Agriculture: New Directions for a New Nation

East Timor (Timor-Leste)

Proceedings of a Workshop 1–3 October 2002, Dili, East Timor

Editors: Helder da Costa, Colin Piggin, Cesar J. da Cruz and James J. Fox

Workshop organisers: National University Timor Lorosae
Ministry of Agriculture, Forestry and Fisheries
Australian National University
Australian Centre for International Agricultural Research

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Foreword

An urgent task in this newly emerging country Timor-Leste is to develop a sustainable agricultural sector. Our mission is to efficiently deliver services to agriculture, forestry and fishing communities in Timor-Leste, services that support improved productivity, income earning potential and exports. This in turn will support improved social welfare in the rural areas of the nation, taking account of MAFF's human, capital and financial resources.

The goals of MAFF are to:

a) achieve food security and improve food self-sufficiency;
b) diversify agricultural production and increase export earnings by the sector;
c) develop agriculture predominantly on the basis of an integrated farming systems approach;
d) facilitate agro-industrial development leading to increased processing and value adding in-country;
e) improve the quality of agricultural commodities produced in the nation;
f) develop the fishing industry aimed at improving local markets and generating export income;
g) manage agriculture, fisheries and forestry resources in a way that supports sustainable production; and
h) increase rural incomes, generate employment in rural areas and, consequently, reduce poverty and improve the welfare of rural communities.

Given that three-quarters of East Timorese are engaged in agriculture, the country will need to improve farming systems, using appropriate technology inputs and farm management to increase crop yields. Inter-Departmental linkages will be developed to enable the establishment of and access to rural banking and micro-credit facilities, which will help the sector's output growth while improving its ability to market surpluses and build linkages with the private sector.

Policies and legal frameworks are being developed to create incentives for private and public sector investment in agriculture, forestry and fisheries and with the aim to provide a sound basis for sustained economic growth and poverty alleviation.

This book provides a comprehensive analysis of the present situation and potential magnitude of agricultural development in Timor-Leste. As well, the papers outline a comprehensive, methodological approach to studying sectoral breakdown of cropping, livestock, forestry and fisheries in a practical manner. The publication responds to several of the tasks given to the organizers and sponsors of the international conference on "Agriculture in Timor Leste: New Directions for a New Nation" to:

- raise awareness among national and international institutions on policy, priorities and decisions
- identify and encourage the network of stakeholders to work together to increase the agricultural sector's performance, so that it can effectively contribute its share to the country's well being.

We hope that this book will contribute in some practical ways to help the world's newest country to achieve its noble mission - sustained growth and prosperity.

Estanislau A. da Silva
Minister for Agriculture, Forestry and Fiesheries, RDTL
February 2003

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Lia Maklokek Husi Ministru Agricultura

Knar ida urjente tebtebes iha nasaun foun ne'e, Timor-Leste, maka atu dezenvolve setór agrikultura ida, ne'ebé sustentável. Ami nia misaun ne'e atu hato'o servisu ba komunidade sira ne'ebé moris ho agrikultura, peska ho silvikultura (kehutanan), ho efisiénsia iha Timor-Leste, servisu sira ne'ebé ajuda atu fó produtividade di'ak liu tan, ne'ebe bele fó osan husi eksportasaun. Ho ida ne'e, depois bele fó fali apoiu ba rahun-di'ak sosiál nian iha foho, tuir MAFF nia rekursu humanu, kapitál ho finanseira.

MAFF nia objetivu maka:

a) hetan seguransa ba hahán no mós hakaas liu tan auto-sufisiénsia ba hahán;
b) habarak produsaun agrikultura nian oioin no mós habarak tan osan manán hosi eksportasaun iha setór ne'e;
c) dezenvolve agrikultura, liliu tuir baze sistema agrikultura ida ne'ebé integradu;
d) fasilita dezenvolvimentu iha agro-indústria para hasa'e tan produsaun ho folin iha rai-laran;
e) hadia kualidade merkadoria agrikultura nian ne'ebé halo iha rai-laran;
f) kaer rekursu agrikultura, peska ho floresta nian ho dalan ne'ebé bele fó tulun bva produsaun sustentável; ho
g) hasa'e rendimentu iha foho, loke servisu-fatin iha área foho nian, atu nune'e bele hamenus pobreza, no mós hadi'a rahun-di'ak ba komunidade foho nian.

Haree katak ema Timór iha 75% maka moris ho agrikultura, rai ne'e sei presiza atu hametin liu tan agrikultura tradisionál, uza mós teknolojia ne'ebé loos atu habarak liu tan kolleita. Loke meius ba atividade bankária iha foho no mós fasilidade micro-credit nian sei ajuda liu tan setór ida ne'e nia produtividade, nune'e mós hadi'a setór ida ne'e nia kapasidade atu hetan exedente merkadu nian i loke ligasaun ho setór privadu. Polítika ne'ebé adekuadu bele fó baze ne'ebé metin ba dezenvolvimentu ekonómoku ne'ebé sustentável ho hakmaan pobreza tuir atividade primária sira ne'ebé iha orientasaun ba eksportasaun nian.

Prosesu sira ne'e fó análize komprensivu ida ba poténsia dezenvolvimentu agrikultura nian iha Timor-Leste. Nune'e, dokumentu sira ne'e fó-sai mós maneira sira ne'ebé komprensivu ho metódiku atu estuda divizaun setór ida-idak nian iha kolleita, animál doméstiku nian, floresta ho peska, ho maneira ne'ebé prátiku. Objetivu konferénsia nian ne'e iha rua:

- atu fó informasaun ba ema-boot sira ne'ebé halo programa ho hola desizaun iha rai-laran (nasionál) no mós rai-li'ur (internasionál)
- atu identifika ho fó-korajen ba ema sira ne'ebé iha ligasaun interese nian atu haburas liu tan setór agrikultura nian, atu nune'e nia bele fó kontribuisaun ne'ebé efetivu iha ninia knar atu fó rahun-di'ak ba nasaun.

Ami iha esperansa katak publikasaun ida ne'e bele fó kontribuisaun ida, ne'ebé prátika ba nasaun ida ne'ebé foin moris iha mundu ne'e, atu hetan ninia misaun nobre ne'e — dezenvolvimentu sustentável ho prosperidade.

Estanislau A. da Silva
Ministru ba Agrikultura, Floresta ho Peska, RDTL
Outubru 2003

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Prefácio

Uma tarefa urgente neste novo país, Timor-Leste, é a de desenvolver um sector agrícola sustentável. A nossa missão, como Ministério da Agricultura, Pescas e Florestas é a de, de uma forma eficiente, prestar serviços à agricultura, à exploração florestal e às comunidades piscatórias do nosso país de modo a apoiar aumentos das suas produtividade, rendimentos e exportações. Isto, por sua vez e tendo em consideração os recursos humanos, em capital e financeiros do Ministério, apoiará a melhoria do bem-estar nas áreas rurais da nação.

Os objectivos deste Ministério são:

a) assegurar a segurança alimentar e aumentar a auto-suficiência alimentar;
b) diversificar a produção agrícola e aumentar as receitas de exportação do sector;
c) desenvolver a agricultura predominantemente com base num *approach* integrado de sistemas agrícolas;
d) facilitar o desenvolvimento agro-industrial de modo a aumentar o nível de processamento nacional dos produtos e, consequentemente, o valor acrescentado para o país;
e) aumentar a qualidade das produções agrícolas produzidas;
f) desenvolver a indústria pesqueira de modo a melhorar os mercados locais e a gerar rendimentos de exportação;
g) gerir a os recursos agrícolas, pesqueiros e florestais de forma a apoiar uma produção sustentável; e
h) aumentar os rendimentos rurais, gerar emprego nas áreas rurais e, consequentemente, reduzir a pobreza, melhorando o bem-estar das comunidades rurais.

Dado que três quartos dos timorenses vivem da agricultura, o país precisa de melhorar os sistemas de cultivo, utilizando *inputs* tecnologicamente apropriados e processos de gestão das explorações agrícolas que permitam aumentar as colheitas.

Serão desenvolvidas ligações entre várias instituições de modo a permitir o *estabelecimento de* e o *acesso a* facilidades bancárias e de micro-crédito que facilitarão o crescimento da produção do sector ao mesmo tempo que melhoram a sua capacidade de comercializar os excedentes de produção e estabelecer ligações com o sector privado.

Estão a ser desenvolvidas o quadro legal e as políticas necessárias para criar incentivos ao investimento privado e público nos sectores agrícola, florestal e das pescas com o objectivo de constituir uma base sólida para um crescimento económico sustentável e a redução da pobreza.

Este livro fornece uma análise aprofundada das presente situação e potencial de desenvolvimento da agricultura em Timor-Leste. Do mesmo modo, os *papers* nele incluídos definem uma metodologia apropriada para estudar, de uma forma prática, a produção agrícola, pecuária, florestal e pesqueira do nosso país. A sua publicação responde a várias das tarefas atribuídas aos organizadores e patrocinadores da conferência internacional sobre “Agricultura em Timor-Leste: novas direcções para um novo país” e que incluíam

- aumentar a consciência, entre instituições nacionais e internacionais, sobre políticas, prioridades e decisões;
- identificar e encorajar uma rede de interessados na questão para trabalharem em conjunto de forma a aumentarem a *performance* do sector agrícola de modo a que ele possa contribuir eficazmente, com a sua quota parte, para a melhoria do bem-estar das populações do nosso país.

Esperamos que este livro contribua, de uma forma prática, para ajudar o mais novo país do mundo a alcançar o seu objectivo fundamental: o crescimento sustentável e a prosperidade de todos.

Estanislau A. da Silva
Ministro da Agricultura, Florestas e Pescas, RDTL
Outubro de 2003

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I

Introduction and Acknowledgments (Lia Maklokek ho Agradesimentu) (Introdução e agradecimentos)

Photographer: Eric McGaw

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THE birth of the world's newest nation, Timor-Leste (East Timor), came at a tremendous cost to its people. The early-September violence which followed the independence ballot of 30 August 1999 severely affected most of the country's rural areas, causing massive displacement and trauma to the people, destruction of buildings and equipment, and loss of livestock and crop seed.

The reconstruction that accompanies the journey towards sustainable independence in East Timor, while it will be arduous and painful, also provides a genuine opportunity to establish appropriate infrastructure, institutions, economic policies, technologies and systems at the outset. However, the reconstruction program needs to be accelerated and extended throughout the country if it is to meet the aspirations of its citizens. Institutional and policy foundations must be firmly and swiftly laid to prepare East Timor for sustainable recovery and growth, so the country can increasingly rely on its own resources to design and implement the policies and institutions required for long-term development. An essential ingredient to provide that firm foundation is the rebuilding of the agricultural sector.

The turbulence of 1999 affected agriculture, but less so than the urban economy. Planting activities were interfered with, especially in the wet season of 1999–2000 but long-term damage to crops, trees, livestock, and rural infrastructure was limited. Subsistence agriculture displays resilience to these kinds of events, just as it did to the economic crisis of 1997–98. Crop (apart from perhaps coffee), livestock, fisheries, and forest industries are not well developed and contribute comparatively little to GDP, though they play important roles in subsistence agriculture. Agriculture will be a key to East Timor's development and social progress, given that it occupies and sustains most of the population. Its share in the economy might appear quite low for such a poor country. During the late Indonesian period, it contributed about one-third of GDP, being overshadowed by the inflated government sector.

Reconstruction has initially benefited from a large infusion of donor and non-governmental organisation assistance during the emergency and post-emergency periods. The Ministry of Agriculture, Forestry and Fisheries (MAFF) RDTL has established a headquarter staff and field officers to manage the rebuilding of the agricultural sector. There has been considerable rehabilitation and replacement of rural infrastructure and agri-processing facilities, such as coffee-bean processing machinery, village rice mills, and maize huskers.

East Timor's agriculture faces many challenges ahead. These range from the immediate issues of population resettlement, infrastructure rehabilitation and land ownership, to verifying and promoting appropriate policies and technologies, to reactivating rural markets and the extension service, and reestablishing cross border commercial ties. Development of opportunities for off-farm, seasonal, income-generating activities are also important. How an independent East Timor manages these issues will have a large bearing on the livelihood of its predominantly rural populace.

The papers in this volume were presented at *Agriculture: New Directions for a New Nation*, held in the Hall of Liceu of the National University of Timor Lorosae in Dili, 1–3 October 2002. The conference, which was reportedly the first international agriculture conference ever held in East Timor, attracted more than 100 national and international participants from 15 different countries. Its purpose was to present and discuss information on cropping, livestock, fisheries, forestry, and agricultural education in East Timor. Locally collected and verified information on such issues in the literature is lacking. It is hoped this volume, with papers by authors from or with strong experience in Timor, will contribute to the base of locally-relevant information to assist future development efforts to develop agriculture in East Timor.

The conference was initiated a year earlier by Jim Fox and Helder da Costa who discussed the idea on a bus in Denpasar after a workshop on Kosovo and East Timor, sponsored by the Council on Asia and Europe Cooperation (CAEC). Jim and Colin Piggin, who worked together on agricultural development in West Timor in the 1980s, further discussed the idea and set about providing Australian support.

While aid and related spin-offs dominate much of the economy of East Timor and oil and gas could soon loom large, most Timorese derive their welfare from agriculture, and this will be the case for many years to come. How an independent East Timor manages and balances declining aid, oil and gas development, and subsistence agriculture will have a large bearing on the livelihood of its predominantly rural populace. Given that three-quarters of the population live and work in rural areas, an independent East Timor will need to strengthen traditional agriculture through interventions such as increasing crop yields and providing access to rural banking and micro-credit facilities to increase output and improve the ability to market surpluses. Appropriate policies to promote export-orientated primary industries will help to provide a sound basis for sustained economic growth and alleviation of poverty.

A group of leading speakers and practitioners with good knowledge and experience in Timor was assembled to set out policy issues and technical information under the four categories of cropping,

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livestock, forestry and fisheries within the agricultural portfolio, and to examine mainstream economic issues of East Timor. Support was canvassed from the Minister for Agriculture, Forestry and Fisheries, RDTL, Estanislau da Silva, and from potential donors and contributors in Canberra and Dili. AusAID and ACIAR expressed interest in the conference and became the major financial supporters.

We would like to thank the Minister for Agriculture for his support and opening address at the conference. We would also like to thank everyone who participated in the conference and made it such a success, particularly the speakers who contributed their time freely and delivered papers, thoughts and commentary. The financial assistance by our main donors, AusAID and ACIAR, is greatly appreciated.

Planning for the conference was a major logistical challenge. Several days prior to the opening, the campus of the National University, the venue for the event, was closed following a student protest over fee increases. The organisers had to consider shifting to another location, which would have diminished local involvement and impact. Fortunately, things settled down, the conference ran very smoothly, and it was an excellent opportunity for a young university to gain experience through hosting an international event in difficult circumstances.

The Centro Nacional de Investigacao Cientifica (CNIC), Universidade National Timor Lorosae assumed responsibility for organising the conference in conjunction with the Ministry of Agriculture, Forestry and Fisheries (MAFF), the Australian National University and ACIAR Canberra. We wish to express our debt to the many individuals who, in very difficult circumstances, together made the conference a great success. The core planning was carried out by James Fox, Colin Piggin, Cesar da Cruz and Helder da Costa — editors of this volume. We also would like to thank organisers and staff from CNIC (Apolinario Magno, Yohanes Usboko, Carrie Taylor, Pedro de Oliveira, Silvino Amaral), Faculty of Agriculture (Matias Tavares, Acacio Da Costa), UNTL (Jose dos Santos) and INL (Rosa Idalinda) for their impressive organisational skills and strong logistical support.

Our appreciation also goes to senior staff of MAFF, Cesar Jose da Cruz, Francisco Tilman de Sa Benevides, Mario Nunes, Fernando Amaral and Acacio Guterres for the support prior to and during the conference, especially ensuring the representation of all 13 district officers of MAFF. These include Sisto Moniz of Café Cooperativa Timor (CCT) and Fernando Amaral of MAFF who organised an excursion to visit the coffee growing areas and processing facilities of Ermera on the afternoon of the second day of the conference.

The contributions of João Cancio Freitas, Filomeno da Cruz, Apolinario Magno and Edmundo Viegas are recognised for their skills in Tetun, English, and Bahasa, and for providing translation and interpretation services during the conference presentations and discussions.

We thank the Minister for Agriculture Estanislau da Silva, the Australian Ambassador Paul Foley, and the State Secretary for Defence and Security Roque Rodrigues, who supported the conference and took time out from busy schedules to address the conference and participate actively in discussions.

We thank Robin Taylor and ACIAR Canberra for assistance in publishing the conference proceedings and Prof. Almeida Serra of ISEG-UTL Portugal for translating the introduction to Portuguese and Alex Tilman for the Tetun translation.

These proceedings provide a record of most of the presentations and discussions from the conference. We hope they are of interest and use to officials, academics and students of East Timor, and that they contribute to better understanding and development of agriculture in the world's newest nation, Timor-Leste. We also hope that the volume will be useful to the international community with an interest in the country.

Helder da Costa, Colin Piggin, Jim Fox,
Cesar J. da Cruz

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Lia Maklokek ho Agradesimentu

RAI Timor-Leste, rai foun liu iha mundu ne'e, moris ho susar barak ba nia povu. Violénsia ne'ebé mosu molok fulan-Setembru hahú, liu tiha referendum iha loron 30 fulan Agostu tinan 1999, fó-todan mós ba área foho nian, hodi muda ema barak tun-sa'e i fó trauma ba povu, halo destruisaun ba uma i ekipamentu sira, ho estraga animál doméstiku sira ho fini ba kuda rai nian.

Rekonstrusaun ne'ebé la'o hamutuk ho pasu ba independénsia sustentável iha Timor-Leste, molok nia sei la'o ho susar oioin, sei fó mós oportunidade di'ak atu harii infraestrutura, instituisaun, programa ekonomia nian, teknolojia ho sistema ne'ebé adekuadu hori hun kedas. Maibé, programa Rekonstrusaun nian ne'e tenke la'o lalais liu tan i loke ba rai laran tomak atu bele hatán ba aspirasaun povu nian. Fundasaun instituisaun ho programa nian tenke nahe metin i lalais atu prepara Timor-Leste ba rekuperasaun ho dezenvolvimentu ne'ebé sustentável, atu nune'e rai ne'e bele depende liu tan ba ninia rekursu rasik para dezenvolve ho implementa programa ho instuisaun sira ne'ebé importante ba dezenvolvimentu prazu-naruk. Fatór importante ida ne'ebé bele fó fundasaun metin maka harii fila fali setór agrikultura nian.

Konflitu iha tinan 1999 afeta hotu agrikultura, maibé ladún makaas iha ekonomia urbanu nian. Atividade kuda-rai nian hetan interferénsia makaas, liliu iha bain udan iha tinan 1999-2000. Maibé, estraga prazu-naruk nian ba kolleita, ai-laran, animál doméstiku sira ho infraestrutura foho nian ne'e limitadu hela. Agrikultura subsisténsia nian tahan bebeik akontesimentu sira hanesan ne'e, nudár nia tahan krize ekonómika iha tinan 1997-98 nian. Indústria kolleita (menus kafé karik), animál doméstiku, peska ho floresta nian ladún iha dezenvolvimentu makaas ida, i sira nia kontribuisaun ba GDP ne'e komparativamente ki'ik hela, embora sira iha papél importante iha agrikultura subsisténsia nian. Agrikultura sei sai hanesan xave ba Timor-Leste nia dezenvolvimentu ho progresu sosiál tanba nia okupa ho sustenta maioria populasaun rai ne'e nian. Ninia fahe iha ekonomia haree hanesan ki'ik hela ba rai kiak ida hanesan Timor-Leste ne'e. Durante tempu Indonézia nian besik ramata, nia fó kontribuisaun besik 1/3 ba GDP, maibé ladún fó-oin tanba inflasaun setór governu nian ne'ebé aas.

Foufoun ne'e, rekonstrusaun hetan benefísiu makaas ho tulun hosi donor ho ONG sira durante períodu emerjénsia ho pos-emerjénsia. Ministru RDTL nian ba Agrikultura, Floresta ho Peska (MAFF) estabelese tiha ona sedé, servisu-na'in sira ho ofisiál kampu nian atu kaer rekonstrusaun setór agrikultura nian. Infraestrutura foho nian ho fasilidade ba tratamentu agrikultura nian mós hetan ona reabilitasaun ho substituisaun, hanesan mákina tratamentu kafé nian ho mákina dulas hare ho batar iha suku laran.

Agrikultura Timor-Leste nian sei hasoru dezafiu oioin iha loron oin. Dezafiu sira ne'e mai hosi problema imediatu sira hanesan fatin ba populasaun atu tuur fila fali, reabilitasaun infraestrutura ho problema propriedade nian, to'o fali verifikasaun ho promosaun ba programa ho teknolojia sira ne'ebé adekuadu i hamoris fali merkadu sira iha foho ho servisu estensaun nian, to'o halo estabelesimentu fila fali ba ligasaun komersiál entre fronteira. Dezenvolvimentu ba oportunidade iha atividade rendimentu nian ne'ebé hala'o hosi kintál li'ur i regulár, mós importante. Timor-Leste nia maneira atu rezolve problema sira ne'e sei iha impaktu boot ba populasaun nia moris, ne'ebé barak-liu hela iha foho.

