRODUCTION PER HOUSEHOLD - "AVERAGE" HOUSEHOLDS

2. Mid Altitude Irrigated				29,719							
Incremental Food Production (Mt)					Total		2016 Adj				2035 Adj
WOP	hh	ha/hh	Mt/ha a/	Total ha	Prod'n Mt		Factor				Factor
Rice (grain)	18,426	0.80	0.94	14,741	13,857		0.12				0.18
Maize	20,506	0.66	1.01	13,534	13,669		0.30				0.44
Peanut (nut)	2,051	0.25	0.53	513	269		0.11				0.16
Legumes	2,051	0.20	0.57	410	234		0.04				0.06
Beans			0.57				0.01				0.01
Cassava	19,020	0.29	4.00	5,421	21,684		0.05				0.07
S/ Potato	15,751	0.25	2.40	3,938	9,451		0.08				0.11
Totals		2.45		38,557	59,164						
					Total	Inc Prod'n	Adj Inc	Prod'n	Total	Mt	Adj Inc
WP	hh	ha/hh	Mt/ha a/	Total ha	Prod'n Mt	Mt	Prod'n Mt	Mt/ha	Prod'n Mt		Prod'n Mt
					2016			2035			
Rice (grain)	18,426	0.80	1.20	14,741	17,735	3,878	477	1.25	18,432	4,575	824
Maize	20,506	0.66	1.58	13,534	21,316	7,647	2,294	1.64	22,154	8,485	3,733
Peanut (nut)	2,051	0.25	0.73	513	373	104	11	1.08	554	285	46
Legumes	2,051	0.20	0.68	410	280	46	2	0.71	291	57	3
Beans			0.93					0.93			
Cassava	19,020	0.29	6.00	5,421	32,526	10,842	542	6.24	33,804	12,120	848
S/ Potato	15,751	0.25	5.04	3,938	19,848	10,397	832	5.24	20,628	11,177	1,229
		2.45		38,557	92,078	32,914	4,158		95,863	36,699	6,684
Adj Incr Food Production - scaled 20 years					Inc Food/HH (kg)--->		140				225

a/ Rice grain, not paddy.

TABLE 22: INCREMENTAL STAPLE FOOD PRODUCTION - ALL LHZS AND "AVERAGE" HOUSEHOLDS

Incremental Food Production (Mt) a/ b/		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Scaled over 20 years		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
1. North Coast Irrigated		1,073	1,107	1,141	1,175	1,209	1,243	1,277	1,311	1,345	1,379
2. Mid Altitude Irrigated		4,158	4,291	4,424	4,557	4,690	4,823	4,956	5,089	5,222	5,355
3. South Coast Irrigated		1,364	1,407	1,450	1,493	1,536	1,579	1,622	1,665	1,708	1,751
4. Mid Elevation Uplands		2,604	2,683	2,762	2,841	2,920	2,999	3,078	3,157	3,236	3,315
5. High Elevation Uplands		1,030	1,062	1,094	1,126	1,158	1,190	1,222	1,254	1,286	1,318
6. Northern Rainfed Areas		2,284	2,357	2,430	2,503	2,576	2,649	2,722	2,795	2,868	2,941
7. Southern Rainfed Areas		2,469	2,546	2,623	2,700	2,777	2,854	2,931	3,008	3,085	3,162
Total Mt		14,982	15,453	15,924	16,395	16,866	17,337	17,808	18,279	18,750	19,221
Incremental Food per Household - for all Households in the LHZs a/											
1. North Coast Irrigated	8,401	128	132	136	140	144	148	152	156	160	164
2. Mid Altitude Irrigated	29,719	140	144	148	152	156	160	164	168	172	176
3. South Coast Irrigated	9,016	151	156	161	166	171	176	181	186	191	196
4. Mid Elevation Uplands	29,996	87	90	93	96	99	102	105	108	111	114
5. High Elevation Uplands	17,178	60	62	64	66	68	70	72	74	76	78
6. Northern Rainfed Areas	24,685	93	96	99	102	105	108	111	114	117	120
7. Southern Rainfed Areas	27,404	90	93	96	99	102	105	108	111	114	117

a/ After allowing for storage losses and retained seed. b/ Based on rice grain and nuts, not paddy and peanuts nis.

4.6.10 Stored Food Losses

72. On-farm stored food losses in Timor-Leste are very high - up to 30% for maize and paddy due to weevil and rat damage and spoilage, respectively[21]. Given that it is illogical to grow more staple food through the use of improved varieties, and to then lose 30% of the total (not the incremental) production to preventable pest destruction, this analysis warrants an assessment of just how much staple food is currently being wasted in Timor-Leste because of a failure to rollout

[21] See: Project Completion Report, Timor-Leste Maize Storage Project, MAF and IFAD, June 2016, for more details on traditionally stored maize losses.

proven technology (use of 200 litre air-tight drums) across the whole country. These figures are shown in Table 23 and reveal: (i) annual losses are about 6,420 Mt; (ii) and are valued at about US$4.82 million. Timor-Leste cannot afford this "cost" particularly when it could be avoided.