Intervensaun sira iha volume ida ne'e aprezenta tiha ona iha *'Agriculture: New Directions for a New Nation'*, ne'ebé hola fatin iha Salaun Liceu Universidade Nacional de Timor Lorosa'e iha Dili, hosi loron 1 to'o 3 fulan Outubru tinan 2002. Konferénsia ne'e, nudár ema dehan hanesan konferénsia internasionál agrikultura nian uluk liu ne'ebé hala'o ona iha Timor-Leste, dada partisipante sira hosi rai-laran ho rai-li'ur liu na'in 100 hosi nasaun 15. Ninia objetivu maka atu aprezenta ho diskute informasaun kona ba edukasaun iha kolleita, animál doméstiku, peska, floresta ho agrikultura nian iha Timor-Leste. Iha rai-laran, informasaun sira ne'ebé ema tau hamutuk ho verifika kona ba kazu sira ne'e ladún iha. Volume ne'e, ho surat hosi autór sira hosi, ou ho esperiénsia makaas iha Timor-Leste, mai ho esperansa ida atu fó kontribuisaun ba baze informasaun nian ne'ebé relevante iha rai-laran atu asiste iha esforsu dezenvolvimentu loron aban nian atu dezenvolve agrikultura iha Timor-Leste.

Konferénsia ne'e nudár inisiativa ida hosi Jim Fox ho Helder da Costa iha tinan kotuk. Sira na'in rua diskute tiha ona ideia ne'e iha bis laran iha Denpasar molok workshop ida kona ba Kosovo ho Timor-Leste ramata, ne'ebé nudár sponsor maka Council on Asia and Europe Cooperation (CAEC). Jim ho Colin Piggin, sira na'in rua uluk servisu hamutuk iha dezenvolvimentu agrikultura nian iha Timor Loromonu iha tinan sira 1980 nian, depois diskute liu tan ideia ne'e i komesa fó apoiu hosi Austrália.

Enkuantu aid ho spin-off sira seluk maka domina kuaze ekonomia tomak Timor-Leste nian, ho petróleu ho gas mós besi sai daudaun ona, ema Timor-Leste barak maka hetan sira nia moris ho agrikultura, i sei hetan nafatin nune'e ba tinan barak atu mai. Timor-Leste nia maneira atu kaer ho balansa

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aid ne'ebé menus daudaun, dezenvolvimentu petróleu ho gas nian, ho agrikultura subsisténsia, sei fó impaktu boot ba ninia populasaun, ne'ebé barak maka hela iha foho. Tanba kuaze 75% hosi populasaun Timor-Leste nian moris ho servisu iha foho, Timor-Leste independente ida tenke hametin liu tan agrikultura tradisionál ho intervensaun sira hanesan habarak liu tan kolleita i loke asesu ba banku iha foho ho fasilidade ba micro-credit, atu haburas liu tan rendimentu i hadi'a kapasidade ba exedénsia merkadu nian. Programa ne'ebé adekuadu atu promove indústria primária ne'ebé haree liu ba esportasaun sei ajuda fó baze ida di'ak ba dezenvolvimentu ekonomia ida sustentável ho hamenus pobreza.

Grupu ida ho oradór-ulun sira ho espesialista ho koñesimentu di'ak i esperiénsia iha Timor-Leste mai hamutuk hodi ko'alia kona ba kestaun programa nian ho informasaun téknika iha kategoria haat iha portfóliu agrikultura nian, kolleita, animál doméstiku, floresta ho peska, no mós atu haree kestaun ekonómika jerál nian iha Timor-Leste. Ministru RDTL nian ba Agrikultura, Floresta ho Peska, Sr. Estanislau da Silva, ho poténsia doadór sira ho kontribuidór sira iha Canberra ho Dili maka fó apoiu. AusAID ho ACIAR hatudu sira nia interese ho sai hanesan apoiante finanseira boot liu ba konferénsia ne'e.

Ami hakarak fó ami nia agradesimentu ba Ministru Agrikultura nian ba ninia apoiu ho ninia diskursu iha abertura konferénsia ne'e. Ami mós hakarak agradese ema hotu-hotu ne'ebé partisipa iha konferénsia ne'e, i halo nia sai susesu, liu-liu oradór sira ne'ebé fó sira nia tempu saugati de'it ho sira nia intervensaun, hanoin ho komentáriu. Ami nia agradesimentu-boot ba asisténsia finanseira hosi ami nia doadór prinsipál sira, AusAID ho ACIAR.

Planeamentu ba konferénsia ne'e dezafiu lojístika boot ida. Loron hirak molok abertura ne'e, kampus Universidade Nacional nian, fatin ba konferénsia ne'e, taka tiha tanba estudante sira halo protestu kona ba osan eskola nian, ne'ebé sa'e tan. Organizadór sira tenke komesa hanoin atu muda fali ba fatin seluk, ne'ebé bele diminui partisipasaun lokál ho ninia impaktu. Felizmente, buat sira ne'e sai kalma tiha, konferénsia ne'e la'o di'ak hotu, no mós oportunidade di'ak ida ba universidade foun ne'e atu hetan esperiénsia atu kaer akontesimentu internasionál ida iha sirkunstánsia difisil nia laran.

Centro Nacional de Investigação Científica (CNIC), Universidade Nacional de Timor Lorosa'e maka assume responsabilidade atu organiza konferénsia ne'e hamutuk ho Ministru Agrikultura, Floresta ho Peska nian (MAFF), Australian National University ho ACIAR iha Canberra. Ami hakarak fó ami nia obrigadu ba ema barak, ne'ebé ho susar oioin, mai hamutuk hodi hala'o konferénsia ne'e ho susesu boot. Planeamentu prinsipál James Fox, Colin Piggin, Cesar da Cruz ho Helder da Costa—editór volume ne'e, maka kaer. Ami mós hakarak agradese organizadór sira ho staff hosi CNIC (Apolinario Magno, Yohanes Usboko, Carrie Taylor, Pedro de Oliveira, Silvino Amaral), Faculdade de Agricultura (Matias Tavares, Acacio da Costa), UNTL (Jose dos Santos) ho INL (Rosa Idalinda) ba sira nia jeitu atu organiza sasán no mós apoiu lojístika ne'ebé forte.

Ami nia agradesimentu mós ba staff seniór hosi MAFF, Cesar Jose da Cruz, Francisco Tilman de Sa Benevides, Mario Nunes, Fernando Amaral ho Acacio Guterres ba sira nia apoiu antes, no mós durante konferénsia ne'e, liu-liu atu asegura reprezentante ofisiál MAFF hosi distritu 13 ne'e to'o hotu. Sira ne'e maka Sisto Moniz Piedade hosi Cooperativa Café Timor (CCT) ho Fernando Amaral hosi MAFF. Fernando Amaral maka organiza viajen ida ba iha área kafé-laran nian ho fasilidade tratamentu iha Ermera iha loraik ida iha loron segundu konferénsia ne'e nian.

Kontribuisaun hosi João Freitas, Filomeno da Cruz, Apolinario Magno ho Edmundo Viegas mós hetan agradesimentu ba sira nia jeitu iha tetun, inglés ho bahasa, no mós ba fornesimentu iha servisu intérprete ho tradusaun durante aprezentasaun ho diskusaun iha konferénsia ne'e.

Ami agradese Ministru Agrikultura nian, Sr. Estanislau da Silva, embaixadór Austrália nian, Sr. Paul Foley, ho Sekretáriu Estadu nian ba Defeza ho Seguransa, Sr. Roque Rodrigues, ne'ebé fó apoiu ba konferénsia ne'e ho hasai sira nia tempu hosi sira nia oráriu ne'ebé okupadu tebetebes atu ko'alia iha konferénsia ne'e, i partisipa makaas iha diskusaun sira.

Ami fó obrigadu ba Robin Taylor hosi ACIAR Canberra ba ninia asisténsia iha publikasaun ba prosedimentu konferénsia ne'e nian ho mos Prof. Almeida Serra husi ISEG-UTL Portugal ba ninia asistensia iha tradusaun Portuges nian.

Prosedimentu sira ne'e rai hela iha maioria, arkivu ba aprezentasaun ho diskusaun sira iha konferénsia ne'e. Ami iha esperansa katak sira bele fó naroman ba ofisiál sira, akadémiku ho estudante sira Timor-Leste nian, no mós katak sira bele fó kontribuisaun atu bele komprende ho dezenvolve di'ak liu tan agrikultura iha rai foun liu iha mundu ne'e, Timor-Leste. Ami mós hein katak volume ne'e sei sai importante ba komunidade internasionál, ne'ebé iha interese ba rai ne'e.

Helder da Costa, Colin Piggin, Jim Fox,
Cesar J. da Cruz

Agriculture: New Directions for a New Nation — East Timor (Timor-Leste)
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Introdução e agradecimentos

O NASCIMENTO do mais jovem país do mundo, Timor-Leste, deu-se com um tremendo custo para o seu povo. A violência do início de Setembro que se seguiu ao votom pela Independência em 30 de Agosto de 1999 afectou significativamente a maior parte das áreas rurais, causando deslocação em massa e trauma à população, destruição de edifícios e equipamentos e perda de animais e de colheitas.

A reconstrução que acompanha a jornada em direcção a uma independência sustentável de Timor Leste, ainda que árdua e penosa, também possibilita a oportunidade genuína de estabelecer, desde o início, infra-estruturas, instituições, políticas económicas, tecnologias e sistemas apropriados. No entanto, o programa de reconstrução necessita de ser acelerado e estendido a todo o país se pretender ir ao encontro das aspirações dos seus cidadãos. Os fundamentos institucionais e de políticas devem ser estabelecidos em bases sólidas para preparar Timor Leste para uma recuperação e um crescimento sustentáveis, de modo a que o país possa contar, cada vez mais, com os seus próprios recursos para definir e implementar as políticas e as instituições necessárias ao desenvolvimento no longo prazo. Um ingrediente essencial para possibilitar essas bases sólidas é a reconstrução do sector agrícola.

A turbulência de 1999 afectou a agricultura mas menos que a economia urbana. As actividades de plantação foram afectadas, especialmente na estação das chuvas de 1999-2000 mas os prejuízos de longo prazo nas culturas, árvores, gado e infra-estrutura rural foram relativamente reduzidos. A agricultura de subsistência tem em si mesma uma capacidade de resistência a este género de acontecimentos, tal como teve na crise económica de 1997-98. As culturas (salvo, talvez, a do café), o gado, as pescas e as indústrias florestais não estão muito desenvolvidas e contribuem relativamente pouco para o PIB apesar de representarem papéis importantes na agricultura de subsistência. A agricultura terá um papel chave no desenvolvimento e progresso social de Timor Leste já que ela ocupa e sustenta a maior parte da população. A sua parte na produção pode, no entanto, ser pequena num país tão pobre. Durante o período de administração indonésia ela contribuiu com cerca de um terço do PIB, sendo a sua importância ofuscada pelo inflacionado sector da administração pública.

A reconstrução beneficiou inicialmente de uma larga infusão de assistência de doadores e de organizações não governamentais durante os períodos de emergência e de pós-emergência. O Ministério da Agricultura, Florestas e Pescas (MAFP) da RDTL organizou um conjunto de pessoal administrativo e de funcionários de campo para gerir a reconstrução do sector agrícola. Houve um esforço considerável de reabilitação e de substituição de infra-estruturas agrícolas e de instalações de processamento de produtos agrícolas, tais como maquinaria de processamento de café, descascadoras de arroz para as aldeias e debulhadoras de milho.

A agricultura de Timor Leste enfrenta muitos desafios pela frente. Eles vão desde as questões imediatas da reinstalação das pessoas nos seus locais habituais de habitação, à reabilitação de infra-estruturas e à propriedade da terra até à definição e implementação de políticas e de tecnologias apropriadas, â reactivação dos mercados rurais e dos serviços de extensão rural e a restabelecimento dos laços comerciais transfronteiriços. O desenvolvimento de oportunidades de actividades sazonais geradoras de rendimento fora da agricultura é também importante. A forma como o Timor Leste independente gerir estas questões vai fazer uma grande diferença na vida da sua população, predominantemente rural.

As comunicações neste volume foram apresentadas numa conferência sobre “Agricultura: novas direcções para um novo país” realizada no “Salão do Liceu” da Universidade Nacional Timor Lorosa’e, em Dili, em 1-3 de Outubro de 2002. A conferência, que foi a primeira sobre agricultura alguma vez realizada em Timor Leste, atraiu mais de 100 participantes nacionais e internacionais de mais de 15 países diferentes. O seu objectivo foi o de apresentar e discutir informação sobre culturas, pecuária, pesca, florestas e educação sobre agricultura em Timor Leste. De salientar que falta em Timor-Leste informação recolhida e confirmada sobre estes temas. Espera-se que este volume, com contribuições de autores de ou com grande experiência de Timor Leste, contribua para o conjunto de informações relevantes sobre o país necessárias para ajudar aos esforços de desenvolvimento da agricultura de Timor Leste.

A conferência começou a ser preparada um ano antes por Jim Fox e Helder da Costa, que discutiram a ideia num autocarro em Denpasar depois de um *workshop* sobre o Kosovo e Timor Leste promovido pelo *Council on Asia and Europe Cooperation* (CAEC). Jim e Colin Piggin, que trabalharam em conjunto sobre o desenvolvimento agrícola em Timor Ocidental nos anos ’80, aprofundaram a ideia e procuraram o apoio necessário na Austrália.

Embora a ajuda externa e as suas consequências dominem actualmente a maior parte da economia de Timor-Leste e o petróleo e o gás possam, em breve, produzir significativos rendimentos, a maior parte dos timorenses depende da agricultura para o seu bem-estar e assim continuará a ser durante muitos anos. Como é que Timor Leste vai gerir a ajuda externa e o seu declínio, o crescimento dos sectores do petróleo e do gás e a agricultura de subsistência terão um impacto enorme na vida da sua população, predominantemente rural. Dado que três quartos da população vive e trabalha nas zonas rurais, um Timor-Leste independente terá de reforçar a agricultura tradicional através de intervenções tais como o aumento do rendimento das colheitas e o facilitar do acesso a facilidades bancárias e de micro-crédito de forma aumentar a produção e melhorar a capacidade para comercializar os excedentes desta. Políticas apropriadas para promover indústrias orientadas para a exportação de ajudarão a constituir uma base sólida para um crescimento económico sustentável e para a redução da pobreza.

Foi possível reunir um grupo de especialistas e de pessoal técnico com um bom conhecimento e experiência de Timor Leste para equacionarem políticas e recolher informação técnica sobre culturas agrícolas, pecuária, florestas e pescas no Ministério da Agricultura e para examinar algumas das principais questões de natureza económica de Timor Leste. Para tanto foi possível reunir apoios do próprio Ministro da Agricultura, Florestas e Pescas da RDTL, Estanislau da Silva, e de potenciais doadores em Canberra e Dili. A AusAID e a ACIAR expressaram interesse na conferência e tornaram-se os principais apoiantes financeiros da conferência.

Gostaríamos de agradecer ao Ministro da Agricultura pelo seu apoio e pelo seu discurso de abertura da conferência. Gostaríamos ainda de agradecer a todos os que participaram na conferência e fizeram dela um sucesso, particularmente aos oradores que contribuíram com o seu tempo e que apresentaram comunicações, reflexões e comentários. A contribuição financeira dos nossos dois principais apoiantes, a AusAID e a ACIAR, foi muito apreciada.

A preparação da conferência foi um desafio logístico. Alguns dias antes da abertura o *campus* da Universidade Nacional, onde decorreu o evento, foi encerrado na sequência dos protestos estudantis contra o aumento das propinas. Os organizadores tiveram de ponderar a possibilidade de alteração do local da conferência para outras instalações, o que diminuiria o envolvimento dos timorenses e o impacto da conferência. Felizmente as coisas compuseram-se e a conferência decorreu com toda a normalidade, tendo sido uma excelente oportunidade para uma Universidade jovem ganhar experiência através do acolhimento de um acontecimento internacional em circunstâncias difíceis.

O Centro Nacional de Investigação Científica (CNIC) da Universidade Nacional Timor Lorosa’e assumiu a responsabilidade de organizar a conferência em conjunto com o Ministério da Agricultura, Florestas e Pescas da RDTL, a Australian National University e a ACIAR Canberra, ambas da Austrália. Gostaríamos de expressar aqui a nossa dívida para com as muitas pessoas que, em circunstâncias muito difíceis, conseguiram fazer da conferência um sucesso.

O essencial do planeamento foi levado a cabo por James Fox, Colin Piggin, César da Cruz e Helder da Costa, os editores deste volume. Gostaríamos igualmente de agradecer aos organizadores e funcionários do CNIC (Apolinário Magno, Yohanes Usboko, Carrie Taylor, Pedro de Oliveira, Silvino Amaral), da Faculdade de Agricultura (Matias Tavares, Acácio da Costa), da UNTL (José dos Santos) e do Instituto Nacional de Linguística (INL) (Rosa Idalinda) pela sua capacidade organizadora e pelo apoio logístico prestado.

O nosso apreço vai também para o pessoal superior do MAFP, nomeadamente César José da Cruz, Francisco Tilman de Sá Benevides, Mário Nunes, Fernando Amaral e Acácio Guterres pelo apoio dado antes e durante a conferência e, particularmente, por terem conseguido assegurar a presença de todos os representantes distritais (13 distritos) do Ministério. Presentes estiveram também Sisto Moniz Piedade, da Cooperativa Café Timor (CCT), e Fernando Amaral, do MAFP, que organizaram, na tarde do segundo dia da conferência, uma excursão de visita às zonas de cultivo do café bem como a algumas instalações de processamento do mesmo em Ermera.

As contribuições de João Câncio Freitas, Filomeno da Cruz, Apolinário Magno e Edmundo Viegas são também aqui reconhecidas, particularmente pela sua assistência na tradução durante a conferência, tornada possível pelo seu domínio do tetum, bahasa Indonesia e inglês.

Agradecemos igualmente ao Ministro da Agricultura, Engº Estanislau da Silva, ao Embaixador da Austrália, Sr. Paul Foley e ao Secretário de Estado da Defesa e Segurança de Timor-Leste, Dr. Roque Rodrigues, os quais apoiaram a conferência e tomaram algum tempo da suas sobrecarregadas agendas para se dirigirem aos conferencistas e participarem activamente nas discussões.

Agradecemos igualmente Robin Taylor e à ACIAR Canberra pela ajuda concedida para a publicação dos *proceedings* da conferência e Prof. Almeida Serra do ISEG-UTL Portugal pela sua assistencia de traducao em Portugues.

Eles constituem um registo da maioria das apresentações e das discussões levadas a cabo durante a conferência. Esperamos que sejam de interesse e úteis para responsáveis, académicos e estudantes de Timor-Leste e que contribuam para um melhor conhecimento e desenvolvimento da agricultura do mais novo país do mundo, Timor-Leste. Esperamos igualmente que o presente volume seja útil à comunidade internacional que tem algum interesse pelo país.

Helder da Costa, Colin Piggin, Jim Fox e César J. da Cruz

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II
Agriculture in East Timor

Photographer: Eric McGaw

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Livestock development in East Timor

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Abstract

One of the main components of agricultural development in East Timor is improvement in livestock production. This paper begins with a description of the characteristics of each district across the country. Small animal production appears to have recovered. Chickens, pigs and goats are now seen again in rural and urban areas. Buffalo and Bali cattle are being imported under the World Bank-sponsored Agricultural Rehabilitation Project (ARP), and others have been brought from hiding places in the mountains, but total numbers of large animals remain below pre-1999 levels. This paper also examines the importance of native pastures on the economic value of a potential primary cattle industry. Combined with better management, animal production and better grazing will enable farmers to market their produce in the future. As well as assessing the role of ruminants and non-ruminants for animal production, the commitment of significant resources to research and development and provision of training and extension to farmers in the villages is strongly recommended to develop the livestock industry. An important feature of this recommendation is the livestock regional mapping that draws on several districts to specialise in certain animals as the centre of production.

Background

EAST TIMOR is a small, mountainous island with an area of about 19,000 sq km, consisting of 13 districts, regionally divided into the three major administration centres of Manufahi, Bobonaro and Baucau. Each district has its own characteristics of geography and weather, which determine the appropriateness of new and improved technologies for establishing and developing agricultural commodities. Food crops (maize, rice, peanut, soybean, cassava and sweet potato), tree crops (candlenut, coconut, coffee and cloves) and livestock (water buffalo, cattle, horses, pigs, goats, sheep, chickens and ducks) are the major agricultural commodities in the East Timor economy.

Regional agricultural overview

Bobonaro district is located in the west of East Timor, and extends nearly 100 km from north (the coast) to south, following the border between Indonesia and East Timor. It consists of six sub-districts and is an important area for maize and rice production, with rice predominant in the flatter sub-districts of Maliana, Atabai and Cailaco. The other sub-districts of Bobonaro, Lolotoe and Balibo are hilly and important for sweet potatoes, candlenut, coffee and soybean. The sub-districts in the mountains have more rainfall, whilst the flatter areas have some permanent irrigation, which provides water for rice fields throughout the year. In normal years, maize planting commences in November and rice planting follows around December/January. A second rice crop is planted in March/April for harvesting around September. Bobonaro sub-district has extensive natural pastures and strong potential for future cattle development. Cattle, water buffalo, horses, pigs and chickens are raised in the lowland rice production areas and goats are common and well suited in other sub-districts. In view of the extensive destruction during the independence referendum in this part of the country, farmers are also comparatively more engaged in reconstruction of houses than in other areas.

Covalima district comprises five sub-districts in the southwest of East Timor, which lie on the

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Indonesian border. The extended rains enable farmers to produce a second crop of maize after the main crop (planted in November/December) is harvested in March. At present, due to security concerns, little maize is planted in the areas bordering West Timor. Elsewhere, in the lowlands and in highlands away from the border, maize is planted extensively. Other crops, such as coffee, candlenut, and soybeans, are grown in the highlands, while rice is planted in lowlands. Livestock (cattle, water buffalo, pigs, goats, sheep, horses and chickens and ducks) are common and more concentrated in the lowlands.

Liquica, on the north coast, west of Dili, contains three sub-districts, and is important for coffee plantations. The district is divided into two production zones; the highlands (Bazartete and Maubara sub-districts), where coffee and maize are produced, and the lowlands, where only maize is cultivated. Some lowland parts of Maubara are planted with rice. Goats and chickens are common, and small numbers of cattle and horses are raised. Some poultry companies have been established to provide eggs and chickens for local and national markets, however, these are facing difficulties due to increasing prices of feed and other required materials.

Baucau district, on the north coast, east of Dili, has five sub-districts. Rainfall is well distributed in the hilly areas and less so near the coast. It is an important food-producing area, with the main crops being rice and maize. The district is also an important area for the production of beans, groundnuts, cassava and sweet potatoes. Baucau is the second most agriculturally developed district after Bobonaro, being mechanised and having access to high quality seeds produced at established centres. It has huge agricultural areas, 30% of which are rice fields with permanent irrigation. Maize is usually grown in tilled fields or with little cultivation under traditional slash and burn systems. Overall, the better rainfall distribution and good soils result in a better yield potential in Bacau than in other areas. Farmers in the district mainly raise cattle, water buffalo and sheep.

Lautem district on the eastern end of the island has five sub-districts and is not a major food crop production area although livestock (cattle, water buffalo, dairy cattle) are prominent. It has huge natural pasture areas where animals traditionally forage. Rice, which is mainly cultivated in the northern lowlands around Iliomar, accounts for approximately 10% of district cereal production. In contrast, cassava, bananas and vegetables are extensively cultivated. During Indonesian times, Lautem district became an important livestock and fish producing area exporting to Dili and other urban centres. Rainfall is well distributed throughout the area and the wet season is longer than the dry — in contrast to most other sub-districts.

Manatuto district comprises six sub-districts and extends from the north-central to the south-central coast. It is important as a livestock and rice production area. In the northern and southern areas, rice is extensively grown, whilst the central highlands support subsistence agriculture based on maize intercropped with cassava beans, pumpkins and other species. Coffee, candlenuts, and cocoa are also extensive in the highlands, especially the Laclubar, Soibada, and Barique sub-districts. Livestock, such as water buffalo, cattle, sheep and goats are extensively raised in Manatuto, with water buffalo and sheep common in the north and dairy cattle well established in Laclubar sub-district. Horses are commonly raised in Laclubar sub-district to provide transport between villages that are impassable by public transport. Rainfall is high in the south and lower in the north.

Viqueque district, which has five sub-districts, is situated on the south-central coast. It is a major maize and rice production area. Rice is predominantly grown in Uatulari and Uatucarbau sub-districts, where 80% of the area can potentially produce two crops a year. Rainfall is relatively favorable, making water available throughout the year and allowing farmers to produce two crops a year. In the past, Viqueque district has been a major producer and exporter of rice, but isolation due to poor roads and the closure of many mills due to a shortage of spare parts could see this situation change. Cattle are predominant but water buffalo and pigs are also significant in the district.

Dili district comprises three sub-districts. It is not agriculturally important but has about 150,000 people living in the capital Dili, which is the main political, administrative and business centre of the country. Agricultural products from other districts are sent to the central market of Dili, where demand is high because of the high local population, although prices are higher than in district areas.

Oecussi, which has four sub-districts, is an enclave isolated on the north coast of West Timor. It is a major cereal-producing district, with rice accounting for about 60% of aggregate cereal production, mainly concentrated around Pante Makassar. Other areas in the district produce only maize. Oecussi district is an important cattle-producing area and natural pastures are extensive throughout the district. The district has a relatively long dry season and a short, unreliable wet season from December to March.

Aileu district is located in the central mountains some 35 km south of Dili. It produces maize, coffee, oranges and pond fish, and has extensive horticulture because the district is cool and has favorable rainfall throughout the year. Livestock production is limited but horses are common and very important for transporting people and luggage as the district has many roads which are not suitable for vehicles.

Ainaro district is an important coffee-producing area, located in the central mountains south-west of Dili. Access can be difficult due to poor road conditions, with roads sometimes impassable by public transport during the rainy season. Cattle are common, especially in Hatu-Udo sub-district. Other sub-districts are important for vegetable and potato producion, and play an important role in determining the availability of vegetables in Dili and other areas throughout the country.

Manufahi district, which is on the south coast, has three sub districts. The Turiscai sub-district contains important coffee-producing areas. Cattle are commonly raised and kept as assets to save and generate income. Natural pastures are extensive throughout the lowlands of the south coast (Alas and Fatuberliu), and these areas have promise for beef cattle development in the future. The road that links Manufahi and Manatuto districts is well established, so the area can be accessed by both public and private transport.

Ermera district, which comprises five sub-districts, is located in the mountains south-west of Dili. It has favorable rainfall throughout and is the largest coffee-producing area in the country. Coffee has become the main primary export commodity and plays an important role as the largest single source of jobs in the country. The National Co-operative Business Association (NCBA), a non-government organisation with a long standing presence in the country, is the largest coffee purchaser. The NCBA has 17,000 farmer members and employs about 3500 people in a four to five month processing season. The district also has large lowland areas, which are important for rice production, and also support cattle and water buffalo.

Natural resources and systems for livestock production

The primary livelihood of most farmers in East Timor is small-scale subsistence cropping of rice, maize and coffee. However, farming systems are diverse and most farmers also raise livestock (cattle, water buffalo, goats, sheep, chickens and pigs).

Cattle ownership largely determines social status in village communities. Owners of large numbers of cattle are important people in society and are always involved in important village events. Animals are considered as valuable assets for farmers to help cope with economic difficulties. They provide funds for emergency needs such as children's schooling, deficits of staple foods in poor seasons, or funerals of family and relatives. Farmers are reluctant to slaughter animals for their own consumption, except during funerals, festivals or wedding celebrations. Occasionally, a farmer will slaughter an animal but will negotiate with relatives, friends and neighbors beforehand to ensure that the excess can be sold. Cattle are more valuable than goats, sheep and pigs from a social point of view but they are not as easy to sell. Goats, sheep and pigs can be sold easily whenever farmers face economic difficulties. Ruminants are important for meeting the needs of major local markets throughout the territory.

Farmers have freely grazed their animals on common pastures for hundreds of years, and these pastures, whether native or introduced, provide a cheap source of feed. Native pastures are extensive throughout East Timor, covering over 200,000 ha or 10% of the country's area (Table 1) and should be able to support a viable livestock industry in coming years. Proportions vary depending on the district and its suitability for other agricultural activities. Pastures comprise mainly native grasses, with speargrass common and some introduced legumes such as *Leucaena* and other edible plants. Livestock range freely with no grazing management. Heavy grazing, leading to loss of vegetative cover and erosion is common. Therefore, native pastures and their management are important issues for sustainable animal production in the future. It is expected that cattle production will become a major industry for both national and international markets.

Table 1. Area of native pasture in East Timor.

District	Native pasture (ha)
Covalima	34,339
Ainaro	6,845
Manufahi	25,454
Viqueque	25,422
Lautem	39,994
Baucau	17,585
Manatuto	13,040
Dili	388
Aileu	501
Liquica	6,575
Ermera	3,396
Bobonaro	18,061
Ambeno	14,626
Total	206,227

Production

Livestock population estimates for 1999 and 2001 are presented in Tables 2 and 3. For ruminants (water buffalo, cattle), the civil disturbances of 1999 caused significant losses and, although numbers are

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increasing again, ruminant production is still less than usual. Apart from that, animals are not well managed in terms of feeding, housing, health, and reproduction because livestock husbandry is not a primary livelihood. Generally, animals are raised traditionally, which means grazing with little restriction in open natural pastures and periodically being penned or tethered in the afternoon after one or two days grazing. There is almost no improved management, although there is an example of dairy cattle being raised and fed with supplements in Lautem and Dili by the Catholic Mission.

Sheep and goats are mostly reared traditionally with open grazing during the day and penning at night. Pens are often set some distance from houses and animal theft sometimes occurs. No feed supplements are given to the animals and underfeeding is common. There is little control of mating and infertility diseases are common in most areas.

Horses are common in many villages to provide transport for people and produce, especially in the mountains where there are no roads suitable for public or private vehicles. For farmers in remote areas, horses are often the only means to carry produce and inputs to and from main roads. Sellers also carry their wares from one village to another using horses. The nutrition of working horses is often neglected and many suffer from hunger.

Pigs are generally reared traditionally without pens. Most farmers feed their animals twice a day with traditional feeds such as sago, pumpkin, cassava and sometimes swill. Boars are customarily more valuable than sows for slaughter on traditional festive occasions. A family might own 10 to 20 pigs.

Table 2. Estimated population of livestock in East Timor (1999).

District	Beef Cattle	Dairy Cattle	Water Buffalo	Goats	Sheep	Horses	Pigs	Chickens
Aileu	1,828	0	1,962	3,787	57	252	4,929	12,635
Ainaro	2,709	0	6,071	4,847	99	2,401	9,252	27,604
Ambeno	18,329	0	1,325	15,605	165	1,706	15,619	20,119
Baucau	3,439	0	8,896	17,927	15,601	1,942	27,926	24,010
Bobonaro	27,168	0	6,943	20,924	346	3,617	39,216	49,502
Covalima	27,139	0	2,963	6,289	92	2,809	20,202	30,716
Dili	249	6	102	20,362	306	540	32,158	40,214
Ermera	1,886	0	2,259	7,049	338	2,329	18,563	41,245
Lautem	3,027	24	6,185	5,018	265	827	15,651	13,561
Liquica	2,452	0	1,075	14,543	250	1,582	17,681	35,719
Manatuto	2,351	0	3,093	8,215	2,330	597	5,772	9,412
Manufahi	2,998	0	1,537	2,463	67	860	9,506	21,416
Viqueque	3,087	0	6,040	3,996	475	934	22,649	24,269
Total	96,662	30	48,451	131,025	20,391	20,396	239,124	350,422

Table 3. Estimated population of livestock in East Timor (2001).

District	Beef Cattle	Dairy Cattle	Water Buffalo	Goats	Sheep	Horses	Pigs	Chickens
Aileu	5,635	0	1,342	1,505	2,209	52	3,734	16,535
Ainaro	11,541	0	10,145	7,985	3,675	118	29,717	37,339
Ambeno	26,818	0	2,037	2,078	9,605	0	26,698	132,205
Baucau	5,829	0	18,648	6,384	16,218	15,750	39,608	61,048
Bobonaro	27,587	0	7,142	3,162	8,109	287	31,404	84,616
Covalima	17,217	0	7,608	1,494	1,765	0	20,049	25,933
Dili	983	21	464	461	8,356	525	27,676	37,722
Ermera	10,768	0	4,703	3,389	2,577	70	19,102	33,272
Lautem	9,588	56	13,426	3,510	4,009	1,306	22,364	36,079
Liquica	10,087	0	2,682	1,458	11,638	55	41,082	97,514
Manatuto	6,765	0	6,656	2,455	5,337	4,063	11,716	21,328
Manufahi	8,661	3	6,026	3,655	1,675	190	16,979	27,853
Viqueque	22,879	0	22,844	6,734	4,206	1,068	48,708	59,483
Total	164,358	80	103,723	45,158	79,379	23,728	338,837	670,927

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Chickens are raised extensively under an open range system without supplements. Local chickens are more valuable than hybrid (broiler) chickens because villagers consider the local ones have better meat quality and are more resistant to the common Newcastle disease.

Animal management and reproduction

Little attention is paid to proper nutrition of village livestock, which suffer feed shortages and starvation, especially late in the long dry season. Supplements are hardly used at all.

Reproduction is through natural mating, often with older bulls as the young ones are sold, and this means diseases such as fibrosis, which reduce fertility of females, are frequently a problem. The ratio of male to female cattle is often low and this can result in low calving percentages and low returns.

Diseases are an important constraint throughout the country, exacerbated because animals are grazed extensively on common pastures. The most common diseases are haemorrhagic septicaemia and leptospirosis, which often cause mortality. Vaccination programs against anthrax and haemorrhagic septicaemia are reported to reach about 80% of cattle and water buffalo. Overall, diseases are not well controlled and high mortality rates occur in some herds and flocks.

Research and development

Some of the areas where research is needed to help develop new technologies for improving livestock production are:

- identify and map species in natural grasslands
- determine the nutritive value of naturalised species in grazing land
- test adaptation and suitability of a range of introduced grasses and legumes
- develop and promote better technical recommendations for pasture improvement
- develop and promote technical recommendations for better feeding and nutrition of animals
- collect and map data of agricultural land use
- develop regional mapping systems for livestock development
- develop understanding of traditional methods of livestock management and encourage appropriate improvements
- develop skills of farmers to be more market-orientated in livestock production
- survey disease constraints and undertake studies on causal organisms, clinical signs, pathogenicity, epidemiology and control of major diseases and promote appropriate disease management strategies
- investigate causes of abortion in cows, heifers and ewes and promote appropriate control strategies

Recommendations

Combinations of traditional and modern methods of raising animals should be introduced and promoted. It is important to realise that pure technology may not meet all the needs of farmers, who often do not have the means to access and understand improved technologies and how these might fit in with their traditional systems. It is most appropriate to modify the way farmers manage their animals, e.g. by providing them with knowledge on how to get good quality feed, how to control diseases, or how to recognise the symptoms of any abnormalities.

Ranch establishment should be considered because of the huge areas of native pasture.

Undertake regular training for farmers in appropriate livestock management and disease control for different animals in the field. Also involve farmers in framing livestock development plans and encourage them to be actively involved in village livestock development

Establish village demonstration plots of appropriate improved technologies such as new grasses and legumes.

Regional mapping and promotion of livestock

In order to develop livestock production systems most efficiently and appropriately, and to make the best use of natural environments and resources, the following focus on particular livestock in particular regions is suggested:

- beef cattle and water buffalo in Bobonaro, Viqueque, Lautem, Baucau, Covalima, Manatuto and Ambeno
- dairy cattle in Lautem, Manatuto and Bobonaro
- goats and sheep in Manatuto, Baucau, Liquica, Lautem, Ambeno, Bobonaro, and Manufahi
- chickens throughout the country, with improved chickens specifically in Liquica, Baucau, Manatuto and Lautem.
- ducks in Ambeno, Lautem, Bobonaro, Viqueque, Baucau, Aileu and Covalima
- horses throughout the country

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Conclusion

Livestock have excellent potential to become a cornerstone of East Timor's economic development now and in the coming years. However, farmers' skills and knowledge about livestock production will need to improve to achieve better production, better profitability and better lifestyles. Considerable local research and verification of technologies must be conducted before such recommendations can be issued. Cultural, social, and economic aspects are important factors that should be understood and considered in recommending new technologies, to ensure they will be attractive and profitable to farmers.

Cropping systems in East Timor

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Abstract

A key element of agricultural development in East Timor is the cropping sub-sector. This paper presents the author's views and assessments of the cropping system in East Timor. A description of the climatic constraints and land-use patterns for cropping is followed by an indication of the shortage of several staple food crops in East Timor. Production from house gardens appears to have recovered, but slowly. While fruit trees and root crops remain productive, seeds for annual crops have been unavailable or unaffordable to impoverished households with no cash income. For instance, rice and maize are usually grown from the beginning of November until the end of February. Limited availability of sweet potato, cassava, taro, bananas, breadfuit and leafy vegetables is common in East Timor. With this system, adverse weather conditions for one crop are compensated for by favorable conditions for another. The goal of the farmer is not to intensify production but to ensure food security through diversification. Given the low production in rice and maize, the challenge, as argued here, is to increase yields of present crops and increase farm productivity. This will require an introduction of better farming techniques, technical resources and extension services.

Introduction

THE mountainous topography of East Timor leaves only a very small area of land suitable for cultivated crops. Mountain ranges spread from east to west and on the southern coast, wider areas of alluvial flat lands or coastal plains gradually rise to areas of undulating hills, stretching towards the mountain slopes. Despite the limitations of its topography, many farming communities live in the fragile areas where the slopes are only suitable for forestry. They often access more favorable conditions for short-term cropping in small inland valleys, narrow banks of rivers, and small level areas within the mountain range.

East Timor can be divided into four topographical areas: 1) the north-west, including the long range of rough mountains with elevations ranging from 800 to 1400 metres, which run parallel to the north coast, 2) the central elevated area which forms the mountain divide that separates drainage to the north and south, 3) the eastern area with at least four different types of topography including the Fatu type which consists of long, flat-topped plateaus with very sharp, steep, and usually vertical sides or limestone rocks, and 4) the south coast area, which is characterised by its low rolling hills and flood plains toward the southern coast.

Area and land-use

East Timor covers an area of 14,916 sq km (1.49 m ha) including the two small islands of Atauro and Jaco. Estimates of the proportions devoted to different uses are given in Table 1. The largest area comprises very steeply sloping lands under shrubs and grasses, with little forest cover. Dry and wet arable lands are mainly used for production of food crops, including irrigated and rainfed rice, and mainly occupy the gently sloping areas of the coastal plains, former river beds and deltas, plateaus, and small inland valley floors.

Table 1. Area occupied by different land uses in East Timor (%).

Land Use	Area (%)
Villages	1
Irrigated rice fields	3
Rainfed rice fields	4
Plantations	3
Mixed farming	2
Light forest	76
Bushlands	9
Other	2

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Climate

Earlier climatic classifications for East Timor suggested the following four climatic types:

1. the hot and dry zone of the northern coast with an annual rainfall of less than 1000 mm which falls in the period from November until March or April, and a mean temperature of over 27°C
2. the hot and moist zone of the south coast below 100 m, with an annual bi-modal rainfall of about 1500 mm over seven to eight months from November to March and May to July, and a mean temperature of 24°C
3. the intermediate zone of the limestone plateau and mountain districts with elevations above 500 m, with an annual rainfall greater than 1300 mm, occurring for six to seven months from October to April, and a mean temperature of less than 21°C
4. the cold zone from 1200 m to the highest point on the Ramelau range of about 3000 m, with a more evenly distributed rainfall of more than 2000 mm occurring over nine months from November to July and a mean temperature of 15–21°C and monthly averages below 10°C around June/July.

A recent study (ARPAPET 1996) separated out the following six agro-climatic zones based on rainfall and elevation:

1. Zone A: Northern Lowlands — Coastal land and valley floors below 100 m (mean annual rainfall <1000 mm, four to five month wet season from November to March)
2. Zone B: Northern Slopes — Northern hills between 100 and 500 m (mean annual rainfall of 1000–1500 mm, five to six month wet season, October to March)
3. Zone C: Northern Highlands — Northern hills and mountains above 500 m, (mean annual rainfall >1500 mm**,** six to seven month wet season, October to April)
4. Zone D: Southern Highlands — Southern hills and mountains above 500 m, (mean annual rainfall >2000 mm, nine month wet season, November to April; May to July)
5. Zone E: Southern Slopes — Southern hills between 100 and 500 m (mean annual rainfall 1500–2000 mm; eight month wet season, November to April; May to July)
6. Zone F: Southern Lowlands — Coastal land and valley floors below 100 m, (mean annual rainfall about 1500 mm, seven to eight month wet season, November to March; May to July).

Crop production and cropping systems

Rice and maize are equally important as staple food crops. However, suitable rice growing areas are limited and maize is more widely grown than rice (Table 1). Farmers grow maize on very steeply sloping lands, particularly at higher elevations. In the highlands of Baucau, Bobonaro, Ainaro and Same districts, some farmers have developed terraced fields to grow rice irrigated with spring water and dry relay crops of maize and legumes.