TABLE 23: ESTIMATED STAPLE FOOD LOSSES (MT AND $'000)

Food Losses - (Mt) a/	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Scaled over 20 years	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
1. North Coast Irrigated	460	474	489	504	518	533	547	562	576	591
2. Mid Altitude Irrigated	1,782	1,839	1,896	1,953	2,010	2,067	2,124	2,181	2,238	2,295
3. South Coast Irrigated	585	603	621	640	658	677	695	714	732	750
4. Mid Elevation Uplands	1,116	1,150	1,184	1,218	1,251	1,285	1,319	1,353	1,387	1,421
5. High Elevation Uplands	441	455	469	483	496	510	524	537	551	565
6. Northern Rainfed Areas	979	1,010	1,041	1,073	1,104	1,135	1,167	1,198	1,229	1,260
7. Southern Rainfed Areas	1,058	1,091	1,124	1,157	1,190	1,223	1,256	1,289	1,322	1,355
Total Mt	6,421	6,622	6,824	7,028	7,227	7,430	7,632	7,834	8,035	8,237
Value of food losses ($750/Mt) ($'000)	$4,816	$4,967	$5,118	$5,271	$5,420	$5,573	$5,724	$5,876	$6,026	$6,178

4.6.11 Summary - Financial Rates of Return

73. The foregoing nine sub-sections have detailed the analyses to estimate SoL's impact at the farm level - in terms of: (i) farm labour demand and supply; (ii) farming systems and farm gross margins; and (iii) incremental supplies of staple food.

74. In terms of calculating FIRRs, in a theoretical sense these are very high because Timor-Leste's farmers used very few if any purchased inputs, and seeds of improved food crop varieties are provided free-of-charge by MAF. Therefore it is not possible to calculate FIRRs. However, a more practical way to express the impact of improved varieties at the farm level is to focus on changes to annual farm gross margins, and returns to incremental family labour inputs. The former results are summarized in Table 18.

75. Farmers are more likely to adopt new agriculture production techniques if these interventions result in increased farm incomes and attractive financial returns to incremental family labour inputs. In Timor-Leste the best "comparator" is the daily cash wage rate which can be earned on construction sites such as national road rehabilitation. This is currently about $5.00 per day for unskilled labour. However, and as shown in Table 24, farmers who adopt improved food (and emerging cash crop) varieties have the potential to earn substantially more than this daily wage rate. For example, in 2016 adopting farmers could, on average across all LHZs, be earning about $7.50 per incremental labour day, or 50% more than the current unskilled wage rate in Timor-Leste. The quite large variations in the returns to incremental family labour inputs are due to different combinations of food crops, and different cropped areas, in the seven LHZ models, not to varying family labour resources.

TABLE 24: INCREMENTAL RETURNS TO INCREMTENAL FARMING HOUSEHOLD LABOUR INPUTS

$/Incremental Family LD a/	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
1. North Coast Irrigated	$7.12	$7.42	$7.72	$8.02	$8.32	$8.64	$8.80	$8.96	$9.12	$9.29
2. Mid Altitude Irrigated	$8.01	$8.33	$8.65	$8.97	$9.30	$9.62	$9.77	$9.92	$10.06	$10.21
3. South Coast Irrigated	$4.21	$4.42	$4.63	$4.83	$5.04	$5.22	$5.36	$5.50	$5.64	$5.79
4. Mid Elevation Uplands	$8.94	$9.28	$9.62	$9.96	$10.30	$10.66	$10.83	$11.00	$11.17	$11.35
5. High Elevation Uplands	$9.20	$9.60	$10.00	$10.41	$10.81	$11.23	$11.36	$11.49	$11.61	$11.74
6. Northern Rainfed Areas	$4.43	$4.64	$4.85	$5.05	$5.26	$5.46	$5.55	$5.64	$5.73	$5.82
7. Southern Rainfed Areas	$8.00	$8.34	$8.68	$9.03	$9.37	$9.70	$9.91	$10.12	$10.33	$10.53

a/ From annual food crops only.

4.7 Economic Internal Rates of Return

4.7.1 Description of Economic Models

76. The economic models prepared for the evaluation of SoL were based on the financial models outlined above, and by applying the methodology described in Sections 4.2 to 4.5. In summary, the financial farm models were converted to economic models and then scaled up based on the numbers of farming households in each LHZ. Table 25 is an example of the resulting economic gross margin model for the North Coast Irrigated LHZ, up to the year 2026. The scaling system used to calculate financial rates of return was also used for the economic analysis. This allowed inclusion of different areas of different crops, and different associated ARs (see the column headed "factor" in Table 25).

TABLE 25: EXAMPLE OF AN ECONOMIC GROSS MARGIN MODEL

1. North Coast Irrigated						($'000)				Factor			Factor				Factor
WOP	hh	ha/hh	Econ GM ($/ha)	LDs/hh inc L/stock	Labour Days	Econ GM /hh/yr	GM/LHZ	Area ha	ARs	2016 (WP)	Area ha	ARs	2021 (WP)		Area ha	ARs	2026 (WP)
Paddy	5,125	0.80	$260	100	512,500	$208	$1,066	82%	15%	0.12	82%	17%	0.14	Paddy	82%	18%	0.15
Maize	5,293	0.66	$250	120	635,160	$165	$873	76%	40%	0.30	76%	45%	0.34	Maize	76%	49%	0.37
Peanut	529	0.25	$210	20	10,580	$52	$28	86%	13%	0.11	86%	14%	0.12	Peanut	86%	16%	0.14
Legumes	529	0.20	$258	16	8,464	$52	$28	86%	5%	0.04	86%	6%	0.05	Legumes	86%	6%	0.05
Beans			$258					86%	1%	0.01	85%	1%	0.01	Beans	85%	1%	0.01
Cassava	4,201	0.29	$129	23	96,623	$37	$155	67%	7%	0.05	67%	8%	0.05	Cassava	67%	9%	0.06
S/Potato	4,201	0.25	$136	20	84,020	$34	$143	78%	10%	0.08	78%	11%	0.09	S/Potato	78%	12%	0.10
	19,878	**2.45**		**299**	**1,347,347**	**$548**	**$2,293**										

			2016 ($'000) (WP)					2021 ($'000) (WP)					2026 ($'000) (WP)				
WP	hh	ha/hh	Econ GM ($/ha)	Econ GM $/hh/yr	GM/LHZ ($'000)	Inc Econ GM/LHZ	Adj GM/LHZ	Econ GM ($/ha)	Econ GM $/hh/yr	GM/LHZ ($'000)	Inc Econ GM/LHZ	Adj GM/LHZ	Econ GM ($/ha)	Econ GM $/hh/yr	GM/LHZ ($'000)	Inc Econ GM/LHZ	Adj GM/LHZ
Paddy	5,125	0.80	$299	$239	$1,225	$159	$19	$311	$249	$1,276	$210	$35	$308	$246	$1,261	$195	$29
Maize	5,293	0.66	$531	$351	$1,858	$985	$296	$557	$367	$1,943	$1,070	$364	$561	$370	$1,958	$1,085	$401
Peanut	529	0.25	$417	$104	$55	$27	$3	$497	$124	$66	$38	$5	$501	$125	$66	$38	$5
Legumes	529	0.20	$356	$71	$38	$10	$0	$374	$75	$40	$12	$1	$377	$75	$40	$12	$1
Beans			$540					$563					$567				
Cassava	4,201	0.29	$291	$83	$349	$194	$10	$303	$86	$361	$206	$10	$306	$87	$365	$210	$13
S/Potato	4,201	0.25	$453	$113	$475	$332	$27	$469	$117	$492	$349	$31	$472	$118	$496	$353	$35
	19,878	**2.45**		**$961**	**$4,000**	**$1,707**	**$354**		**$1,018**	**$4,178**	**$1,885**	**$446**		**$1,021**	**$4,186**	**$1,893**	**$485**
Inc hh and hired LDs - scaled by Inc. Econ. GM					**$2.50**		**52,851**					**61,920**					**70,988**
Opp Cost of Inc hh & Hired Labour - scaled by Inc. Econ. GM ($'000)							$132					$155					$177
Incremental Economic Gross Margin - scaled over 20 years							**$222**					**$291**					**$307**

4.7.2 Economic Benefits

77. Table 26 shows how SoL's "historical" economic benefits were calculated for inclusion in the calculation of SoL's EIRR. The estimated incremental benefit in 2016 ($2.775 million, see Table 27) was scaled back to 2007 and then inflated at 3.0% per annum to a present day value of about US$16.7 million.

TABLE 26: SOL'S ECONOMIC BENEFITS FROM PHASES I AND II

	Historical Benefits ($'000)									
Year	2007	2008	2009	2010	2011	2012	3013	2014	2015	**2016 a/**
% 2016 benefit b/	20%	30%	40%	50%	60%	70%	80%	90%	95%	100%
Net benefit in 2016										$2,775
Inflation factor c/	1.3048	1.2668	1.2299	1.1941	1.1593	1.1255	1.0927	1.0609	1.0300	1.0000
Adjusted benefit	$724	$1,055	$1,365	$1,657	$1,930	$2,186	$2,426	$2,650	$2,715	
a/ Estimated net economic benefit in 2016 is US$2.775 million							**Present Value--> d/**			**$16,708**

b/ Percent of 2016 benefit achieved in each year.

c/ Factor to allow for inflation

d/ This figures is equivalent to the accumulated present value of net benefits during SoL I and II.

78. Table 27 shows how the incremental economic gross margins models (economic benefits) were scaled up for each LHZ, using the information on household numbers in Table 6. In addition, because SoL has been running for 16 years, it was necessary to calculate and include in the

analysis the economic benefits which were generated in Phases I and II (mainly Phase II as some improved food crop varieties were available when Phase II commenced). This is shown in Table 26.

TABLE 27: SCALED-UP ECONOMIC GROSS MARGINS, AND CALCULATION OF SOL'S EIRR (EXCLUDES YEARS 11 - 20)

Incremental Economic Gross Margins ($'000)		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
(Scaled over 20 years)		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
1. North Coast Irrigated		$222	$236	$250	$264	$278	$291	$294	$297	$300	$303
2. Mid Altitude Irrigated		$859	$908	$957	$1,005	$1,054	$1,101	$1,119	$1,137	$1,155	$1,173
3. South Coast Irrigated		$264	$279	$294	$309	$324	$337	$343	$349	$354	$360
4. Mid Elevation Uplands		$202	$218	$234	$251	$267	$284	$287	$290	$292	$295
5. High Elevation Uplands		$116	$125	$134	$143	$152	$163	$164	$165	$167	$168
6. Northern Rainfed Areas		$523	$552	$581	$609	$638	$665	$676	$687	$699	$710
7. Southern Rainfed Areas		$589	$618	$647	$677	$706	$737	$751	$765	$778	$792
Total Incremental Gross Margin		**$2,775**	**$2,936**	**$3,097**	**$3,258**	**$3,419**	**$3,578**	**$3,634**	**$3,690**	**$3,745**	**$3,801**
plus PV of 2011 - 2015 Net Econ Benefits		**$16,709**									
less PV Aus. SoL Investment - Phase I and II		**$11,356**									
less PV Aus. SoL Investment - Phase III		**$24,210**									
less PV TL's/MAF's Historical Investment		**$3,034**									
less Ongoing Expenditure	**EIRR**	**$400**	$800	$800	$800	$800	$800	$800	$800	$800	$800
= Net Programme Benefits	**13%**	**-$19,516**	**$2,136**	**$2,297**	**$2,458**	**$2,619**	**$2,778**	**$2,834**	**$2,890**	**$2,945**	**$3,001**

4.7.3 Economic Costs

79. There are two components to SoL's total package of economic costs (see the lower part of Table 27): (i) costs incurred by Australia and Timor-Leste during Phases I, II and III; and (ii) estimated ongoing costs to be incurred by Timor-Leste in order to continue the funding of three key and essential activities - variety testing, seed multiplication and seed distribution. If these fundamental activities are not continued by MAF and funded by either the Government of Timor-Leste of another DP under a new bilateral agreement, many of the projects and programmes in the agriculture aid pipe, such as SAPIP and TOMAK will struggle as most of the anticipated incremental benefits from these projects and programmes will depend on the regular supply of good quality seed and planting materials to target farmers.