The pre-conflict estimate of per capita consumption was about 50 kg of milled rice and 139 kg of maize per person per year. These figures do not indicate people's preference for maize as food. Rather, they indicate the insufficiency of supply of local rice since the population, particularly in rural areas, eats largely what they produce. Production of rice is constrained by availability of water and topography, whilst maize can be grown in most areas in the wet season.

Shortages of rice or maize staples usually occur between November and February. At this time, people depend more on food security crops from home and shifting gardens such as sweet potato, cassava, taro, bananas and breadfruit. Leafy vegetables, beans, squash/pumpkin, young jackfruit, papaya flowers and young papaya fruits are common foodstuffs from household gardens.

Table 2. Production and percent of households growing various crops in East Timor (2002).

Crop	Production (000 Mt)	Households growing crop (%)
Maize	68.9	81
Cassava	55.3	68
Sweet Potato	31.6	44
Taro	13.5	33
Bananas	19.3	27
Squash	9.4	18
Rice (all ecosystems)	57.8	26
Coffee (cherries + dry beans)	18.6	28
Kidney bean	3.7	11
Vegetables	1.9	8
Other fruit crops	3.1	5
Mungbean	1.8	5
Peanut	1.7	4
Coconut	2.1	4
Soybean	0.8	3
White potato	0.9	3

(from Timor Lorasae Household Survey (TLHS), 2002)

The major commercial crops prior to 1999 were arabica coffee, chimeri (candlenut tree), vanilla and coconut. The disruption of trading activities due to the independence conflict left farmers without markets for these commercial crops. Trading is gradually returning, particularly for candlenut and coffee.

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The typical cropping patterns involving the various food crops are as follows:

1. Northern Lowlands:
   Irrigated rice dependent on river water:
   (a) rice then fallow (seasonal irrigation)
   (b) rice-rice (irrigated by underground springs)
   Dryland farming
   (a) maize then fallow
   (b) maize followed by cassava, beans, pigeon pea, sweet potato, or pumpkins
   (c) maize + peanut then fallow
   (d) peanut followed by maize, pumpkins
2. Northern Slopes
   (a) rice-rice (in irrigated areas, e.g. Baucau)
   (b) maize followed by cassava, sweet potato or pumpkins
   (c) mixed crops of maize, cassava, long beans, pigeon pea, peanuts, sweet potato, pumpkins
   (d) peanut then fallow
3. Northern Highlands
   (a) rice-rice or rice-fallow depending on source of water
   (b) maize then fallow
   (c) maize followed by cassava or sweet potato
   (d) mixed crops of maize, cassava, sweet potato, taro, beans, pumpkins
   (e) red beans + white beans then fallow
   (f) peanut then fallow
4. Southern Highlands
   (a) maize then fallow
   (b) red beans + white beans then fallow
   (c) maize followed by red beans + white beans
   (d) red beans + white beans followed by another beans crop
   (e) maize + cassava or maize + sweet potato
5. Southern Slopes
   (a) maize then fallow
   (b) red beans + white beans (sometimes with maize) then fallow
   (c) maize followed by red beans + white beans
   (d) maize or beans followed by upland rice followed by mungbean
   (e) maize + cassava or maize + sweet potato
   (f) upland rice + cassava or sweet potato
6. Southern Lowlands
   (a) irrigated rice then fallow
   (b) irrigated rice followed by dry season rice
   (c) maize then fallow
   (d) upland rice then fallow
   (e) mixed cropping of maize, cassava, sweet potato, taro
   (f) maize followed by mungbean

Other crops, including bananas, citrus, pineapple, mangoes, breadfruit, avocado, white potato, watermelon, and a variety of vegetables, are grown on small scales and traded only in limited quantities within the districts or sub-districts.

Conclusion

The limitations imposed by climate and available favorable soil resources are among the major factors that will determine East Timor's capacity to produce an adequate supply of food in the future. However, there appears to be potential for increasing yields of present crops and improving farm productivity on relatively favorable lands. We must, therefore, work hard to recognise specific limitations to crop yields and farm productivity and to contribute to improving food supply and cash income opportunities.

The choice of crops and cropping systems under a wide range of agro-climatic and soil environments reflects farmers' indigenous knowledge and resources and certainly their determination to survive under very difficult environmental conditions for human settlement. These cropping systems need to be further investigated since most farmers still find themselves in a subsistence situation. Cropping systems will have to improve and some may eventually need to be replaced. Application of modern science, certainly, should improve not only the choice of crops, varieties, cultural practices, and cropping patterns but also allow modification of the physical environment to promote better yield and sustainable production.

This meeting of minds on "new directions" for agriculture will, hopefully, be a major step towards identifying better and more feasible cropping systems or farming system practices under the wide range of soil and climatic environments in East Timor. There is no doubt that technical experts, knowledge bases, other resources needed and the authority to make things happen in order to find the best for Timor-Leste's farmers already exist. However, we should not overlook the fact that implementation of agriculture-related programs depends on the preparedness of our colleagues in the government sector to determine and promote better technologies, and clientele farmers who will eventually make decisions to evaluate, modify and adopt the recommendations.

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Forest conservation and fauna protection in East Timor

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Abstract

This paper discusses the efforts of the government of East Timor to rehabilitate 10 watershed areas throughout the country. Because of the critical conditions of these sites, the focus on conservation should be aimed at increasing public awareness, development of a framework for management of watershed areas, protection and conservation of biodiversity and recognition of the socio-cultural significance of imported natural resources. This calls for protected natural areas (PNA) and public information and involvement in community-based integrated management planning, building upon existing management activities. In addition, better links are needed between environmental interventions and poverty reduction for target beneficiaries in the protected areas, through: an improvement in people's health due to access to resources such as potable water; enhancement of the livelihoods of rural people; and reduction in vulnerability to natural disasters.

Introduction

EAST TIMOR has a total forest area of 1.4 m ha, with an estimated 350,000 ha of this under threat from degradation. Agroforestry is regarded as a good alternative to traditional slash and burn cultivation in the uplands, as farmers are able to produce forest trees and fruit trees as well as cash crops and livestock. Around the coast, mangrove areas are common and these have been exploited for fuel wood and other products. Mangroves are an important coastal habitat and hence a priority for rehabilitation.

There are 10 major watersheds in the Laclo, Loes, Caraulun, Seical, Tavara, Irabere, Comoro, Tono, Sahe and Nunura areas. These are under pressure from unwise forest exploitation over long periods, forest fires and unsustainable upland management, including widespread collection of firewood. Unsustainable exploitation needs to be stopped and sustainable rehabilitation and conservation mechanisms developed. Some of the measures to achieve this include: reforestation of degraded areas with valuable local timber species, in particular sandalwood; restoration of the ecological balance of degraded areas and arresting environmental problems resulting from their degraded condition (while promoting the development of forest resources in those areas); and encouraging community participation in the rehabilitation of East Timor's degraded forest areas.

Strategies for conservation

The protection and conservation of the forest resources of East Timor began in 2000 with the establishment of 15 protected natural resources which must be managed according to UNTAET Regulation No. 19, 2000. As part of the conservation effort, a forest commission was set up in three villages (Pitilei, Mehara, Muapitine) in the protected natural areas of Tutuala and Jaco in the Los Palos district and at the forest commission in Natarbora. Expansion of these forest commissions to all protected areas is planned, with active villager involvement and focus on conservation management through increased public awareness; development of a framework for management of watershed areas; and protection and conservation of the biodiversity and recognition of the socio-cultural significance of important natural sites.

The program will cover projects in the areas of watershed management, protected natural areas, and public information, building upon existing watershed management activities.

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Protection of biodiversity

Biodiversity is a basic support system for life, which represents a system of many interdependent processes. There is a need to guard and protect against changes that disturb capacity to utilise the environment and important life-supporting ecological processes. One fixed conservation area has been set aside by the government for the purpose of demonstrating with the people a basic system of use and development so that protection and preservation is guaranteed. Protection of biodiversity requires effort and covers the following:

- conservation of mountain and erosion-prone areas with forests
- conservation of coastal areas through controlled management of shoreline forests and coral areas
- conservation of watershed areas, steep slopes and lake margins with controlled management of vegetation such as prohibition of felling of trees and promotion of replanting
- development of watershed areas and conservation areas according to overall management plans
- conservation of areas with unique value, natural beauty and interest and special features of nature and culture
- environmental impact statements as an absolute condition for implementation of all plans for development activity that may have a negative effect on the environment.

Sustainable use of natural resources and ecosystems

Living natural resources are an element of the ecosystem which can be used to improve the prosperity of the people and the quality of human life. Efforts to use natural living resources sustainably must be implemented consistently in the future. Alternatives are sustainable use through activities such as:

- use of natural conservation areas for recreation, tourism, experimentation and study
- controlled use of wild flora and fauna
- continuous invitations to and development of the people around conservation areas to be partners in management.

Basic conservation efforts

To achieve the objectives mentioned above, a range of basic actions must be undertaken:

- conservation in forest areas with the goal of representing all ecosystem types in East Timor in 15 natural conservation and protection areas throughout the country between Jaco Island, Tutuala, Clere and Manucoco on Atauro Island
- conservation outside these areas to protect flora and fauna through establishment of fauna parks and botanic gardens
- development of one or two national gardens to commemorate independence
- establishment of protected forests in mountain areas which cover most of the country to conserve and protect water and soil
- encourage a concern and love of nature to develop the role of the people, especially farmers and the young, in conservation of natural resources
- analysis of environmental impacts to suppress, as much as possible, negative effects of development

Conclusion

Consideration of the links between environmental interventions and poverty reduction in East Timor should allow: an improvement in people's health due to access to better resources such as potable water; enhancement of the livelihoods of poor people, particularly those in rural areas where people depend on land, water, forests and biodiversity; and reduction of people's vulnerability to natural disasters such as violent storms, floods and fires.

Target beneficiaries include the communities within the targeted watersheds and protected areas, farmers wishing to use resources of the protected area, and East Timor in general through the protection of its biodiversity and cultural heritage. The expected outcomes of the program include a greater understanding amongst communities of regulations on protected areas, more involvement in community-based integrated management planning, and raised public awareness.

Planning for fisheries development in East Timor

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Abstract

This paper outlines strategies and priorities for fisheries development over the medium term. These will focus on bridging the country's potential fishing zone into the national marketing network, developing viable offshore fisheries, establishing aquaculture enterprises, introducing seafood safety standards and facilitating seafood exports. An estimated loss of US$20 million per annum from illegal fishing can be reduced with proper planning, with potential earnings from fishing licences of up to US$16 million over the next few years. It is envisaged that by 2005 fish production will reach more than 8000 kg/year with per capita consumption of 10 kg/year. Fish exports will generate US$5 million and fishing licences US$15 million, which in turn will contribute 5% to the country's GDP. Short-term and mid-term planning are in place to facilitate the development of the fisheries sector so that it contributes to economic growth, incomes, employment and export earnings. Granting fishing licences, coupled with the provision of fishing equipment, will help to spur the development of fisheries in East Timor.

External assistance at this stage should be channeled towards developing the regulatory and legal framework for inshore fisheries management and investment in offshore fishing. Enforcing fishing regulations through partnerships between government, communities and private operators (co-management arrangements) and recognition of user rights for coastal communities have proven effective in many Asian–Pacific countries. External assistance can also be directed towards rehabilitating the fishing harbor at Hera port, promoting further inland aquaculture and improving post-harvest handling and processing.

Introduction

THE need to strengthen development in East Timor has forced policy makers to rethink the role of agriculture, particularly fisheries, to ensure it plays an important role in national food security, improved rural incomes and income generation. The principle of sustainable development is an important feature of East Timor's fisheries. These extend along a shoreline of some 650 km, with a fishing area of about 16,000 sq km and an Economic Exclusion Zone (EEZ) of 61,500 sq km. The annual catch is expected to be about 116,000 tonnes/year from a variety of marine fish. Up to 1988, catches were only 3.5% (3000 tonnes) of this potential. Annual fish consumption was only 4.6 kg/head in comparison to Indonesia (19.6 kg/head), Portugal (60 kg/head), Spain (70 kg/head) and Japan (80 kg/head).

Vision and mission

The overarching goal of fisheries and marine development in East Timor is to manage the nation's aquatic resources sustainably, while maximising benefits for coastal communities, employment and income generation for the country. These can be achieved through: a) improving the production and quality of harvested fish; b) increasing employment and opportunities for value adding; c) increasing fishing areas and opportunities for exploitation; d) sustaining aquatic resources and their supporting ecosystems; e) developing better information and technology: and f) strengthening capacity of institutions and fishermen.

Policy goals

The goals of fisheries development are to:

- maximise sustainable economic returns from fishing
- promote income generation of traditional and commercial fishermen and shore dwellers
- better manage the environment around freshwater, shoreline and ocean water fisheries
- improve development of fishing villages

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- improve capacity and capability of fisheries institutions

The policy strategy options for achieving these goals include the following: a) develop appropriate legislation, regulations and management instruments for sustainable development of fisheries in East Timor; b) develop each fishery via a step-wise, precautionary approach; c) develop fisheries-specific management and development plans consistent with the principles of ecologically sustainable development (ESD); d) establish a responsive extension system that works closely with commercial, private and subsistence fishers; e) provide a regulatory system that promotes community-based management for reef and coastal fisheries, including the development of local by-laws that protect the interests and user-rights of the community; g) provide staff training across the full spectrum of fisheries-related disciplines, including socio-economics and sustainable fishing practices, thereby upgrading staff skills to meet the needs of a modern fisheries sector.

Fisheries development program

Fisheries development is one of the top priorities for development in East Timor. Short-term and mid-term development planning are in place to facilitate the development of the fisheries sector so that it contributes to economic growth, incomes, employment and export earnings.

By 2005, the government expects fish production to reach more than 8000 kg/year with per capita consumption of 10 kg/year. Fish exports will generate US$5 million and fishing licences US$15 million, which will contribute 5% to the country's GDP.

Over the next 12 months, the Government will rehabilitate the coastal fishing industry, rehabilitate hatcheries at Same, Loi Huno, Gleno and Maliana, define the new offshore fishing zones, set up stock assessment programs, and build the capacity of national staff to take on future monitoring, management, and licensing roles.

In the short term, the north coast of East Timor will be the main focal area for industry development and the establishment of a national seafood marketing network. The government commitment to keep the north coast road open and the strong demand for fresh fish in Dili, coupled with the Fisheries and Marine Environment Service's commitments to assist north coast fishers and to provide 20 tonnes/day of cheap ice at Hera, just east of Dili, will encourage private transport and marketing development in the sector. Once this major network is in place, methods to include south-coast communities will be developed and implemented. No fishery can be effectively managed or utilised unless government and industry personnel know the composition of the resource and the sustainable catch rates. If East Timor is to maximise returns from the sea, it urgently needs to know what maximum sustainable yields can be achieved. This will take longer than one year and will form part of the short to medium-term activities.

Capacity building of staff to effectively run the Fisheries and Marine Environment Service will also take longer than one year. Study at international academies and on-site training with visiting experts will be a focus for medium-term capacity building activities.

Other medium-term activities will focus on bringing the rest of East Timor's fishing communities into the national marketing network, developing viable offshore fisheries, establishing aquaculture enterprises, introducing seafood safety standards, and facilitating seafood exports. Regulation of foreign vessels will also be improved as it is estimated that coastal zone losses might be as high as US$20 million per year, with the value of marine licences expected to reach US$16 million in East Timor's Economic Exclusion Zone in 2003.

In the longer term (after 2006) the industry must become self-sufficient and operate under a user pays system. The government will eventually take on a monitoring, management and licensing role and leave exploration, fishing technology, product quality and marketing activities to the private sector.

Problems and challenges

The key problems confronted by the fisheries sector and needing attention in East Timor are as follows:

1. inadequate human resources, including a need for more staff and better knowledge of staff and fishermen
2. lack of tools and infrastructure, including tools of production, training institutes and supporting facilities in villages
3. lack of information on the potential and sustainability of fisheries resources
4. an inadequate technology base, including slow adoption and verification of modern technology
5. poor marketing, including low economic returns, low business investment, poor post-catch handling and poor quality.

East Timor has a large Economic Exclusion Zone and fisheries resources, but determining and agreeing on an international maritime boundary is a matter of urgency. The challenges are to utilise resources sustainably for the benefit of the 10,000 or so fishermen of East Timor and for the nation as a whole, so that consumption of healthy fish can increase, employment is increased for young people, and ocean communities remain viable and stable.

Prospects for coffee development in East Timor

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Abstract

Coffee is East Timor's leading export commodity, with an estimated 16,000 ha of productive coffee gardens and an additional unproductive 16,000 ha. Some 20,000 farm families receive a substantial amount of their income from small coffee holdings, while another 15,000 get a minor portion of their income from this source. Yields are about 150–200 kg of green beans per ha, less than half their potential if improved cultivation techniques were employed. Most of the large coffee estates established in colonial times have been abandoned, and the coffee bushes on them are picked by nearby farmers.

Better and proper application of technology in coffee production needs to be made available to improve the quality for exports. The international standard requirement by OCIA gives rise to continuous inspection of organic coffee to ensure high quality products. There is an important need to improve the quality of coffee and all players in coffee development, namely the farmers' association, government, NGOs and academics need to address this issue. It is envisaged that in 10 years time a better road network and transportation system will be in place and that improvement in the field of education and training, provision of technical expertise and extension services and better management in post harvest will be achieved. The ultimate objective is to generate income for the country.

Introduction

FOR centuries, coffee has been an export commodity, valued not only for its economic worth but also for its unique refreshing taste and soothing properties. It has long been a leading export earner for the East Timorese. Even with minimal inputs, farmers in the coffee-growing areas of Ermera, Liquica, Maun-Fahe, Ainaro and Aileu manage to obtain reasonable yields, and production will increase with better management. Three varieties of coffee, namely arabica, robusta and liberica, are grown in these five production centres. Coffee is regarded as a leading commodity with a long tradition and good marketability. In the three years following the independence referendum in East Timor, it is the one agricultural commodity that has remained profitable and export earnings have been remarkable. However, a survey needs to be conducted to determine the extent of coffee production per year for the benefit of the country.

Prospects for coffee

Following the international recognition of an independent East Timor, efforts to develop the coffee industry in the future need the close attention of government officials, academics and NGOs. At present, the government focus is on organic coffee with a view to achieving high yields with better quality and price. Coffee sales are still being hampered by quality and production deficiencies. These problems need concerted attention by key players, namely the policy makers, governmental institutions, university colleges and NGOs.

Coffee productivity is declining, with little cleaning/weeding of plantations, pruning of existing trees or planting of new trees. The average coffee production per hectare ranges from 150 to 200 kg per year. In addition, farmers have been unable to achieve a consistently high coffee quality, which leads to cyclical annual problems of low prices and difficulty in locating markets and marketing channels.

Efforts to improve coffee quality

Most areas are covered by old coffee trees, and productivity remains low with current minimal management. The following steps are proposed for improvement:

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1. development and establishment of high yielding varieties of arabica coffee where suitable
2. replanting of plantations with new trees
3. development and promotion of better technology for planting, pruning, fertilising, pest control, harvesting, drying, sorting and handling.

Vision and mission

The vision of the coffee industry in East Timor is to develop coffee plantations in a sustainable way so they are able to compete and respond to changes in markets and competition both nationally and internationally, and able to contribute increasingly to the national economy. The mission is to: a) increase the quality of coffee in East Timor; b) empower the coffee growers; c) contribute to the country's export earnings; and d) create employment.

Issues for the development of coffee plantations

Production

Coffee culture began in East Timor many decades ago and coffee has long been the country's leading agricultural commodity. The climate in most of the country, especially the mountainous areas, is well suited to coffee production. Table 1 shows the production, areas, and farmers involved by districts in 1997, illustrating that coffee is grown in most of the 13 districts, with the majority in Ermera, followed by Maun-fahe, Liquica, Ainaro, Bobonaro, Manatuto, Covalima, Viqueque, Baucau, Dili, Lautem and Ambeno.

Coffee production in East Timor is based on relatively unmanaged plantations, with bean-gathering and processing by villagers, and scant attention paid to cleaning/weeding, pruning, pest and disease management or planting of new trees. There has been some extension and demonstration of better management, but not much uptake by farmers. Some growers harvest and sell coffee cherry directly to industry processors, while others, without access to processors, process and sell their products in the villages, sub-districts, districts and Dili. Farmers generally receive a low price due to poor quality, owing to the lack of best practice in coffee production techniques.

The most common insect pest of coffee in East Timor is the coffee flower beetle (*Stephanoders hampei*) and the most common disease is a rust (*Hemilia vastatrix*). These affect the quantity and quality of coffee production. Common weeds which affect coffee production are alang alang (*Imperata cylindrica*) and volunteer coffee seedlings. Recently, farmers have raised concerns about decline of the common shade tree (*Paraserianthes falcataria*, formerly known as *Albizia falcataria*) caused by gall rust (Old and Dos Santos Cristovao, these proceedings), which is now common over all production centres of East Timor.

Harvest and post-harvest

Coffee is harvested between March and August/September. Harvesting is not continuous but occurs in three stages — the initial stage (*lelesan*), middle stage (*panen besar*) and final stage (*racutan*). The first stage involves collection of dry and damaged

Table 1. Plantings, production and number of farmers in coffee production by district (1997).

District	Area of Planting				Production (ton)	Average Production (kg)	No. of Farmers
	TBM	TM	TT	Total (ha)			
Covalima	56	106	105	267	42	396	265
Ainaro	542	3,695	81	4,318	1,498	405	4,535
Manufahi	655	4,325	1,032	6,012	1,786	413	6,322
Viqueque	0	0	284	284	0	0	245
Lautem	0	10	6	16	3	300	20
Baucau	15	56	60	131	22	393	113
Manatuto	152	411	129	692	159	387	650
Dili	2	14	8	24	5	357	43
Aileu	168	244	371	783	102	418	679
Liquica	1,045	3,244	1,077	5,366	1,381	426	5,342
Ermera	3,900	10,510	13,411	27,821	4,562	434	25,790
Bobonaro	263	815	986	2,065	339	415	1,965
Ambeno	1	3	1	5	1	333	3
Total	6,799	25,434	17,551	47,784	9,900	360	45,972

Source: Timor Timur Dalam Angka 1997.

cherry, the middle is when the bulk of harvest occurs, and the final stage is devoted to picking the few remaining ripe, green and fallen cherries to break pest and disease cycles. In the unmanaged conditions of East Timor, many coffee trees are very tall and this poses difficulties for farmers. Much time is spent picking cherries, with little time for local sorting into red green and black cherries. This, in turn, contributes to the low quality of coffee.

Coffee is traded as dry beans, referred to as hulled (beras) or *makt* coffee, after removal of flesh and skins. There are two systems of processing: dry processing or *Oost Indische Bereiding (OIB)* and wet processing or *West Indische Bereiding (WIB*). Some farmers use the dry processing system where the cherry is picked and dried under the sun for 10 days and then stored until it is powdered and sold. The wet processing system in general is handled by larger processing plants, such as Cooperativa Café Timor (CCT). Since the purchasing power of CCT is limited (20–30% of the crop), not surprisingly, many farmers prefer to process their own coffee beans using the wet processing system. This process follows a procedure of collecting cherries, sorting, pulping, fermenting, washing, drying and sorting again, often in a traditional way using an open hole which allows contamination and loss of quality. Some farmers are able to use a local pulping machine for this processing, although the end product is often still poor.

Marketing policy

The price of coffee on the world market fluctuates widely, which poses difficulties in setting the local price. Coffee exporting countries such as Brazil, Colombia, Uganda, Ethiopia, and Angola determine the world price, with exporters in East Timor having little influence and often receiving low prices because of low quality. As the main coffee exporter in 2000, CCT exported about 20–30% of production or some 2000–3000 tonnes. Other companies wanting to buy coffee from farmers for export were restricted by the low quality. CCT can guarantee quality as it buys red cherry direct from farmers and processes immediately in the factory, which in turn enables the company to offer good prices to farmers. Other factors, in terms of marketing, that need attention, are the availability of market information, understanding of marketing channels, establishment of farmers' associations and availability of infrastructure.

Many improvements in coffee production and marketing are needed. Access to market information is very important in considering price fluctuations and market directions and to serve as a base for policy making. A feasibility study on marketing channels is needed to provide an overview of maximum and minimum prices that must be received by farmers, middle agents and exporters. Another important factor to be taken into account is the expansion of farmer associations or groups which serve as forums to discuss and promote common interests. Appropriate infrastructure also needs upgrading, including a better telecommunication system, established associations and business partners, and better road and transportation systems.

Expected outcomes

Better management of coffee plantations with appropriate improved technologies should lead to better yields. It is estimated that some 16,000 ha of ageing coffee trees are no longer productive. Given that about 3200 ha can be replanted each year, it would take five years to replant 16,000 ha. To undertake this work, farmers need a better understanding of good techniques and access to micro-credit facilities. To minimise the burden on the government and farmers, selective replanting is suggested. For example, farmers with one hectare of coffee would replant and rehabilitate 0.25 ha each year for four years, to create a continuous production and income stream, where the first year planting was already productive when the third and fourth year replanting was undertaken.

In replanting, it is important to select superior seed with high yield potential and resistance to pests and diseases. In managing plantations, it is desirable to prevent trees from becoming too tall and difficult to harvest by regularly trimming primary branches, and regularly controlling pests, diseases and weeds. A combination of replanting and better management can increase production from 150–200 kg/ha to 260–300 kg/ha.

An emerging national crisis for the coffee industry, as mentioned above, is the gall rust disease caused by *Uromycladium tepperianum* which has appeared on the common coffee shade tree *Paraserianthes falcataria* (formerly *Albizia falcataria*). Technical staff of MAFF have commenced intensive monitoring in five production centres to develop a better understanding of the disease. It is thought initially that the problem might be best managed by replanting resistant *Paraserianthes falcataria* or replacing it with *Casuarina junghuniana* and *Leucaena leucocephala*.

In terms of harvesting, it is expected that careful application of better technology, such as pruning, will make it easier and quicker to harvest coffee in the field. Attention to removal of insect-damaged fruit at early and late harvests will help with crop hygiene, especially control of *Stephanoderes hampei*.

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After harvest, coffee can be processed either wet or dry, as described above. Wet processing is costly, as it involves capital investment, but it guarantees good quality. At present, MAFF staff and some NGO representatives are developing and rehabilitating several processing centres as a demonstration, with the hope that all farmers in farmer groups will be able to develop simple processing centres for use where there is no access to bigger processing factories. It is hoped to develop three or four processing centres a year over a period of five years. It is important in processing, after separation of the flesh and skin, that coffee beans are dried to an optimum moisture content of 10 to 13%, as above this range, moulds are a risk and below it, breakages may occur.

Coffee is marketed as beans with a moisture content of about 13%. It is hoped that the value of coffee exports from East Timor will increase every year. This will require better information on a weekly basis about market related issues and coffee prices, to facilitate the buying and selling process between farmers and traders and to ensure farmers do not feel they suffer financial losses. To strengthen the bargaining position between farmers and traders, there is a need to establish farmer associations at the village and district level, and it is hoped this can be encouraged to promote better marketing outcomes for farmers. Marketing also requires better infrastructure and the government is allocating budgetary support for road infrastructure that links market centres to areas of coffee production. It is hoped that in five to 10 years time road transport facilities will not be a constraint to coffee marketing.

Recommended programs and solutions to improve the coffee industry include the empowerment of human resources by providing education and training for agricultural staff, extension and training for farmers, training in organisational management and development of a professional coffee association; and increasing the quality of coffee from Timor by: establishment of one quality seed centre, replanting of 16,000 ha of old plantations, establishment of three or four processing centres a year, providing better means of production, intensive monitoring of gall rust on *Paraserianthes falcataria* and testing of alternative shade trees for coffee.

Figure 1. Villagers making mulch in a coffee plantation. Photographer: Colin Piggin

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The Cooperativa Café Timor (CCT)

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Abstract

Many complex cultural and social, as well as economic, factors affect coffee cultivation in East Timor. Very little work is invested into the husbandry of coffee. Bushes are not pruned or mulched, replanting hardly takes place, fertiliser and pesticides are not used to enhance yields, and families are said to harvest coffee only for present cash needs rather than profit maximisation. In the past, the emphasis was placed on harvesting a large quantity, regardless of quality, as the organic coffee was sent to Indonesia for blending. Only in more recent years has the emerging cooperative organisation under the USAID-sponsored NCBA and CCT begun to pay a premium for better quality cherries and to improve the quality of local processing.

Better and proper application of technology in coffee production must be made available to improve the quality for exports. The international standard requirement by OCIA gives rise to continuous inspection of organic coffee to ensure high quality products. As a country that exports premium organic coffee, it is imperative that East Timor maintains its international competitiveness. As East Timor is registered as one of the international organic coffee members, efforts to maintain good quality are of importance to the farmers and the government.

Background

THE Cooperativa Café Timor (CCT) is a 100% Timorese owned secondary cooperative involved in the processing and marketing of organic coffee on behalf of its producer members. The CCT was established in 2000 under the Timor Economic Rehabilitation and Development Project (TERADP), which is being implemented by the National Cooperative Business Association of the USA (NCBA) with a grant from USAID. Initially the program was developed by NCBA in cooperation with East Timor Center for Village Unit Cooperatives (PUSKUD) 1994 with the mission to develop organic coffee as an international market commodity for East Timor. Organic coffee became very popular around the world in the late 20th and early 21st centuries in response to consumer concerns about chemicals in food. Organisations in at least 68 countries have joined the International Federation for Organic Agricultural Movement (IFOAM) in developing and promoting organic farming. Also the demand for organic arabica coffee had shown an upward trend from 197 tonnes in 1992 to 445 tonnes in 1993, an increase of 126%.

In line with the stated mission and vision, an agreement was signed between PUSKUD and NCBA to develop organic coffee by setting up an autonomous organic coffee division as a unit under PUSKUD Timor-Timur in 1995. This positive cooperation was important and eventually became a competitor to other coffee traders such as PT Batara Indra and PT Denok. Following independence for East Timor after the ‘popular consultation’ on 30 August 1999, and by written agreement of the directors, PUSKUD changed its name and became the CCT. The goals of the project were, and still are, to improve the level of welfare of the coffee growers; introduce marketing chains to the population; and contribute to the planning and policy development for a commodity which supports the economy of the people of East Timor.

Production of CCT organic coffee has grown in line with the increasing demand for organic coffee in the USA, Europe and Australia. Production was 30 tonnes in 1995; 457 t in 1996; 775 t in 1997; 1363 t in 1998; 1476 t in 1999; 1255 t in 2000; and 1320 t in 2001. Reflecting demand, prices per pound on world markets are US$0.20–0.30 higher for

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organic arabica coffee than for non-organic coffee. When world coffee prices fell to US$0.70 in 1998, the prices of washed organic coffee still remained substantially higher in the markets of Germany, Holland and Switzerland. The prices of organic coffee tend to be higher and more stable compared to non-organic produce because of the easy access of organic coffee to both the specialist organic and the conventional markets.

As mentioned above, PUSKUD was redefined as CCT in early 2000 based on the CCT-NCBA mission and vision, the Memorandum of Cooperation between CCT-NCBA, programs of the Department of Agriculture, RDTL, and the current five-year (2002–2005) programs of the USAID-NCBA grant.

The aim and scope of this paper is to outline the TERADP program, with its focus on the organic coffee industry and with the development of the cooperative movement. In the case of the TERADP program the objectives also encompass the provision of primary health care to the CCT member families, and the development of vanilla and cattle fattening industries as diversification for organic coffee on a national level. The program also includes a formal and non-formal educational program in the development of cooperatives and small businesses, as well as a cooperative trading in the essential household commodities for rural people at reasonable prices, in an effort to reduce the excessive general cost of living for the people of East Timor.

The organic coffee industry

Understanding organic coffee

Organic coffee is produced without the use of inorganic fertilisers or pesticides, with traditional low-input and manual approaches to the planting, management and harvesting operations. Organic coffee farming not only involves the absence of non-organic materials, but also takes into account other naturally sustainable methods such as erosion control on steep land, good pruning, maintenance of shade, weed control and the supply of organic inputs, e.g. composts and mulches.

In social and economic terms, organic coffee production is not only beneficial to coffee growers, but also to the processors, traders and consumers. Organic culture also has the aim of improving the biological cycle through the increase of micro-organisms, flora, soil fauna, plants and animals, preserving soil fertility and curtailing pollution as well as balancing the social impacts on the wider ecological environment.

Culture of organic coffee

Based on organic coffee standards formulated by IFOAM in 1992 and the limits fixed by the EEC in 1991, organic farming techniques are not so different from conventional coffee culture in many respects, with attention being paid to the following:

1. The location of the coffee production area must be clearly delineated, inspected and certified annually, in the case of CCT, by the Organic Crop Improvement Association of the USA. The areas must be free from contamination or influence from synthetic chemicals or pesticides, with a buffer zone between the organic crop and other crops where inorganic fertilisers and pesticides are used or sprayed.
2. The varieties or clones to be grown should be adapted to the soil conditions and local climate as well as being resistant to pests and diseases. Farmers in East Timor plant arabica and robusta coffees, both of which are well suited to the natural conditions and climate of the country. Shade trees such as *Casuarina junghuhniana* and *Paraserianthes falcataria* (formerly *Albizzia falcataria*) are used widely to provide the necessary protection from direct sunlight and wind.
3. The pattern of cropping is to plant shade trees 2–3.5 years in advance, after which the coffee is planted in a traditional, random arrangement. The coffee is not planted as seeds, but as self-sown seedlings, which are collected from existing production areas.
4. The soil fertility is increased and maintained by returning adequate organic matter to the soil from other organic gardens, compost, animal manure, plant wastes, green manure or other mulches. Crop and animal residues may need to be composted to make the nutrients available. The shade trees used in East Timor also fix atmospheric nitrogen and enrich the nitrogen status of the soil.
5. Pest and disease problems are considered in relation to the overall agricultural ecosystem management, which aims to limit use of even organic pesticides by focusing on integrated pest management (IPM) through resistant varieties, rotation of varieties, and mixtures to encourage natural predators, parasites and pathogens

CCT’s implementation and extension activities

CCT provides extension and other advisory services to its cooperative members in the following five districts: Ermera (8828 families on 10,629 blocks), Liquica (2988 families on 3801 blocks), Aileu (1019 families on 1021 blocks), Ainaro (5361 families on

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8948 blocks), and Manufahi (1388 farm families on 1489 farm blocks). Since early 1994 CCT has conducted a number of activities including:

1. identifying and arranging for the organic certification of the 19,584 member farm families on 25,888 coffee production blocks, who are organised in 493 groups in 16 organic coffee cooperatives (CCOs).
2. setting up demonstrations of coffee rehabilitation based on pruning in Ermera (7 ha), Letefoho (1 ha), Liquica (3 ha), Aileu (1 ha) and Maubisse (1 ha), and undertaking pruning extension programs more widely across all locations every year.
3. setting up wet processing factories for coffee in four locations with capacities as follows: Liquica, 60 tonnes/day, Aifu 100 t/day, Estado 320 t/day and Maubisse 320 t/day. These facilities are to be expanded for the 2003 harvest season.
4. setting up a dry-processing factory for coffee in Dili, with a capacity of 200 t/day. There are also two sun-drying fields for the coffee in Tibar, Liquica District, along with warehouses to store the coffee parchment until the factory is ready to accept the batch for processing. The final export product is the coffee green beans in various quality grades established by professional tasters (cuppers).
5. collection of data on coffee blocks and levels of production.

In addition, two divisions of CCT are involved in improving and developing the industry through:

- improving quality of organic coffee
- improving the operation of cooperative coffee organisations
- planting of vanilla starts (currently 40,000) as an alternative crop
- a pilot project with selected farmers to fatten and market Bali breed cattle as an alternative income source
- improving the management of product marketing
- preparation and distribution of 200,000 shade trees to farmers
- training farmers to run their own business enterprise to increase their income levels.

In addition, there are ongoing efforts to improve the health and education of cooperative members and their families as follows:

- provision of primary health care services by Clinic Café Timor in all coffee-growing areas through professionally staffed clinics established in the districts of Ermera (three clinics), Aileu (one clinic), Ainaro (two clinics), Manufahi (one clinic), and Liquica (one clinic), along with a central clinic in the CCT headquarters in Dili. The rural clinics also service outreach centres with regular mobile clinic visits.
- provision of educational courses in such topics as information technology and English and Portuguese languages as well as basic accounting training conducted by the Klibur Mata Dalan no Fila Liman Ba Cooperativa (Cooperatives and Small Business Training Center) based in Dili.
- Establishment of a commodities cooperative trading in basic houshold commodities at reasonable fixed prices to assist in the control of the high cost of living in East Timor, especially Dili. This cooperative currently has 94 member small kiosks and stores in Manatutuo, Baucau, Viqueque, Aileu, Ermera, Liquica and Dili which are serviced by regular visits with supply trucks.

Implementation of organic coffee technologies

The CCT is promoting better practices in coffee production in many ways. This includes trimming of coffee trees before they reach 7–10 m high to provide greater sunlight, facilitate air circulation, reduce humidity, and remove old unproductive branches. The system has been demonstrated in 1997 involving 1000 farmers and up to 10 ha in the Ermera, Ainaro, Liquica, Aileu and Manufahi districts — responses have been impressive with production increasing from 500–1000 kg/ha to 2000–2500 kg/ha over three years. Other steps to maintain good quality coffee production have been demonstrated and promoted, including the planting of a shade tree nursery, manufacture of compost, replanting of coffee seedlings, field measurement and registration, assistance with regular coffee production block certification inspections by the Organic Coffee Improvement Association of USA (OCIA), and cooperative training management in the 16 CCOs.

Organic coffee inspection

OCIA is an internationally recognised organic crop certification authority based in Nebraska, USA which provides inspection, accreditation and certification services to growers who want to achieve organic production standards and use OCIA certification on their products. Certificates provided to member groups, i.e. the CCT and CCOs, upon attainment of necessary standards, provide assurance to customers that the produce is organically grown using:

- no synthetic pesticides or fertilisers in production or processing
- sustainable methods of production involving crop rotation, green manure, composting, and sound weed and pest management to obtain high yields and healthy soil

- no handling or runoff to soil and waterways of chemicals.

Producers must document at least three years of operation without synthetic chemicals, grow the crop according to OCIA standards, and pass annual certification based on inspections of fields, record keeping, and processing operations, before OCIA certification is approved. In the case of East Timor, all CCT/CCO member coffee blocks have been registered and certified as organic producers by OCIA, however this is only about 50% of the families who claimed to be coffee producers in the (most recent) 1997 census. The annual certification includes the inspection of 10% of the CCT member coffee blocks, the wet and dry processing locations, the drying fields and warehouses, as well as CCT's administrative and transport systems that trace the coffee from farmer's field to export containers full of green bean. It also involves the laboratory analysis of coffee characteristics and quality, which determines the proper labelling of the final product. This gives the country a competitive advantage in marketing its coffee as it has been widely recognised for decades to be a natural organic system, with minimal inputs.

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Agricultural mechanisation: managing technology change

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Abstract

Rural and agricultural development is high on East Timor's agenda aimed at achieving food self-sufficiency and ameliorating the quality and standard of living of its people. The plan envisages major increases in agricultural productivity, for which agricultural mechanisation has a key role to play. Mechanisation, properly implemented, will be instrumental particularly in saving energy and resources and promoting use-efficiency and productivity of other farm inputs. Its implementation in the past, however, for various reasons, was not well coordinated or supported by adequate policy measures. As a result, many resources have been used inefficiently and farmers, largely resource poor, continue to rely mostly on conventional means of farming, using indigenous tools and equipment. This paper aims to discuss selected issues of agricultural mechanisation experienced elsewhere that are relevant to East Timor. Particular emphasis is given to a general understanding of mechanisation technologies, their management, and a policy approach that enables a gradual, evolutionary, and rural-economy based technical change.

Introduction

THE farmer who has access to and knows how to use what science knows about soils, plants, animals, and machines can produce an abundance of food though the land be poor (Schultz, 1964)

Agriculture is the mainstay of East Timor's economy, yet numerous bottlenecks — socio-economic, political, and techno-cultural — need to be overcome before it can be an engine of growth and source of adequate food production.

Recent surveys indicate that agriculture is the main source of income for the vast majority of villages and food and cash shortages are of major concern nationwide.[1] Cash shortage, in particular, will be a major constraint to introducing improvements in rural areas where the majority of the poor live. At the national level, there is increasing willingness to adopt strategic agricultural development plans to address issues such as poverty alleviation, hunger and malnutrition. Included in such plans is the necessity to pursue improved technologies, which enhance food security, while preserving the resource base. Farmers, extension workers and policy makers will be frequently required to make decisions on the level of technology that is suitable for individual farmers. This involves determining the appropriate combination of manual, animal and mechanical powered technologies that are technically suitable and meet economic and social development objectives.

Historical background

Much has been recorded about East Timor's colonial past, however very little is known about agricultural technology development, especially during the pre-1975 Portuguese administration.[2] After the

[1] Details of the latest village and household surveys can be seen in the Poverty Assessment Report, a work in partnership by the East Timor Transitional Administration (ETTA), the Asian Development Bank (ADB), Word Bank and UNDP (2001). Much of the data was also reported in East Timor: State of the Nation Report (Planning Commission, 2002).

[2] Data on selected agricultural development indicators can be found at FAOSTAT (www.fao.org), covering a period from 1961 to 2000. See also Saldanha and Da Costa (1999) for an overview of development policies from the Portuguese regime to the end of Indonesian rule. For the Portuguese era, an official data source of development indicators was the Speech Report of Governor Aldeia in 1973 cited by the authors.