80. Table 5 details the total expenditure on SoL over its three Phases. These figures have been used in the calculation of SoL's EIRR - see the lower part of Table 27.

4.7.4 Economic Internal Rate of Return

81. <u>If 100% of all of SoL's historical and predicted costs are included, SoL's EIRR is a credible 13%.</u> Another way to express this figure to allow comparisons with other forms of investment is - 13% is the discount rate at which the present value of SoL's economic costs and benefits are equal. Given that SoL not only focused on variety testing and release, etc. but also on building MAFs institutional and Ministerial staff capacity[22], an EIRR of 13% is very acceptable.

4.7.5 Sensitivity Analyses

82. As outlined in Section 3.5, the analysis of SoL's impact has been based on a number of important key assumptions. These have been set up as key variables in the economic tables with the objective of testing the sensitivity of SoL's EIRR to various combinations of these variables. When estimating the EIRRs for one changed variable, all other variables are held constant. For example, when the percentage of Programme costs attributable to benefit generation is reduced from 100% to 15%, the EIRR increases from 13% to 19% - provided that all other variables are held at their predicted values - see right hand side of Table 28.

[22] See footnote 8 for more detail.

83. Table 28 summarizes these sensitivity analyses, and the following points list the main conclusions:

(i) <u>SoL's base case EIRR is 13%, if all other variables are set at conservative values</u>;
(ii) If "attributable" costs are set at 90% of total costs, the EIRR increases to a very strong 19% - and given the wide-spread allocation of SoL's costs over the past 16 years, this is not an unreasonable assumption;
(iii) However, if there has been a further decline in the number of farming households in the target LHZs by (say) 15%, as could be confirmed or denied by the recent 2015 Census, then SoL's EIRR will decline to 11%;
(iv) If the areas cropped to paddy and maize are reduced by 10% - perhaps in response to lack of domestic markets. SoL's EIRR declines to a low 6%;
(v) Similarly, if farm-gate staple food crop prices fall by 20%, SoL's EIRR is 10%, and if these prices increase by 20%, the EIRR increases to 16%;
(vi) If MAF's contributions are treated as non-incremental (or fixed) costs with very low associated opportunity costs, then SoL's EIRR increases to 16%;
(vii) Faster improved food crop variety ARs (say 4% per annum) would increase the EIRR to 16% but if ARs fall to 1.0% per annum, the EIRR declines to 12%; and
(viii) Increased rates of growth in food crop yields (from say 2.5% to 5.0% over five years) would increase the EIRR to 17%, and if this rate declined to only 1% over five years, the EIRR would fall to 10%.

TABLE 28: SENSITIVITY TEST RESULTS FOR KEY VARIABLES

Sensitivity Analyses					Constant Values for Sensitivity Analysis of Variables on LHS of table						
1. Percent Programme costs attributable to benefit generation (base 100%)		EIRR-->	13%	19%		2 Value	3 Value	4 Value	5 Value	6 Value	7 Value
			100%	85%		100%	100%	100%	100%	2%	2.5%
2. Further decline in no. farming hhs, from 2010 (base none = 100%)		EIRR-->	13%	11%	1 Value		3 Value	4 Value	5 Value	6 Value	7 Value
			100%	85%	100%	100%	100%	100%	100%	2%	2.5%
3. Areas of maize and paddy reduced (base = 100% - no change)		EIRR-->	13%	6%	1 Value	2 Value		4 Value	5 Value	6 Value	7 Value
			100%	85%	100%	100%		100%	100%	2%	2.5%
4. Farm-gate prices decline/increase (base = 100% = no change)	EIRR-->	16%	13%	10%	1 Value	2 Value	3 Value		5 Value	6 Value	7 Value
		120%	100%	80%	100%	100%	100%		100%	2%	2.5%
5. Ignore MAF's Fixed Costs (base = 100% = no change)		EIRR-->	13%	16%	1 Value	2 Value	3 Value	4 Value		6 Value	7 Value
			100%		100%	100%	100%	100%	100%	2%	2.5%
6. Faster/slower changes in Adoption Rates (base = 2.0 % in five years	EIRR-->	16%	13%	12%	1 Value	2 Value	3 Value	4 Value	5 Value		7 Value
		4.0%	2.0%	1.0%	100%	100%	100%	100%	100%		2.5%
7. Faster/slower inc. in food crop yields (base = 2.5% in five years)	EIRR-->	17%	13%	10%	1 Value	2 Value	3 Value	4 Value	5 Value	6 Value	
		5.0%	2.5%	1.0%	100%	100%	100%	100%	100%	2%	

84. The above-listed combinations of SoL's key variables could be further expanded to encompass various more specific combinations to test a wide range of "what-if" scenarios which might include consideration of some or all of the topics listed in Section 5.3. For example, the costs saved by MAF not having to import seed every year (in 2014/15 180 Mt were imported valued at about $0.75 million) have not been factored into the EIRR calculations. However if this reduced economic cost is included in the EIRR calculations (over a period of 10 years) the base case EIRR increases from 13% to 17%.