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establishment of plantation-based agriculture in the 1950s, the government embarked on creating the foundation infrastructures of a modern economy. The opening of new land for rice cultivation and improvement of irrigation systems in the major agricultural centres of Viqueque and Baucau in the 1960s marked the start of a new agricultural era. The introduction of tractors in substantial numbers and the establishment of several rural extension centres, such as those in Natarbora, Betano and Loes, occurred during this period. As well as government efforts, missionary colleges in Fatumaca, Fuiloro, and Maliana may have contributed to the introduction and promotion of agricultural machinery.[3] New varieties of rice, namely IR-5 and IR-8, were brought from the International Rice Research Institute in Los Baños Philippines and introduced and disseminated with considerable success. Rice farmers in some parts of East Timor are still using variants of these early seeds. Another innovation introduced alongside the new seeds was the transplanting method of rice cultivation.

A similar path was followed during the more than two decades of the Indonesian regime. Thinking on agricultural development was mainly preoccupied with the problem of how to achieve food self-sufficiency through the adoption of 'green revolution' technologies such as large-scale machinery, hybrid seeds, chemical fertilisers and a large irrigation network. Unlike the situation in the Portuguese era, agricultural development priorities focused on regions offering fewer security threats in the western part of the territory, namely Maliana and Suai.[4] Despite being referred to as a period of uncertain development (Saldanha and da Costa, 1999), the last decade of the Indonesian era provided some measurable achievements. Data from this period are essentially useful for future potential assessments and policy design, especially in the area of agriculture and rural development.

The transitional phase under the United Nations administration was, in part, aimed at recovering developmental assets which were severely damaged during the September 1999 tragedy and also establishing necessary foundations for the new country's short-term and long-term development plans. There is a great deal of interest among the country's policy-makers in adopting mechanisation as a way of enhancing agricultural productivity. Although it is potentially promising in theory, the success of such a plan depends on a large number of factors — many site-specific and others macro in nature. Consequently, the real cost of mechanisation and its impacts has to be assessed over time. An approach that could make this task possible is to put in place realistic mechanisation policies from the outset.

Table 1 presents a general picture of East Timorese agriculture developed over the years, recorded from the last decade of the Portuguese regime until the period of Indonesian administration. Figures are mainly estimates and so, should be approached with caution. However, they may provide a rough indication, especially of the pre-1975 status of mechanical power and labour input. Since the introduction of the *Plano de Fomento* (Five-Year Development Plan),[5] the use of tractors has gradually increased. Not surprisingly, however, labour intensity was also on the rise, suggesting that agricultural production has been predominantly labour intensive.

The scope of agricultural mechanisation

Agricultural mechanisation embraces the use of tools, implements and machines for farming and land development, production, harvesting, and on-farm processing. Within the historical and economic context, agricultural mechanisation has seven stages of evolution (Rijk, 1989; Speedman, 1992).

1. Stationary power substitution, where mechanical power is substituted for human power used in stationary process.
2. Motive power substitution, where operation systems previously based on human power are replaced by mechanical power.
3. Human control substitution, where emphasis is placed on mechanising operations previously controlled by human decision making.
4, Adjusting cropping systems to the requirements of mechanisation (cropping system adaptation).
5. Adjusting farming systems to the requirements of mechanisation (farming system adaptation).
6. Adjusting plant physics to the requirements of mechanisation (plant adaptation).

[3] In terms of sustainability and reliability, the management of agricultural machinery in these missionary colleges provides a model of success. The Fuiloro School of Agriculture in Lautem and Fatumaca Technical School in Baucau for instance, apart from being educational institutions, have long been assisting local farmers with the provision of mechanical tools and equipment.

[4] See Fox (2001) for an anthropological viewpoint of East Timor's agricultural development with particular emphasis on its stages of transformation.

[5] Plano de Fomento started in 1960 with development priorities given to vital sectors such as infrastructure (transport and communication), agriculture, education and health. Introduction of new plants (cinnamon, cacao and other fruits) occurred during this period.

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Table 1. Selected agricultural development indicators for East Timor 1961–1999*.

Indicator	1961	1965	1970	1974	1980	1985	1990	1995	1999
Tractors in use	7	8	98	110	114	115	115	115	115
Tractor use intensity (ha/tractor)	11,429	10,000	816	727	702	696	696	696	696
Agricultural labour force (thousands)	244	259	280	313	273	298	322	360	316
Agricultural workers as a percentage of labour force (percent)	86.8	86.3	85.9	85.5	84.8	84.4	83.6	82.8	82.3
Agricultural labour intensity (worker/ha)	3.05	3.23	3.5	3.9	3.5	3.6	3.95	4.5	4.1
Cereal yield (kg/ha)	1404	1197	1277	1500	1305	1492	1608	1954	1962
Cereal import (thousand metric ton)	0.8	1.9	2.4	2.5	na	na	na	39**	50**

* Based on FAOSTAT database (www.fao.org). na: data not available.
** Figures for rice only, from East Timor provincial statistics.

7. Automation, where operations in agricultural production are fully automated.

The sequence of these stages is generally identifiable at the farm level.[6] In East Timor, as in many other developing countries, stages I and II are clearly pronounced and often adopted simultaneously. In other countries, stage III may be implemented on a few large state plantations before the majority of farmers have adopted it.

Despite the distinct technical features, the reasons for mechanisation are mainly economic, as indicated in desired outputs such as an increase in labour productivity, increase in land productivity, and decrease in production costs. Therefore, the mechanisation stages may be presented as the result of a change in factor prices (Fig. 1).

The mechanisation possibility curve (MPC) represents the envelope of all possible mechanisation technologies the farmer may select. The reasons for mechanisation are mainly expressed in economic terms such as increase in labour productivity, increase in land productivity and decrease in production costs. Therefore, the mechanisation stages may be presented as the result of change in factor prices. The relative factor price for capital/labour in slope I indicates a cost minimising process representing stage I (labour-intensive) while stages II and III require a greater capital-using process with a relative price change to L'K' and L"K" respectively (capital-intensive).

A jump from stage I to II and higher stages is not simple for many developing countries as it is governed by a number of factors and issues. Land and labour endowments, demand for off-farm labour, and demand for agricultural products are the major factors determining the rate and pattern of mechanisation. Issues may range from choice of techniques, technology transfer and adoption, and type of technical changes, to farming system evolution. A comprehensive analysis will help identify the impacts of mechanisation on land and labour productivity, employment, income distribution, and change in social and cultural values across different regions and agro-ecosystems within a country. The role of the public sector will be pivotal in setting up the right direction based on a long-term vision for East Timor's mechanisation program. Regional experiences and studies conducted elsewhere may serve as useful references.

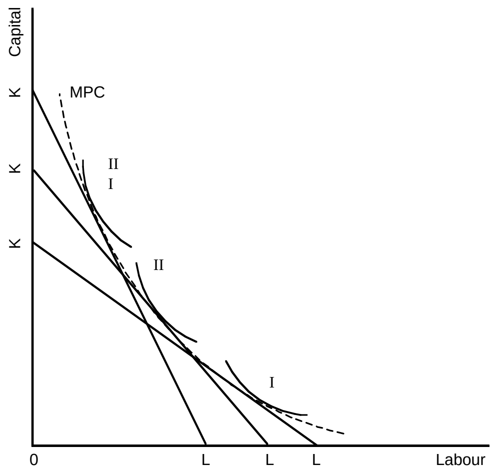

Figure 1. Mechanisation Possibility Curve (MPC) (adapted from Rijk, 1989).

6 Another grouping of agricultural operations is based on the relative intensity of the use of power as compared to the use of human judgement namely *power intensive* (land preparation, threshing, milling, etc.) and *control intensive* (weeding, sifting, fruit harvesting, etc.) (Pingali et al., 1987)

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Table 2. Estimated inputs of human, animal and mechanical power, tractor use intensity and labour intensity for crop production in selected countries of Asia.

Country	Input (hours/ha)[a]					Tractor use intensity (ha/tractor)[b]		Labour intensity (worker/ha)[b]	
	Ctg[c]	1956	1970	1975	1978	1990	2000	1990	2000
Japan	H	1410	1178	815	694				
	A	15	2	—	—	2.4	2.4	0.89	0.57
	M	144	185	179	148				
Taiwan[d]	H	1088	985	778	601				
	A	122	103	51	36	na	na	na	na
	M	40	56	84	98				
Korea	H	1356	1284	1176	937				
	A	92	101	80	56	51.2	10	1.68	1.24
	M	4	8	18	48				
Philippines	H	504	552	640	640				
	A	200	136	136	136	923.4	873.9	1.11	1.23
	M	42	45	45	45				
Thailand	H	490	480	470	462				
	A	170	165	160	146	356.8	81.8	0.97	1.17
	M	10	15	20	30				
India	H	1218	958	992	1285				
	A	230	247	221	125	171.5	111.3	1.35	1.55
	M	120	na	na	113				
Pakistan	H	619	637	637	637				
	A	312	308	284	128	78.8	68.5	0.98	1.11
	M	na	neg	2	6				
Nepal	H	1200	na	na	1448				
	A	312	na	na	304	522.9	645.2	3.75	3.76
	M	neg	na	na	2				

[a] Figures estimated for rice production only. Source: Duff and Kaiser (1984).
[b] From FAOSTAT data (www.fao.org).
[c] Category: H = human; A = animal; M = mechanical.
[d] Tractor use intensity and labour intensity data not available (na) from FAOSTAT. Taiwan official source indicates that agricultural machines have gradually replaced labour input in farm production since the 1970s. For rice production, the labour input was only 255 hours per hectare in 1996, a 69% decrease in labour input compared to 1970 (www.coa.gov.tw/english/agricultural/).

Table 2 demonstrates a clear differentiation in mechanisation stages among selected countries in Asia during the period of the green revolution until recent times. Figures for Japan, Taiwan and South Korea suggest a higher degree of mechanisation and larger degree of urbanisation as indicated by the declining use of human power. Interestingly, for Japan, machine hours were also decreasing, which may suggest the preferential use of larger machines allowing rapid completion of work. A very low labour intensity also indicates a very advanced stage of mechanisation, where field operations are fully mechanised, involving some degree of automation. Rice cropping in Taiwan is nearly 100% mechanised from planting to harvesting. For other countries, the increasing labour use was mainly induced by the adoption of labour-intensive modern rice varieties while the increasing machine hours were largely devoted to land preparation and threshing, particularly in the Philippines and Thailand (Duff and Kaiser, 1984).

A tremendous increase in the irrigated area of many Asian countries promoted by extensive irrigation schemes to increase cropping intensity has been one of the major reasons to acquire more power inputs. The number of tractors (as one of the major power sources) and other farm machinery shows an increasing trend for all Asian countries (Salokhe and Ramalingan, 1998). Mechanisation in most of these countries is associated with rice production as the main crop. A different scope and degree of mechanisation may be promoted by countries which have crops other than rice as the main crop, e.g. Pakistan (wheat), Sri Lanka (tea, spices), and Malaysia (rubber, oil palm). As well, varied characteristics of geography also require different types of machinery and equipment. These are some of the soil and crop technical issues related to mechanisation that need to be considered for a successful and sustainable mechanisation program in East Timor.

Mechanisation technologies

Much of the controversy over agricultural mechanisation, both at academic and policy-making levels, has emerged from the fact that it is often considered only as the application of mechanical power technology, particularly tractors. However, three main levels of mechanisation technology need consideration: hand-tools, draft animals, and mechanical power technologies[7], with varying degrees of sophistication within each level (Rijk, 1989), on the basis of capacity to do work, costs, and, in some cases, precision and effectiveness (Morris, 1985).

Hand-powered tools

The predominant form of rural technology is based on manual labour, with the hand hoe as a basic ingredient. The main attributes of this system are that it represents a low-cost, low-energy, labour-using, family-oriented technology, which is closely attuned to traditional and subsistent farming methods such as shifting cultivation and intercropping, and is largely self-sufficient and drawn on locally made implements (Morris, 1985). Much of the agricultural production in poor rural communities emphasises risk minimisation and home consumption, with only a small part passing through market channels.

Hand-powered tools are the technology most widely used by East Timorese farmers. Tools include axes and machetes for land clearing, hoes and steel digging sticks for seedbed preparation and tuber and root crop harvest, and sickles and knives for weeding and harvest. Other hand-powered tools include those for winnowing, rice polishing, maize grinding, and candlenut, coconut and coffee processing. Most of these tools are present in any traditional household, both in upland and lowland communities. Given the simple nature of many traditional implements, much scope exists for increasing productivity by improved hand tools and man-powered machines.

A recent study by Clarke and Bishop (2002) reveals that humans are the most significant power source in sub-Saharan African countries where 65% of the land is cultivated by human power. In central and western Africa, they account for an estimated 85% and 70% of harvested area respectively, while the land cultivated by humans is estimated 40% in East Asia and 30% in South Asia.

Animal traction

Animal traction is often seen as an outdated and backward technology. Therefore, rapid agricultural development is often taken to imply the bypassing of the animal-traction stage and going directly from hand tools to the use of tractors and other purchased inputs such as fertilisers and pesticides. This is also the case in East Timor. Except for the *rencah* system, where a group of water buffalo are used to puddle the soil, and the use of horses for transport and rice threshing, there is little, if any, evidence of the use of animal traction in combination with implements for land preparation and crop husbandry. Efforts were made during Indonesian times to introduce the *luku* system, a moldboard-plough pulled by a single or pair of oxen, for primary and secondary tillage. It involved the use of Bali cattle and was demonstrated primarily by Indonesian farmers who were relocated to several transmigration centres in East Timor.[8] It was not widely disseminated, probably for technical reasons such as lack of animals and skills in animal husbandry, and lack of fodder. Another reason may be the cultural aversion of local farmers to the use of animals for work. However, given the minimal adoption of modern technologies used elsewhere, methods of reintroducing appropriate animal-powered technologies should be explored.

Animal power is still widely used in China, while Indian agriculture has been traditionally dependent on draft animal and human power as the major source of energy. During the 1960s, several newly independent African countries, among them Tanzania, Zambia, Guinea, Ghana, and the Ivory Coast, adopted policies that were designed to leapfrog the animal traction stage by providing tractors and tractor-hire services at subsidised rates. Most of these attempts at rapid 'tractorisation' failed and several countries subsequently reverted to encouragement of

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[7] See Clarke and Bishop (2002) for a detailed analysis of farm power present status and future projections for developing countries. Countries were categorised into six types of farm power: predominantly manual; significant use of draft animal power (DAP); DAP predominant; significant use of tractors; tractors dominant; and fully 'tractorised'.

[8] The ETADEP Foundation, through its agricultural and community development program, is also promoting the use of animal traction for soil preparation in Natarbora and Raimate.

animal-draft power (Pingali et al., 1987). As mentioned earlier, in countries with advanced levels of mechanisation, the use of animal power has been gradually falling (Korea and Taiwan) and even totally displaced (Japan) (Table 2).

The introduction of tractors

Tractors were imperative to modernisation in the view of many, including policy makers in the past. During the last decade of Indonesian administration, through the agricultural intensification program (BIMAS), a huge number of tractors and implements were introduced annually. Table 3 indicates the machinery status in 1997, an approximate figure to that of the pre-1999 crisis, and the situation in 2000, at a time when the machinery demand for land cultivation was at its peak.

The inclusion of crop production figures in Table 3 does not necessarily imply a relationship with the use of the tractors. The use of mechanisation is not the sole factor contributing to increased yield. The concepts of *net contribution effect* (increased crop production) and *substitution effect* (machinery substituting for labour) help explain the relationship between the two (Ruthenberg, 1985), since it is difficult to view the specific economic benefits of mechanisation technology in isolation. So, the crop production in those years comes as a result of mechanisation being applied in conjunction with other crop production technologies such as irrigation, improved seeds, the use of fertilisers and pesticides, labour and higher levels of management. Available data for 1997 on selected tools and equipment for crop protection is given in Table 4.

According to Rijk (1989) a statistical correlation between the level of mechanisation and yield does not necessarily indicate a causal relationship and may lead to the incorrect conclusion that mechanisation increases production. In many cases, the increased production induced by factors such as fertiliser application and good irrigation may result in higher net income, which in turn could stimulate investment in mechanisation. Research results also indicate that when adjustments are made for the level of fertiliser used, yield differences between mechanically and traditionally tilled fields become insignificant (Duff and Kaiser, 1984; Bernsten et al., 1984).

The tractor mobile brigades

The willingness of policy makers in the recent past to adopt the use of tractors as a way of speeding up agricultural crop production is understandable, especially at a time when the need for food was paramount. The

Table 3. Number of tractors, maize and paddy production (ton) for East Timor 1997–2000.

Districts	Number of tractors		1996–1997[a]		1999–2000[a]	
	1997/1998[b]	Aug 2000[c]	Paddy	Maize	Paddy	Maize
Aileu	9	6	1,700	10,500	1,411	9,240
Ainaro	9	11	1,600	4,500	1,072	3,195
Oecussi	72	6	5,300	8,800	1,325	3,080
Baucau	42	37	12,000	14,000	9,720	13,300
Bobonaro	127	22	15,000	28,600	8,100	15,444
Covalima	14	17	5,000	16,000	3,600	12,160
Dili	6	7	200	2,000	172	1,900
Ermera	14	6	3,300	6,200	2,838	4,774
Lautem	24	7	3,200	7,700	2,880	7,392
Liquica	6	6	500	5,000	210	1,400
Manatuto	13	29	4,800	4,000	3,984	3,680
Manufahi	47	20	2,200	5,000	1,848	5,000
Viqueque	34	14	17,200	14,000	13,760	14,000
Total	417	188	72,000 (43,200)	126,300	50,920 (30,552)	94,565

[a] Figures in brackets are polished rice taken at 60% from unhusked paddy.
[b] From Dinas Pertanian Tk. I records. Figures include non-operational tractors. Numbers for Oecussi, Baucau, Bobonaro, Manufahi and Viqueque consist mainly of handtillers.
[c] *Source:* Wilson (2000). Tractor figures composed of John Deere tractors purchased by CNRT with funds from Macau, Tonyang handtillers purchased by UNDP with funds from Norway, and Kubota handtillers supplied by JICA.

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Table 4. Selected agricultural tools and equipment for plant protection, 1997.

Districts	Pedal/power thresher	Sickle	Water pumps	Hand/power sprayer	Mist blower	Swing fog
Aileu	4	95	2	102	15	0
Ainaro	4	0	0	61	2	5
Ambeno	49	0	2	37	2	20
Baucau	66	36	0	33	2	30
Bobonaro	12	0	4	216	5	25
Kovalima	54	0	6	48	0	20
Dili	0	0	7	16	1	110
Ermera	5	175	6	57	1	0
Lautem	4	0	0	79	7	0
Liquica	3	0	0	33	3	0
Manatuto	2	0	0	36	1	20
Manufahi	32	34	0	178	2	20
Viqueque	41	0	0	120	7	20
Total	276	340	27	1016	48	270

Source: Dinas Pertanian Tk. I records.

small-scale mechanisation scheme suggested through the World Bank-led joint assessment mission in November 1999 became a large-scale shceme,[9] which may not be easy to sustain over time.

Earlier assessments of the tractor brigades suggested that farmers had little or no understanding of what was necessary for maintenance and that spare parts were difficult to obtain. At the policy-making level, requests emerged for the need for international expertise to assist with the planning and implementation of mechanisation promotion programs (Wilson, 2000; Watahiki, 2000). Only one spare parts dealer exists in Dili and parts have to be imported, especially from Surabaya. Local manufacturers are non-existent, even since the Indonesian period. Private sector repair and fabrication workshops are currently running in small-scale units. The Chinese Government assigned a team of engineers and technicians from May–December 2002, to assess the condition of all agricultural machinery and to train Timorese operators and mechanics in repair and maintenance (Benevides, pers. comm.).

Since all the tractors are operating in districts where there is little institutional support, they face enormous difficulties. When machines are stationed in remote parts of the country, it is very difficult to keep them properly fuelled, lubricated and serviced. Not surprisingly, many machinery breakdowns do occur, and often these occurrences coincide with the time when the machines are under greatest stress, especially during the peak cultivation season. Since spare parts and competent mechanics are extremely scarce, delays in getting machines operational can be lengthy.

The mobile brigades have been dissolved and the tractors and implements are now being held under the responsibility of the agricultural division of the District Administration. Given the very limited public sector resources to manage the machinery fleet, Wilson (2000) identified five possible ways for long-term machinery management (and ownership).[10]

1. Incorporate the mobile brigades within the Pilot Agricultural Service Centers (PASCs)
2. Transform the mobile brigades to farmer-owned cooperatives
3. Contract arrangement with locally-owned business companies with mobile brigade staff becoming shareholders
4. Farmer group ownership through a credit scheme
5. Individual farmer ownership through a credit scheme.