4.7.6 "Best Guess" EIRR

85. Table 28 contains a wide range of variables which can be combined into a myriad of different scenarios, all of which generate different EIRRs. However in analyses such as these it is an accepted practice to identify a "best guess" combination of variables in order to calculate the "most likely" overall Programme EIRR. In the case of SoL: (i) if "attributable" costs are reduced by 15% to reflect that SoL invested considerable funding in areas and topics which did not and

will not result in the direct generation of incremental economic benefits; and (ii) MAF's historical costs are excluded from the analyses because they were not incremental - then SoL's EIRR is estimated to be 24%.

4.7.7 Comparison with EIRR Estimate at Time of Design

86. As part of preparing for this analysis of SoL III, the Consultant Agriculture Economist reviewed the original design documents, including the models used to estimate FIRRs and the EIRR. Note that there were some errors in these models but once corrected to reflect missing economic benefits from maize production, and the imposition of a ceiling of a maximum of 70% of target households adopting improved varieties, the revised design stage EIRR was also 24%. This outcome is entirely coincidental, as whilst the analytical methodologies used at the time of design and for the EOP evaluation were the same, the numerous models were re-worked and fine-tuned to reflect the current situation in Timor-Leste's agriculture sector, and the information and knowledge on the targeted food crops which accumulated during Phase III.

4.7.8 Complementarity with other Projects and Programmes

87. An important feature of SoL Phase III was the formal agreement between SoL and the IFAD-funded Timor-Leste Maize Storage Project (TLMSP) which focused on improved post-harvest storage at the farm level. TLMSP was based on the distribution of 200 litre air-tight maize storage drums which prevent 30% storage losses due to weevils. The memorandum between SoL and TLMSP reflected an agreement for the latter to also distribute small quantities of improved maize seed to drum recipients, with the objective of twinning the complementary benefits from increased production and reduced storage losses. This partnership worked well and resulted on more wide-spread use of Sele and Noi Mutin (the two main improved maize varieties) and reduced losses of the resultant increased maize production. TLMSP's Project Completion Reporting process modelled and analyzed the complementarity between these two development interventions and the results are summarized in Table 29.

88. The graph embedded in Table 29 shows that if SoL and TLMSP are implemented in partnership, the economic value of maize (grown on 1.0 ha) increases from about US$340 to US$1,000, or by about 200%. This is a very high figure and indicates just how strong the complementarity is between these two projects. Note that the foregoing is just one example of the importance of driving complementarity between various DPs' projects and programmes. During its 16-year life, SoL forged many productive partnerships with a wide range of NGOs and other bilateral DPs - see the commissioned report on "Seeds of Life Partnerships" for more details.

4.7.9 Non-Quantified Benefits

89. Calculation of EIRRs is usually based on economic benefits which are measurable and therefore quantifiable. However in Programmes such as SoL, particularly given an implementation period over 16 years, there are always various benefit streams which cannot be quantified and are therefore not included in the calculation of EIRRs. A good example in the case of SoL is its "additional" investment in supporting the development of the Raumoco watershed in Lautem District. Working with national and international NGOs, SOL has developed and implemented a sound and sustainable systems of community-based natural resource planning and development which is now ready for replication throughout Timor-Leste. This benefit has not been included in the EIRR analysis. Similarly, SoL has invested considerable resources to support MAF's devolution efforts as districts evolve into municipalities - in terms of capacity building support for MAF's municipal-level staff. This secondary benefit has also not been included in the Economic Analysis.

4.8 Conclusions

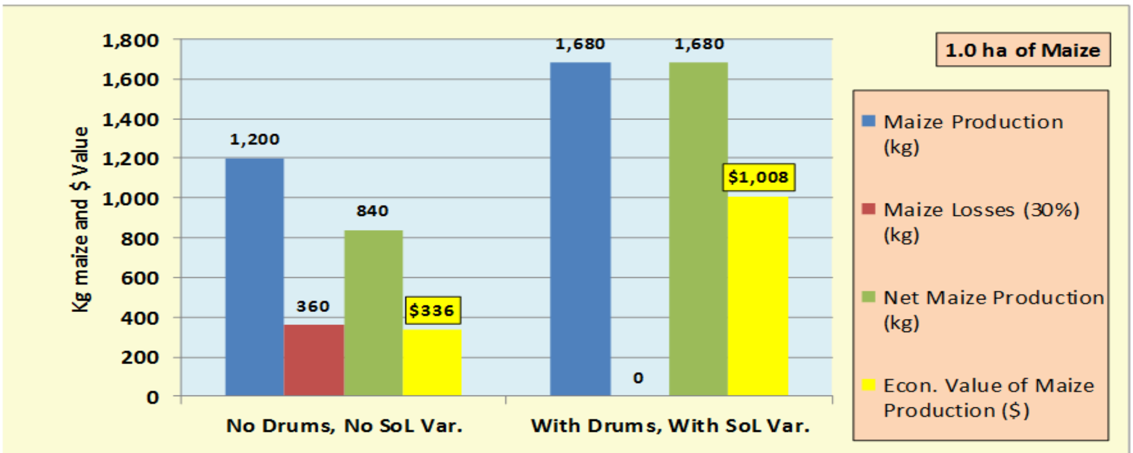
90. The foregoing Financial and Economic analyses of SoL's impact on: (i) Timor-Leste's rural households who grow staple annual food crops; and (ii) Timor-Leste's broader national economy has concluded that:

(i) At the farm-level, SoL has and should continue to contribute to increased production of all important staple food crops in Timor-Leste, plus those foods (such as legumes and beans) for which improved seed is only just becoming available - provided that AR's remain at the current rates (at a minimum) and are (preferentially) increased, the latter though strengthened MAF agriculture extension services and/or ongoing support from one of more of MAF's DPs.