For a short introductory period, a subsidised tractor-hire service run by government agencies can be beneficial as a demonstration scheme. The demonstration effect, linked with extension efforts, will help promote technology adoption, leading to machinery ownership by farmers. The entry of

9 The distribution of hand-powered tools was part of the small-scale mechanisation scheme. Parallel with this were the immediate projects of water buffalo population recovery, reconstruction of meteorology stations, and the rehabilitation of major irrigation networks.

10 Similar types of ownership were suggested earlier by Watahiki (JICA, 2000).

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private contractors into the hire market will also be encouraged beyond this introductory period. In the medium to long term, however, the involvement of the public sector will be limited, ideally, to policy making and creation of an environment conducive to private sector investments.

Since PASC is associated with public sector management, the first option appears to be the least viable, except for research and experimentation purposes. PASCs, or similar government-owned centres, in the future are required to focus primarily on promoting and facilitating research (Viegas, 2002). In this regard, research for the improvement of manual and animal-powered technologies, as described above, deserves priority. Opportunities for research into sophisticated technologies ranging from genetic engineering to improve local seeds to machine vision and GIS to aid precision in agriculture should also be allowed, whenever possible.

Farmers are used to working in (kinship) groups, therefore, with proper assistance in developing managerial and entrepreneurial skills these groups could be transformed into potential and profitable cooperatives (options 2 and 4 therefore could be seen as one and/or complementary to one another). Many of the non-governmental organisations, especially the local ones dealing with rural community development, have experienced a long and healthy relationship with local farm communities. With mutually beneficial arrangements, these NGOs are in a better position to provide the services suggested in option 2, than the business companies, which are more profit-oriented. The last two options are the ones most socially acceptable and likely to be affordable, especially for small tractors and handtillers. Providing there is timely service and assistance, either from the public or private sector, an individual or group of farmers could certainly manage their own machines. Opara (1999), studying the Nigerian case, identified four types of machinery ownership: traditional hand-powered system; tractor and equipment hire system (TEHS); sole ownership and use system; and cooperative ownership and use system.

Rational technology development

Experience in many countries indicates that land limitations are not necessarily a critical constraint to the growth of agricultural output. Australia, Japan, and New Zealand for example, have achieved relatively high crop productivity despite agricultural land and labour resource limitations (Tables 5 and 6). Following the classification of Clarke and Bishop (2002), these countries fall into the category of fully tractor powered where agriculture is no longer the dominant sector. In countries such as Bangladesh, India, and Nepal, where GNP is low and there is an ample surplus of labour, land productivity through higher yields and cropping intensity is required, thus providing additional employment. Similarly, expansion, control and efficiency in irrigation are also ways to improve the productivity of agricultural land in the high man/land ratio economies of Asia.

As was discussed earlier, a high level of mechanisation does not necessarily imply higher crop productivity. Data from selected Asia Pacific countries indicates only a moderate relationship between the number of tractors/1000 ha and cereal productivity (r = 53) (Fig. 2). Fertiliser use, on the other hand, has a very strong relationship with cereal yield (r = 0.84). Similarly, GNP per capita has a highly positive correlation (r = 0.86) with investment in tractors (Fig. 3) (FAO/RAP, 1999).

Depending on their land and labour endowment, countries could rely on different technological strategies in agricultural growth. Japan for example, emphasised yield-raising technology up to the 1950s, while mechanisation played only a minor role. Following this pattern, Korea and China also initially emphasised yield-increasing technology and later pursued mechanisation. The Unites States has emphasised mechanical technology rather than yield-increasing technology since pre-1880. Unlike other Asian countries, Thailand has also rapidly expanded its agricultural area enhanced by mechanisation, rather than pursuing yield-raising technology (Rijk, 1989).

Both strategies were employed in East Timor during the Indonesian era, part of a national policy to address the issue of food self-sufficiency as mentioned earlier. Yield-raising technologies such as hybrid seeds were introduced but such technologies usually require a certain level of inputs to achieve their potential. These additional inputs are often hardly affordable, which consequently leaves farmers with very little option but to revert to their local seeds. The main problems associated with the introduction of tractors revolve around issues such as: poor availability of spare parts; low realisation of tractor utilisation per season; poor skill of tractor operators and owners; low mobility associated with poor infrastructure; and technically inefficient machinery design with respect to the socio-economic conditions of farmers.

A chosen strategy and its net effects of technological change on farm productivity, farmer income, and societal welfare is highly dependent on agricultural production systems. This is particularly challenging for subsistence-based communities in East Timor, which are by nature conservative and use methods and techniques that have withstood the test of time.

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Table 5. Total land area, percentage of agricultural area, total population (TP), percentage of agricultural population (AP), and GNP per capita of selected countries in the Asia Pacific Region (1998).

Country	Total land area (1000 ha)	Agricultural land as percentage of total land area (%)	Total population (TP) (1000)	Agricultural population (AP) as percentage of (TP) (%)	GNP per capita (US$)
Australia	768,230	6	18,329	4.80	20,090
Bangladesh	13,017	62	122,650	58.70	260
Fiji	1,827	14	786	41.50	2,470
India	297,319	57	966,192	56.30	380
Indonesia	181,157	17	203,380	46.10	1,080
Iran	162,200	12	64,628	28.70	2,200
Japan	37,652	12	126,038	4.80	40,960
Korea	9,873	21	45,731	10.50	10,610
Malaysia	32,855	23	20,983	19.90	4,370
Nepal	14,300	19	22,316	93.30	210
New Zealand	26,799	11	3,761	9.20	15,720
Pakistan	77,088	28	144,047	52.20	480
Papua New Guinea	45,286	1	4,499	78.50	1,150
Philippines	29,817	31	71,430	41.20	1,160
Sri Lanka	6,463	29	18,274	47.20	740
Thailand	51,089	40	59,736	51.20	2,960
Vietnam	32,549	21	76,387	68.60	290

Source: FAO/RAP (1999).

Table 6. Mean productivity and annual growth rates of cereals, tubers and root crops, fertiliser use and number of tractors in selected countries in the Asia Pacific region.

Countries	Cereal Yield 1998 (kg/ha)	Growth 1988–98 (%)	Tubers & root-crops yield 1998 (kg/ha)	Growth 1988–98 (%)	Fertiliser use 1997 (kg plant nutrients/ha)	Tractors/ 1000 ha 1997
Australia	1952	1.8	30,838	1.4	42.6	6.67
Bangladesh	2669	1.3	10,960	1.1	130.1	0.66
Fiji	2089	–0.8	10,792	13.0	67.4	26.92
India	2207	2.2	17,011	0.9	95.3	8.54
Indonesia	3789	0.6	11,726	0.2	79.5	2.32
Iran	1921	4.8	19,411	3.4	59.4	12.40
Japan	5849	1	26,819	0.6	366	499.77
Korea	6631	1	20,842	0.0	471.1	64.61
Malaysia	2957	0.9	9,513	–0.1	157.8	5.69
Nepal	1968	0.7	8,092	1.6	36.7	1.66
New Zealand	5379	2.3	42,679	4.7	210.7	24.75
Pakistan	2159	2.2	14,164	2.5	123.1	14.90
Papua New Guinea	4170	7.7	5,338	–2.6	19.4	1.81
Philippines	2241	2.3	6,669	–0.3	85.1	1.23
Sri Lanka	3156	0.8	8,174	–0.8	111.7	3.54
Thailand	2466	1.8	14,200	–0.3	72.3	7.31
Vietnam	3838	3	7,013	–0.8	218.3	17.08

Source: FAO/RAP (1999).

Managing technology change

One of the major capital investments in agricultural development is in the form of land. In the context of technical change, any form or patterns of agricultural technology can be grouped as land-saving technology (hybrid seeds, irrigation, drainage) and labour-saving technology (mechanisation, herbicides, varieties, cropping techniques) as shown in Figure 4. A technical change is land saving if the labour/land ratio increases (I_1) while technical change is labour saving if the labour/land ratio decreases (I_2). I_0 is the original situation and I_n represents a neutral technical change.

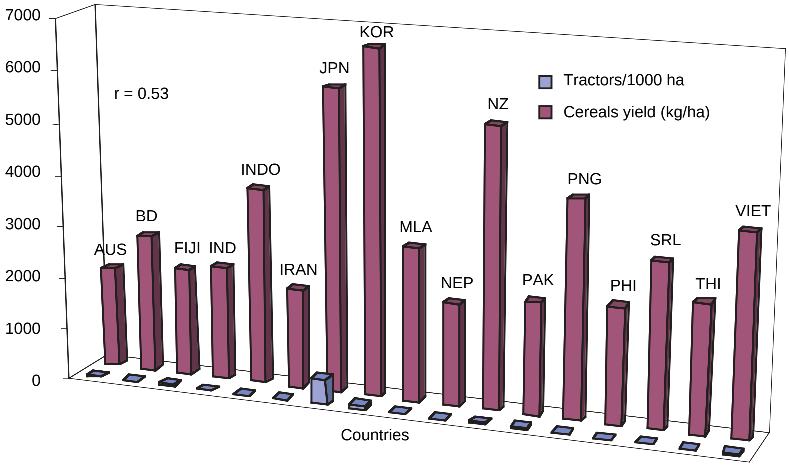

Figure 2. Relationship between number of tractors/1000 ha and cereal yield.
Data source: FAO/RAP (1999).

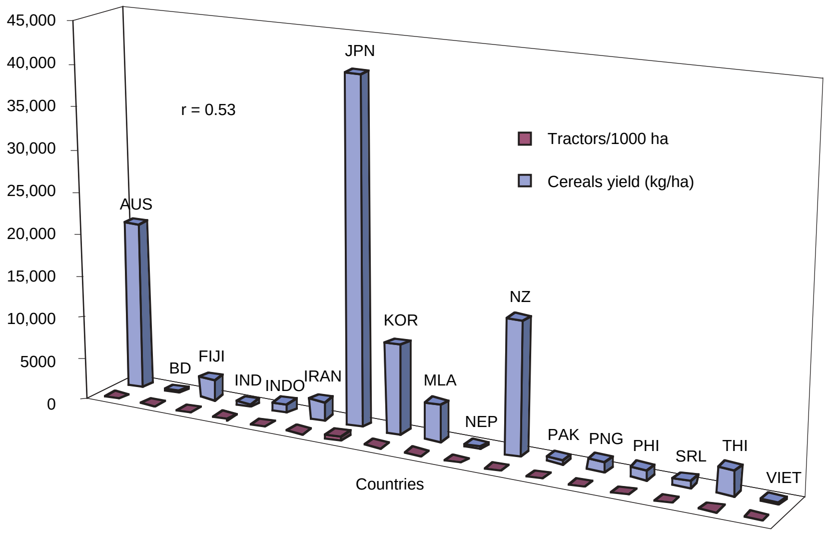

Figure 3. Relationship between GNP per capita and number of tractors per 1000 ha.

This technical change, where the move from I_1 to I_2 occurs along an isoquant reflects the view mentioned earlier that mechanisation substitutes for mechanical and animal power. The net contributor view, on the other hand, sees mechanisation as an engine of growth due to better tillage and more timely operations, and allows more cropping intensities (more output from less inputs). It can be represented by a move from I_1 or I_2 towards $I_{n.}$. Both these views can occur simultaneously.

When given a choice, farmers will weigh up the relative attributes of alternative approaches to technical change. Traditional farmers are efficient allocators of available resources according to their knowledge of technology (Schultz, 1964) and therefore tend to make rational decisions about new technology (French and Schmidt, 1985). According to Schultz (1964), every new technology represents a disequilibrium impulse which causes inefficient resource allocation. A new equilibrium will only be achieved through learning and experimentation. In fact, empirical evidence suggests that investment in human capital through education enhances early technology adoption and promotes greater productivity.

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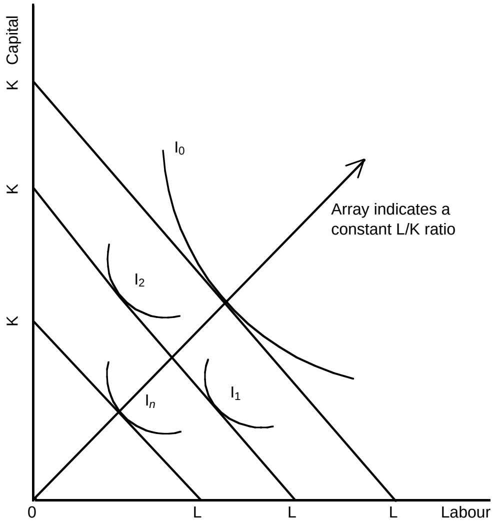

Figure 4. Capital-saving versus labour-saving technical change (adapted from Rijk, 1989).

Based on contemporary research findings, French and Schmidt summarise four major components influencing technology acceptability and transfer as follows:

1. technology compatibility with the biophysical and cultural environments
2. availability of resources that facilitate the adoption of technology
3. adequacy of technology to address the needs of the target population
4. appropriateness of the transfer mechanism.

In order for a technology to be appropriate, the first three components have to be met and channeled through a proper transfer process. The level, appropriate choice and subsequent proper use of mechanised agricultural inputs have a direct and significant effect on achievable levels of land productivity, labour productivity, the profitability of farming, and ultimately the farmers' quality of life (Clarke, 2000).

Much of the technology-induced innovation proceeds along with the evolution in farming systems. In this context, it is relevant to mention four common sequential phases of farming system research:

1. the examination of existing production systems with respect to constraints (appraisal)
2. the identification of potential improvements (experimentation)
3. the evaluation of promising product possibilities under local farmers' conditions (design)
4. extension to more farmers' fields (implementation).

For traditional farmers, therefore, the justification for acquiring an improved technology, to some extent, needs to conform to the features of their subsistence mode of farming. Following Morris (1985) some of the features relevant to technology change warrant important mention.

Farm size and structure. Land characteristics such as topography, drainage, natural vegetation, and accessibility can limit the feasibility of mechanisation. Land holdings are small for the majority of the population, with about 24% of households owning less than 0.5 ha, and a further 60% owning between 0.5 and 1.5 ha each (Planning Commission, 2002). Farm sizes, therefore, are generally small, and there will be little mechanisation unless machines appropriate for smallholdings are available or substantial farm amalgamation takes place.

Land tenure is a delicate matter in East Timor, involving a complex of legal issues. Limited access to land ownership, or where property ownership based on customary law is common, often means that farmers do not possess the collateral needed to qualify for medium-term machinery credit. Inheritance customs combined with population pressure can lead to excessive fragmentation and dispersal of holdings.

Population, labour and gender. The family is usually the most reliable labour source. The widespread introduction of tractors is usually associated with labour displacement in areas where labour is abundant. However, the relative deterioration in access to basic social services in rural areas has forced a significant increase in rural–urban migration. Labour shortages during critical periods, such as weeding, can act as a constraint to overall productivity.

Women play an important role in virtually all the agricultural production cycle. Some researchers, observing the impact of technology on women, argue that, far from being beneficiaries, the role of women can deteriorate as a result of farm mechanisation. Men are quicker to associate with machinery, leaving the unmechanised and most tedious jobs for women.

Subsistence farming. The two main types in this category are lowland rice and maize cultivation and upland mixed farming. The former is being gradually influenced by the introduction of tractors in many production centres while the latter is still very much associated with bush-fallow and shifting cultivation. In both cases, production is typified by low and unreliable yields, unimproved species, low use of fertiliser or animal fodder, and limited pest and disease measures.

Low income and poverty. According to a recent survey, the number of poor people is about 341,000 (43% of the population). Of these, 15% live in urban areas and the other 85% of poverty occurs in rural

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areas. Within the rural population, lowland areas account for 47% of poor while 38% live in the highlands (Planning Commission, 2002). This scenario leaves little room for the introduction of any form of new technology, much of which remains expensive and inherently risky.

Institutional support. Mechanisation requires institutional support in the form of input supply, marketing, credit, extension and training, and adaptive research. Generally, the more capital-intensive and the less indigenous the technology, the greater are the demands for institutional support. In the long run, productivity growth is likely to come from three main sources: agricultural research, technology transfer systems (extension and education), and agricultural support facilities.

Mechanisation policy

Given the role of mechanisation in the process of getting agriculture moving, and its important social ramifications, mechanisation policy becomes an important aspect of agricultural planning. International experience shows that agricultural mechanisation strategy formulation has been initiated for a number of countries in partnership with the Agricultural Engineering Service (AGSE) of FAO (Clarke, 2000; Rijk, 1989). National governments are required to provide the basic conditions for a largely self-sustaining development of agricultural mechanisation within a policy of minimum intervention.

In an attempt to remove smallholder power constraints, while avoiding the wasteful and undesirable effects of over-mechanisation, particularly labour displacement, many governments have embarked on a program of ‘selective mechanisation’ (Schultz, 1964; Morris, 1985). This involves, by means of a detailed farm management and agricultural engineering study, the identification of power peaks and the most appropriate, cost-effective way of dealing with them. At the present levels of productivity, it is debatable whether the average smallholder should give priority either to yield-increasing inputs such as improved seeds and fertilisers, or to mechanisation. In practice, the two are often inseparable.

Conclusion

Change is inevitable. The challenge is how to manage a gradual and evolutionary transformation with minimum social costs. Technical change, for instance, cannot be viewed as the replacement of an entire set of traditional activities by a new set of modern activities. Certain tasks need to be modernised first, then others, until eventually the complete transition to modern farming is made. What is needed is a task-by-task analysis of the components of technology acceptability and transfer mentioned above.

From a policy point of view, a ‘selective approach’ to mechanisation is highly relevant for East Timor. It requires a careful assessment of mechanisation needs, an appraisal of available technology, and the formulation of policy measures, which would encourage the development and selection of an appropriate mechanisation that supports overall agricultural development objectives.

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The evolution of agricultural policies in East Timor

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Abstract

This paper presents an overview of policy issues affecting the agricultural sector and indicates a number of cash crops, such as coffee and sandalwood that need to be developed in the years ahead. For years, domestic policies, including East Timor's agricultural transformation, were guided by a set of economic objectives. Current East Timor agricultural, trade and environmental policies, and exploitation of natural resources have been questioned in relation to their economic viability and their impacts on sustainable rural development, efficient trade and degradation of the environment. The economy of East Timor is dominated by the agricultural sector which contributes about one-third of GDP and employs about 80% of the working population for production for consumption and trade. Given the strong link between the growth of the agricultural and non-agricultural sectors, it is important that adequate resources in East Timor are channelled into the agricultural sector to get the economy moving.

Policy challenges to get agriculture moving again include agricultural extension services; openness to international markets in view of current external developments and investments in physical infrastructure. While markets remain poorly developed there is a case for a more interventionist regime. However, it is not obvious that East Timor will have either the resources or the capacity to manage such a regime. Under the current, very tight, fiscal regime the agricultural extension service has been trimmed severely. In these circumstances the key will be to work with local institutions and communities. Much of the required extension services need not be capital-intensive — better mulching, improved coffee pruning, local irrigation systems and basic road maintenance can all be developed through local community organisations, combined with judicious extension inputs.

Introduction

THE need to reconstruct East Timor's economy has forced policy makers to rethink the role of agriculture in the economy, society and the environment. Inaugurated with the publication of the Brundtland Report in 1987, the principle of sustainable development[1] has quickly become an important feature of East Timor's economy. Agriculture is not only required to enhance rural incomes, increase yields and expand export earnings, it is also expected to sustainably manage ecological processes, environmental services and economic goods.

Employing more than 80% of the population, contributing 40% of GDP, and accounting for 90% of foreign exchange, agriculture is of vital importance in the economy and life of East Timor. Despite the setbacks caused by the destruction of September 1999, agriculture is the activity that depends most on the Timorese themselves and is also the sector that is now showing the clearest signs of recovery in the three years since independence. However, many problems prevent the majority of East Timorese escaping from poverty. The pockets of malnutrition that persist are found especially in the highlands, often in coffee-growing areas. As coffee is the territory's main cash crop, there is a danger of it becoming a monoculture in areas more suitable for other crops, forestry and livestock. The people's best protection against food insecurity lies in diversification, which deserves greater attention.

[1] The World Commission on Environment defines Sustainable Development as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*".

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The purpose of this paper is to examine the policy options available to East Timor to achieve its plans. This requires an overview of the performance of East Timor's agriculture in a poor open economy and a look at the likely evolution of production and trade in the future.

Sustainable agriculture?

Like other small island countries of the Pacific region, East Timor is attempting to establish a planning framework to design and implement its development policies. The development strategy focuses on growth, employment, improved living standards and better delivery of services in a culturally appropriate and environmentally sustainable manner (see Box 1).

The emphasis on sustainability presents today's agricultural policy makers with a formidable challenge: how to develop appropriate market incentives, institutional structures and regulatory systems that are not only compatible with ecologically sustainable agricultural development, but that contribute towards it? To address this task, producers, suppliers, processors, marketing bodies, and governments need to answer several questions:

1. how is deepening international economic and environmental integration influencing East Timor's domestic agricultural policy objectives?
2. what are the pathways by which international trade and environmental agreements shape and constrain how agricultural producers and traders use natural resources?