TABLE 29: SUMMARY OF COMPLEMENTARITY BETWEEN SOL III AND TLMSP

1.0 ha maize				**Current**
Without Drums, Without SoL				**Situation**
Maize Production (kg)				1,200
Maize Losses (30%) (kg)				360
Net Maize Production (kg)				840
Value of Maize Production				**$336**
1.0 ha maize				**Improved**
With Drums, With SoL				**Situation**
Production (kg) + 40% with SoL varieties				1,680
Losses (kg)				0
Net Maize Production (kg)				1,680
Value of Maize Production				**$1,008**
Inc. Economic Value of Maize Production				**$672**
Percent inc. in Net Maize Production				**100%**
Economic Costs	**Unit**	**No.**	**$/Unit**	**Total ($)**
No of Drums to Store Crop				10
Investment Cost of Drums (Economic) a/	drum	10	$120.00	**$1,200**
Annual Cost of inc. hired labour	day	30	$5.00	$150
Annual Opp. Cost of inc. household labour	day	30	$2.50	$75
Annual Econ. Cost Impr. Maize Seed (lasts 2 yrs)	kg	20	$5.00	$100
Annual Drum Maintenance Cost ($0.50 per drum)	drum	10	$0.50	$5
Total Annual Cost (economic)				**$330**
Inc. Annual Economic Return				**$342**
EIRR over 20 years				**40%**

a/ $120 per drum: manufacture and delivery Dili, distribution, and overheads (training, etc.)
Note: drums last for 20 years.



This last point has been highlighted in this section of SER because current ARs are not as high as predicted in the Phase III design of SoL. The EOP survey indicated that MAF and all DPs should focus on increasing this AR figure as resulting benefits are substantial and wide-spread. On the other hand, if attention to ARs post SoL III is diverted to other areas or sub-sectors, SoL's ongoing impact will wane and the Programme's EIRR will decline - see Table 28 for sensitivity analyses. In this regard, SoL "follow-on projects" such as TOMAK and SAPIP have important budget and technical support roles to play over the next five to seven years.

(ii) Provided MAF continues to fund and support improved food crop variety identification, seed multiplication and seed/planting material distribution (see Section 5.2.2 for more details on the institutional risk) SoL will continue to result in increased household incomes, and generate acceptable (and competitive) returns to incremental investment in farm labour. Note that the above comments on the importance of focussing on increasing the ARs for all types of food crops also applies to this specific point - in summary there must be committed ongoing Timorese- and/or DP-funded support for SoL's key legacies. At this point in the sectoral development cycle, it seems that support for the continued operation of the NSS is embedded in MAF's annual planning and budgeting processes, but if for some reason essential ongoing support for the NSS is not provided, SoL's legacy will be short-lived.

(iii) At the national-level, SoL has and should continue to have a major impact on the national objective of staple food self-sufficiency, provided that Government policies are conducive to sectoral development and some inefficiencies are removed and/or overcome. For example, it is difficult to envisage any expansion in irrigated paddy production when there are very limited markets for resultant incremental production. These SoL "externalities" are difficult to model and analyse, but cannot be ignored when assessing the "bigger picture" and attempting to predict how future staple food production might be influenced by factors which are beyond the control of one (although major) bilateral Programme. Section 5.3 contains more comments in this important point.

(iv) <u>Finally, an EIRR of 13% for a 16-year support Programme in a developing country's agriculture sector is a commendable achievement</u>, particularly when this figure is based on the allocation of 100% of all costs against incremental benefits.

5 THE FUTURE

5.1 Core Lessons

91. SoL's three Phases have generated valuable and ongoing lessons which should be reflected in the design and implementation of all projects and programmes which support the development of Timor-Leste's agriculture sector.

92. The first and perhaps the most important lesson to emerge from 16 years of SoL support for Timor-Leste's agriculture sector is the importance of sustained and focussed support over a prolonged period of time. It is becoming increasingly apparent that five-year projects and programmes are too short, particularly when new projects often achieve very little in terms of development targets in the first two years. SoL and its supporters had the foresight to realize that it would take multiple and progressive Phases to achieve a sustainable impact and to embed systems into an institution such as MAF which changes constantly and is subject to external political influences.

93. An important aspect of this step-by-step approach to rural development was to build on previous results - which in the case of SoL were the progressive release of well-tried and tested improved food crop varieties. Some of the improved varieties were released early in Phase II and now form the foundation for sustained increases in staple food crop production - as evidenced by the outcomes from this analytical work. In summary, the approach of: (i) identifying and testing new food crop varieties (for yield and taste); followed by (ii) bulking up improved seed and planting materials; and then (iii) establishing farmer-managed seed production and distribution systems - proved to be a "winning formula" for SoL.

94. A particularly important feature of SoL's three Phases was the deliberate intention to embed the Programme within MAF's organic structure - especially within the (former) Research and Special Services, and Agriculture and Horticulture National Directorates. This approach has resulted in sustained and progressive development of institutional and human resource capacity within MAF. It is noteworthy that other DP-funded projects and programmes have elected to work "outside of MAF". Whilst this approach to implementation may prove faster in the short-term, it does not build institutional capacity (technical or managerial) and therefore increases the risk of longer-term failure once support is withdrawn. SoL is to be commended for selecting the slower, and some-times more difficult implementation strategy, but the decision to embed SoL in MAF (and to in fact name Phase III as MAF/SoL) has, according to results from this analysis, increased the chances of real and sustained changes in Timor-Leste's food crop sector.

5.2 Risks

5.2.1 Introduction

95. Despite the positive conclusion discussed in Section 5.1, there are a number of risks which could impact on SoL's legacy. These can be categorized as: (i) institutional; (ii) technical; and (iii) market.

5.2.2 Institutional Risks

96. The main institutional risk is that MAF is unable to continue to fund, manage and monitor SoL's core activities - those listed in para 93. MAF's annual budget is at best stable (about US$22.0 million) and even though there are promising signs that MAF fully accepts its ongoing institutional responsibility for SoL (mainly through the formal allocation of budget to fund its research centres in 2015 and 2016) there is always a risk that a new Government and therefore a new Minister might change priorities with resultant negative outcomes for NSS operations.

97. Fortunately, there is a good chance that this risk can be managed by using funds from other pipeline projects/ programmes (such as SAPIP and TOMAK) which will rely on ongoing National Seed System operations for support in the form of adequate supplies of seeds and planting materials. The current draft design of SAPIP includes budget allocations for NSS operations and strengthened adaptive research programmes. However, SAPIP's design is not final and could change at the time of appraisal, or as Annual Work Plans and Budgets are prepared. In addition it is noteworthy that SoL III's team has placed considerable emphasis on ensuring that the importance of ongoing support for the National Seed System is understood throughout MAF.

98. Never-the-less this institutional risk should not be under-estimated. It is without doubt the main issue which could not only under-mine SoL's past achievements, but also limit the effectiveness and impact of the National Seed System in the future.

5.2.3 Technical Risks

99. The technical risks which might impact on the National Seed System's future are not so much "negative risks" but possibly less than optimal outcomes from failures to support improved varieties with other elements of improved food cropping packages, i.e. failure to extract full value from the improved food crop varieties by adding value in the form of other elements of improved food cropping systems. For example, there is very little use of inorganic fertilizer in Timor-Leste, yet use of these inputs (and also weedicides to reduce farming labour requirements) are "standard" practices in countries which have increased food crop production. To some extent this risk has been recognized by the SoL follow-on ACIAR-funded adaptive research programmes (which focus on legumes and non-timber agro-forestry), and other projects such as FAO's Conservation Agriculture. However there are many opportunities to build on the released improved varieties as key elements of improved food cropping systems, and if these are not factored into the designs of pipeline projects, an opportunity will be missed. This is the risk.

100. Another more obvious risk is the failure to twin improved food crop varieties (and their potential to increase staple food production) with improved on-farm, post-harvest food storage. It is illogical to only focus on increasing food crop production, when at least 30% of total production (not just the increase) can be lost in a few months to rodents and weevils. As new legume and bean varieties are released by MAF in 2016 and 2017, support in the form of improved post-harvest storage will increase in importance. Section 4.6.10 contains more details on this important point.

5.2.4 Market Risks

101. This risk relates mainly to markets for increased paddy production. It seems some-what pointless for MAF to release improved varieties of rice when farmers are reacting to a lack of markets for paddy by reducing areas planted and moving away from improved production systems because of low gross margins and returns to household labour inputs. The issue of rice marketing in Timor-Leste is a national one and beyond the remit of a Programme such as SoL - but this negative factor does have an impact on the uptake of improved rice varieties.

102. On a more positive note, markets for maize varieties and the in April 2016 released varieties of legumes and beans are growing. Feeding surplus maize to non-ruminant livestock is likely to increase as the demand for locally-grown poultry and pork increases (see Section 3.5.5), and export markets in Indonesia are opening up for pulses and possibly legumes.

5.3 Continued Use of Models to Guide Decision Making

5.3.1 Introduction

103. As the SER was progressively compiled and the various models linked together to enable overall Programme assessment, it became increasingly obvious that the resultant model of Timor-Leste's staple food cropping sector might be of greater use than just a one-off evaluation of SoL. This realization resulted from the decision to set up the various models to test key assumptions and linkages, so that "what if" type questions could be asked and answered. Use of these SoL models for such purposes was raised with MAF's Secretary General and the Australian Team Leader of SoL III during the end of SER mission meeting. A brief discussion at that time revealed that MAF would benefit by using these models to guide product prioritization setting and sub-sector investment decisions, and by using the models to prove outcomes and impact to Government and the Council of Ministers.

104. It is beyond the Terms of Reference for the SER to delve into these ongoing opportunities in any detail, but listing the more obvious and important was a simple process as these options become apparent as the models were assembled and then linked together. The remainder of this section of the SER therefore lists these possibilities and provides initial comments on their relative importance.

5.3.2 Guiding On-going Investment Projects and MAF's Operations

105. Support for TOMAK in terms of identifying priority products and its target LHZs is the first non-SoL use of these models which is immediately apparent. TOMAK will commence in mid-2016 and therefore this important initial decision - in terms of "on what and where to focus" - could be assisted by using the SoL food crop models as the basis for decision making. Similarly, participants from the private sector could use the models to identify where to make investment decision for commercial crop production.

106. Even though MAF's current operational budgets are small, use of the SoL models to identify where investments have the greatest impacts in terms of food production and farmers' incomes (and on nutrition in LHZs where legumes have potential) would result in improved targeting and also improved M&E as the models would provide some indication of current and future situations. For example, MAF is currently investing considerable funds in irrigation rehabilitation with support from JICA, but a recent assessment of this investment strategy[23] concluded that resulting EIRRs were very low or negative. An alternative investment strategy such as focusing on improved on-farm post-harvest storage is likely to generate much higher rates of return (see Table 29). The SoL SER models could be used to fine-tune this comparison with the objective of improving sectoral investment priorities and decisions.

107. Rural poverty and hunger remain very high in Timor-Leste[24]. Targeting pockets of severe poverty and associated high levels of malnutrition is a high priority for Government and its supporting DPs. SoL's SER models could be useful as a support tool for this exercise as it should be possible to overlay poverty, food deficiency and malnutrition maps over LHZ maps (and associated food crop production models) to identify priority target areas, and various combinations of food crops which might have the biggest impact on reducing poverty, hunger and nutrition.

108. Using the models to determine where investment in secondary and farm access roads might generate the highest returns would also be appropriate. Road rehabilitation EIRRs are low in

[23] MoF and WB (World Bank) 2015. Timor-Leste public expenditure review: Infrastructure. A joint Ministry of Finance and World Bank review of the quality of infrastructure spending in Timor-Leste, focusing on roads, irrigation and electricity. Dili and Washington DC: Ministry of Finance, Timor-Leste and World Bank.

[24] See HPA agencies El Niño group (CARE, Oxfam, PLAN and World Vision) El Niño assessment report.

Timor-Leste[25] and therefore improved targeting through the use of the SoL SER models could prove useful[26]. For example, the forthcoming European Union (EU)-funded Agro-Forestry Project under Rural Development Programme (RDP) Phase V could use the SoL SER models and information on the road network to select initial target areas.

109. Adaptive research prioritization and investment planning could also benefit by using SoL's SER models as a decision-making tool. These models would allow decision-makers to test possible outcomes and impacts from improved production systems developed through targeted investment to overcome production constraints, such as improved weed management in annual rainfed crops. SAPIP is expected to support MAF's adaptive research programmes and therefore it would be logical for SAPIP to used SoL's SER models to guide initial priority setting.

110. In a similar way, it should be possible to use the SoL SER models to predict the impact of events such as continued rural-urban drift, and the effect (in terms of food production) of El Niño-influenced rainfall patterns.

111. SoL's SER models could also be used by MAF and its DPs as the basis for improved sectoral policy analysis. There are currently numerous policy topics, such as food (mainly rice) importation, organic vs inorganic, irrigation vs rainfed production systems, etc. which warrant further analysis and assessment, followed by clear policy announcements. The models would require some adjustment and fine-tuning, but could form the basis of the modelling required to clarify some of these important policy issues and constraints.

112. MAF has been attempting to establish a sector-wide M&E system for years. It now seems that SAPIP will assist with this important task, with support from the Food and Agriculture Organization (FAO). Again, SoL's SER models could be used as the basis of this system, at least in terms of identifying the key indicators and working out how to collect and report on the data and information which are required to prove progress in terms of sectoral development.

5.3.3 Focusing on ARs and Improved Food Production Systems

113. As mentioned above, there is an ongoing need for continued support to farmers with the objective of increasing ARs, some of which are currently lower than expected. Where to focus on this issue (in terms of which LHZ and which crop or combination of crops) could be guided by further use of SoL's evaluation models. The same approach could be used to identify the need for new food crop varieties - once it is understood which are not being adopted and why. Testing the impact of improved food crop production systems on changes in FIRRs, food production, and farm incomes - based on increased use of inputs (fertilizer, weedicides, labour-saving devices, etc.) is another potential use for the SoL SER models.

5.3.4 "What Ifs"

114. As mentioned above, SoL's SER models have been developed and combined in such a way that they can be used to answer a range of "what-if" questions, such as: (i) what is the impact on household incomes of increased use of farming inputs?; (ii) what is the impact of improved post-harvest food storage?; (iii) what is the impact of rapidly increasing ARs for new legume and bean species?; and (iv) what might happen if the NSS collapsed? This use of the models is logical and requires no further elaboration.

[25] World Bank and Asian Development Bank pers com with Timor-Leste staff.

[26] The Consultant Agriculture Economist has personal experience with Transport Economists in Timor-Leste who always seem to struggle to identify sufficient incremental benefits to warrant investment in road rehabilitation.

6 ANNEX 1: DETAILED TERMS OF REFERENCE FOR THE SER

6.1 Introduction

During the design of SoL III a pre-programme evaluation was completed in the form of estimating SoL's impact at the farm and national levels. This involved the estimation of: (i) farmers' returns to investment in new food crop varieties (farm rate of return, or Financial Internal Rate of Return [FIRR]); and (ii) the Programme-level impact on food production in Timor-Leste (Economic Rate of Return [EIRR]). Such estimates are an accepted part of Programme Appraisal before approval is given by Development Partners for implementation to proceed.

SoL III is now coming to an end and the Programme will be completed by end June 2016. Therefore, and as part of an EOP evaluation exercise, it is appropriate that the FIRR and EIRR estimates at the time of Appraisal are re-calculated using baseline (2011) and EOP data (2016) on seed use, variety acceptance, and its impact on increased farm incomes and national food production.

6.2 Proposed Methodology

Determination of SoL's FIRR and EIRR will comprise the following steps:

(i) Total Programme costs expended over the 5.5 year time-frame, broken down by component and activity. This level of cost detail is required as SoL III has invested considerable budget in institutional capacity building and various types of training. Not all these investments can be expected to generate tangible (measurable) benefits in the shorter-term and are therefore termed "non-attributable" costs. In other words these costs will be excluded when calculating SoL's FIRR and EIRR. SoL's accounting system will enable this information to be obtained quickly and efficiently, followed by agreement with SoL's team as to which costs are "attributable" and which are not.

(ii) Once the costs have been clarified, the next step is to estimate farm- and national-level net benefits which SoL has generated over the past five years, and which are considered to be sustainable over the next 20 years. The "net" situation will be calculated by considering the 'without programme" and the "with programme" farm-level and national situations and extracting the value of the former from the latter to determine incremental net benefits. This will involve the preparation of individual crop and whole farm budgets to determine returns to family and hired labour and farm gross margins. The latter models will then be scaled up and phased over time to reflect SoL's national-level impact

(iii) In addition, SoL has laid the foundation for the generation of what are termed "intangible benefits" such as the cadre of internationally trained agriculture scientists and the establishment of a national seed system. It is difficult to quantify such benefits but in Programmes such as SoL, they are often considerable and therefore need to be taken into account during programme evaluation.

(iv) Preparation of conclusions, recommendations and lessons for the future will be the final step in the analysis.