Questions such as these are leading to calls for small nations to actively contribute in mutually supportive ways to the common goals of sustainable development and improvement in quality of life.

Current agricultural practices

The following traditional agricultural production systems are commonly used by farmers in East Timor:

- swidden cultivation of rainfed crops, mainly maize
- lowland cultivation of rice, either rainfed or irrigated
- household gardens with rainfed crops of maize, cassava, and beans and small livestock such as chickens, goats, and pigs
- production of Bali cattle and buffalo for marketing and for puddling paddy land in preparation for planting of rice (the technique of herding many animals around the field, called rencah)
- harvesting forest products such as tamarind, candlenut, fuel wood and stand-by foods such as yams.

A World Bank study in 2002 indicated that, in addition to these production systems, certain areas have extensive plantings of tree crops such as coffee in the highlands and coconuts in the lowlands. Some are large plantations established by the Portuguese but the majority are smallholder plantings. The agricultural systems overlap each other with swidden cultivation of maize being by far the most dominant activity. In some parts of the country, swidden

Box 1. Key Development Indicators

1. Increased food production, rural incomes and per capita nutritional intakes

The increase in food production is possibly the most critical indicator. It will be measured by both the overall amount of food production and food production per household.

2. Increased total area (ha) planted to new crop varieties
3. Higher incomes and employment among farmers adopting a farming systems approach
4. Increased foreign exchange earnings from exports of quality agricultural and fisheries products
5. Higher proportion of irrigated land relative to total arable land
6. Higher crop yields and productivity due to intensification, adoption of new varieties, farmer training, and improved genetic stock in livestock, aquaculture and fisheries
7. Increased number of agricultural service centres, along with production and post-production infrastructure
8. Quality standard improvements in agriculture and fisheries products
9. Increased number of livestock volunteer workers, water user associations and other farmers' associations
10. New protected areas through improved resources management and development, terrestrial and marine parks, law enforcement and information dissemination
11. Enhanced utilisation of forestry and fishery products
12. Increased production and quality of fishery products due to training, improved harvest and post-harvest fish handling and infrastructure development

Source: RDTL, 2002.

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agriculture is practised on a sustainable basis with long rotations while in other areas population densities are too high (>50 persons per sq km) for sustainable swidden cultivation. This gives rise to a need to promote conservation and resettlement.

Degradation of upland areas is a serious environmental concern. Numerous cases indicate that the "slash and burn" farming frequently practised by local farmers can initiate or exacerbate land degradation through soil erosion, loss of fertility, build up of weeds and loss of forests (Da Costa, 2001). Long-term conservation and rehabilitation programs with adequate funding and the participation of local communities are essential to address and reverse land degradation.

The mountainous topography of East Timor gives rise to a diversity of microclimates which affect crop production. Productivity of most crops has shown a decreasing trend over the last decade. Reliable rainfall is restricted to the months of December to March when over one-half of the annual precipitation occurs. But even during these four months, distribution can be uneven. The annual average temperature is above 21°C and Timor can be included in the hot climate zones (A. Miller's classification) of the equatorial type (Agencia Geral do Ultramar, 1960). However, temperature varies considerably because of altitude and some mountain areas, which rise up to 3000 m, can be quite cool. The dry season usually occurs from June to October, when there is very little rain, and food shortages are common. Conservation practices in dryland farming systems, through moisture retention during the dry season and erosion control during rains, are of critical importance to avoid resource degradation in the uplands.

Accurate assessments of agroclimatic conditions and suitable primary commodities and technologies are needed to obtain maximum benefits from the land. Almost all farmers rely on traditional technologies to cultivate food crops and pursue food security. Farming systems are predominantly rainfed with extensive fallow periods due to long dry seasons. Typical yields for staple food crops are sufficient for domestic consumption with little surplus for sale due to the absence of improved technology appropriate to the conditions of the country. In the case of cattle, supply of drinking water and improved veterinary services could have a significant impact on growth of the livestock sector. In fisheries, efforts are required to improve the infrastructure, technology and manpower to explore the potential resources on the coastline of East Timor (Timor Timur Dalam Angka, 1997).

The importance of agriculture in the economy[2]

Aid and related spin-offs dominated much of the economy of East Timor during 1999–2002. However, this is an artificial economy that is not sustainable. Although it grew by 18% over the period 2001–02, this growth was from a base of almost zero, fuelled mainly by reconstruction, development and humanitarian aid and supplemented by the local coffee industry, where world prices are improving after several miserable years (da Costa, 2002).

East Timor has a very high level of imports, at more than 70% of total trade. This is due to the fact that most basic needs and commodities are imported, even food such as rice and materials for reconstruction. To correct this imbalance, East Timor needs investment in productive sectors so as to increase its exports. The country needs to continue to invest in and develop fields such as agriculture, fisheries and tourism. This can only be achieved through a carefully designed strategy of diplomacy, clear economic and financial policies, and a transparent legislative framework.

Total real growth is estimated to be negative in 2002 and 2003 (–0.5% and –2.2% respectively), projected to commence recovery in 2004 and 2005 (1.2% and 3.3%), and then continuing to achieve its longer-term underlying potential of 5.1% and 5.9% in 2006 and 2007 respectively (Fig. 1). Significant progressive withdrawal of the international presence from 2002 is the main negative influence on growth in the early years, with negative impacts on transport and communications, wholesaling, hotels and restaurants, utilities, construction, finance, rents, business services and government services.

A number of sectors were expected to sustain positive growth throughout 2002, notwithstanding the decline in foreign presence. As shown in Fig. 2, the main sectors with expected positive growth are agriculture, forestry and fisheries; quarrying; and manufacturing. Most other sectors are expected to directly or indirectly experience negative effects from the international drawback, before recovering and reaching their underlying potential production and growth levels, beginning from around 2004. Many of the transitional negative effects will be felt in urban areas; with large parts of the rural population insulated from them, providing growth in productive sectors (especially agriculture) can be sustained.

The largest structural change expected to occur over the period relates to the declining importance of

[2] Information for this section of the paper has been drawn largely from the Report of East Timor Development Plan (2002).

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Box 2. Guiding Principles of Macroeconomic Policy Framework

The following broad principles will guide economic policy development and the management of the economy and public finances:

1. A market economic system; but with strategic and regulatory roles for government, including the provision of a social safety net during difficult times
2. A strong role for the private sector in development
3. Open trade and investment policies
4. Government's role will be limited to ensuring that physical and social infrastructure and services are provided and to establishing a growth enabling policy and legal environment; including provision of macroeconomic stability
5. The government will not venture into particular areas, including operating commercial business ventures such as banks and airlines, regulating/controlling prices, or trying to pick winners and providing subsidies/exemptions to particular businesses or industries
6. Effective, transparent and corruption free management of the economy and public finances
7. Pursuing a fair and equitable economy and society with equal opportunities and improving living standards for all
8. Developing ways to preserve the beautiful environment, traditions and customs of East Timor

Source: RDTL, 2002.

government services, which fall from 33.7% of GDP in 2000 to 27.7% of GDP in 2007 (at constant prices). This mainly reflects the decline of the large United Nations Transitions for East Timor (UNTAET) influence. For 2002–03 growth was expected to fall to zero. Thereafter, a more balanced and sustainable form of development could set the country on a stable upward path.

The majority of Timorese derive their welfare from agriculture, and this will be the case for many years to come (Fig. 3). East Timorese policy makers will face agricultural challenges, ranging from the immediate issues of the substantial population movements after the September 1999 crisis with connected land ownership issues, to infrastructure rehabilitation, reactivating rural markets and the agricultural extension service, and re-establishing commercial ties across the border to Indonesian West Timor. Development of off-farm, seasonal, income-generating activities needs to be encouraged (Da Costa, 2000).

Besides the promised oil and gas and the already noted coffee, fishing and tourism are also important potential income-earners, although they are seriously constrained at present by weak infrastructure, limited international air links and lack of skilled personnel.

Production and trade for East Timor — the likely evolution

An important question for the future is: how will East Timor use resources to the economy's best advantage? The following considers key areas to be developed in the years ahead.

In the medium term, the government needs to prioritise the building-blocks (investments, laws, regulations, policies, public good activities) that define the enabling environment for agriculture. Investments would include re-establishing adaptive research stations and agricultural training facilities, and providing extension services for agriculture, land management, and rural household management/self reliance. Laws and regulations would include the establishment of rules and regulations for agriculture, livestock, forestry, fisheries, land management, resource management, and conservation. Whenever possible, the government should adapt existing regulations and policies used by other countries to develop its own standards as a first step, and only create new regulations where absolutely necessary.

An example might be competition policy. In addition, it would be advisable to recognise the testing and certification processes of other countries, such as Australia, so that East Timor need not establish its own institutions to conduct certification of agricultural products. Foreign grants for agriculture over 2000–2005 are likely to be considerable, exceeding US$10 million in FY 2001–02 alone. These foreign grants are likely to be one-off events and should be used to put in place the framework and infrastructure for a vibrant agriculture and for longer-term sustainable development of the sector (World Bank, 2002). The primary goals of government policy should be geared to achieving:

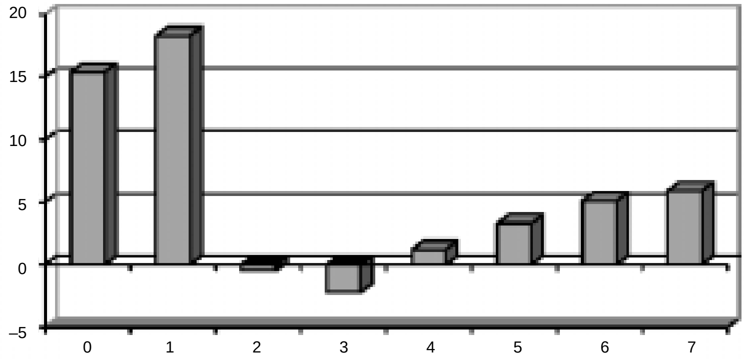

Figure 1. Real Total GDP Growth, 2000–2007(%). *Source:* RDTL, 2002.

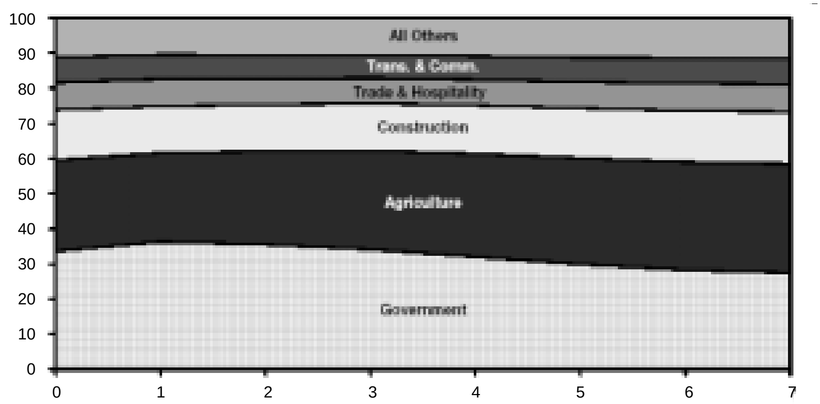

Figure 2. Sector components of real Total GDP (%). *Source:* RDTL, 2002.

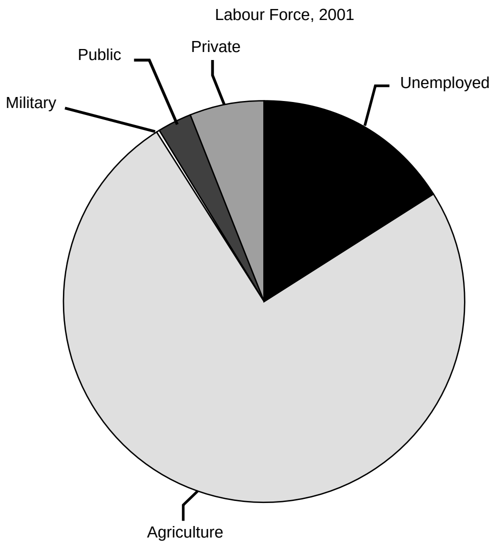

Figure 3. Labour Force in 2001. *Source:* RDTL, 2002.

- food security through improvements in the production of a diverse set of staple foods and the restoration of household and village crop storage facilities
- improvements to the production of niche crops and animals, and promotion of internal markets and alternative income generation able to provide cash income for subsistence communities
- improvements to swidden farming systems in the uplands that will improve livelihoods and reduce environmental degradation

Rice

East Timor's economy resembles the economies of most small islands that have gained independence from colonial rule. Despite significant efforts in the primary and construction sectors within East Timor over these years, marketed consumption needs were largely met by imports from outside. The increase in rice imports was stimulated by several policy initiatives that deserve some comments. During the 1990s,

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the amount of rice imported reached an average of 30,000 tons a year (Fig. 4). Although there are no official reports on rice imports prior to 1984, one would expect them to have been much higher as most of the paddy fields were either not producing due to lack of irrigation, drying, and storage facilities or farmers were displaced from the fields.[3].

Imported rice has been reaching markets throughout East Timor, especially where local rice has difficulty penetrating. Rice imports increased from an estimated 10,600 tons in 2000 to 20,500 tons in 2001, 57% from Vietnam, 35% from Indonesia, and 8% from Thailand (via Singapore).

Prior to 1999, rice was imported into East Timor by Budan Urusan Logistik (BULOG), the Indonesian buffer stock body responsible for maintaining rice stocks nationally. Annual imports are estimated to have been between 36,000 and 38,000 tons per annum. Following the 1999 disruptions, Indonesian imports suddenly ceased and were replaced by other sources. These included the donor community, traders and smugglers. Quantities imported by the donor community and traders are registered at UN Border Control and these figures suggest that in 2000 and 2001, about 10,600 and 20,500 tons of rice were imported respectively. However, data from the Timor Lorosae Household Survey (TLHS, 2001)[4] suggest that some 50,000 tons of imported rice was consumed in East Timor in 2001.

Based on this figure, smuggling accounted for about 30,000 tons of rice in 2001. However, the World Bank states that the distribution of imported rice between donors/traders and smugglers (which has huge implications on the effectiveness of any tariff) is not clear, and will require further investigation.

In addition, time series data on the per capita consumption of rice in East Timor is difficult to obtain. Based on surveys carried out by the Pilot Agricultural Service Center design team[5] and advice from the Ministry of Agriculture, Forestry and Fisheries (MAFF), a consumption of 84 kg/head/annum is estimated. Per capita consumption is about 65% that for Indonesia, reflecting cultural differences and the use of maize as a substitute. Based on this figure and population estimates, annual consumption of rice rose to 74,566 tons in 1998, declined in 1999 to some 58,400 tons and rose again to 78,394 tons in 2001 (Fig. 5). Analysis of TLHS data suggests that per head consumption of rice in late 2001 was around 95 kg/annum. The TLHS estimated a population of 825,000 people compared to earlier estimates of just under 740,000, so latest estimates of national annual consumption of rice suggest consumption to be around 78,000 tons. For a more comprehensive overview on rice production and consumption, see The World Bank (2002).

The current estimated rice consumption of 78,000 tons per annum comes from local production estimated at 29,000 tons (in 2001) and imported rice estimated at around 50,000 tons. Production, consumption and imports were all disrupted following the 1999 violence but production has improved and seems to be returning to pre-1999 levels, while consumption is thought to be higher than pre-1999 levels.

The World Bank (2002) study suggests that rice imports are undertaken by private traders responding to market forces rather than by a government agency, donors and smugglers. Some 57% of traders' imports come from Vietnam, 35% from Indonesia and 8% from Thailand according to UN Border Control data. Local rice tends to retail at marginally lower prices than foreign rice.

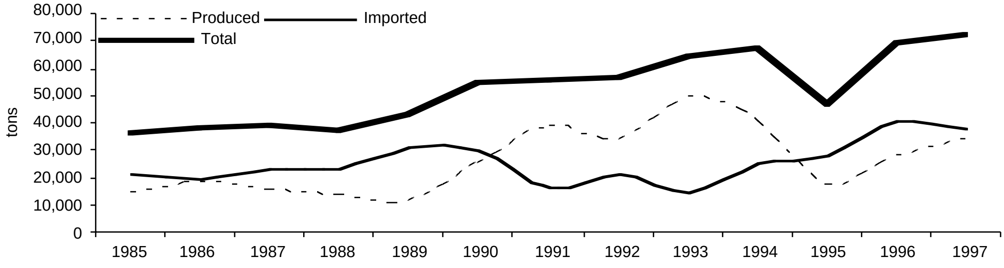

Figure 4. East Timor: Rice Production and Imports 1985–1997. *Source:* Gomes (2001).

[3] See Gomes (2001) for a brief overview on *East Timor: An Overview of Indonesian Pembangunan*.

[4] A nationwide survey sponsored by ETTA, the World Bank, and UNDP.

[5] Eight pilot agricultural service centres initiated by the World Bank, providing agricultural services, staff training and community radio stations for technical information and advice, land mapping, training for research, research laboratories and experimental stations (US$6.0 million).

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Imported rice is slightly more expensive in rural areas including the centre, the highlands and some urban areas in the districts. Imported rice is cheaper in urban areas including Dili/Baucau and in the west. In response to the difficulties experienced by rice farmers, the thrust of policy should be to address the issues affecting them, such as post-harvest processing, packaging, marketing, credit access, and facilitating the availability of inputs coupled with tariff exemption. At the same time, allegations of smuggling need to be investigated. Rehabilitation of irrigation systems, where warranted by long-term sustainability, also needs to be accelerated. But, since the solutions to these problems will take time to implement, powerful pressures for increased protection in the form of higher tariffs on rice have arisen. Such a policy could perhaps be warranted if the higher tariff was modest and temporary — to allow a reasonable time-frame for the above adjustments to be developed.

The World Bank study also highlights a number of serious drawbacks to raising the tariff on rice. First, rice farmers comprise about 26% of the population and the proportion of net sellers is considerably less than this; any boost to their incomes from higher protection must be weighed against the loss of purchasing power by the rest of the population, in particular the reduced consumption of rice by poor consumers in urban areas and upland farmers (the latter is where poverty is most acute). Second, as rice is a basic consumer good, raising its price would exacerbate problems with competitiveness. Third, even if a higher tariff was intended to be temporary, international experience indicates that reversing higher protection can be very difficult in practice.

This, in turn, could promote shifts in cropping patterns not necessarily beneficial or sustainable in the long term. These factors suggest that a hasty decision on higher protection should be avoided, and any such decision should be preceded by developing feasible ways to assist the poorest rice consumers, particularly those in the uplands, who are currently benefiting from the greater availability of imported rice.

Coffee

Coffee has traditionally been East Timor’s principal export commodity, earning about 90% of export revenue. Between 1987 and 1990, coffee exports contributed some US$12.5 million to foreign exchange earnings. Successive policy makers have attempted to increase the production of coffee from the approximately 78,000 ha grown mainly in Ermera, Manufahi, Bobonaro and Liquisa districts. The most obvious attempt was the abolition of the monopoly by PT Denok Hernandes Indonesia and other related companies which came into effect in 1992 (Saldanha, 1994). Since then, small and medium-sized coffee growers have had greater opportunity to produce, process and trade with other agents. With the presence and assistance of an American company, National Cooperative Business Association (NCBA) in the producing areas of Ermera, Liquica, and Ainaro, there was a gradual increase in coffee exports to overseas markets. For

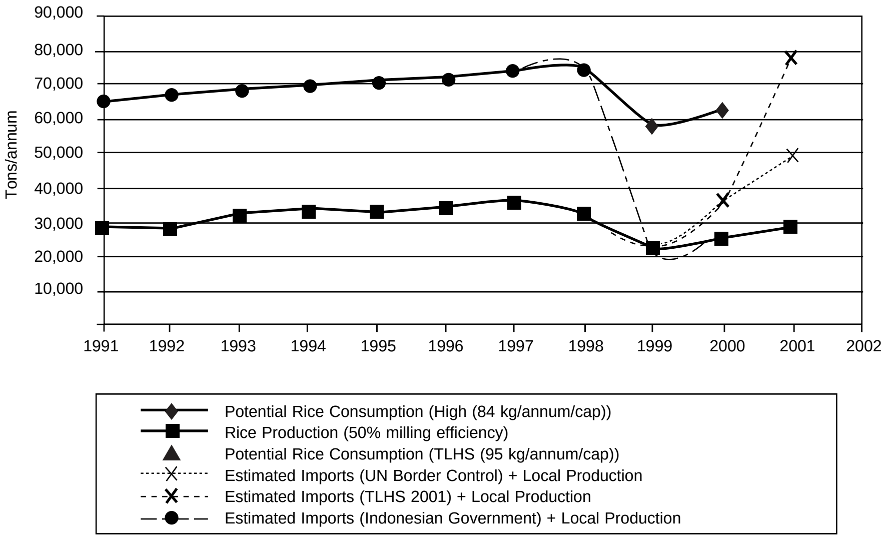

Figure 5. Rice Production, Consumption and Imports in East Timor (1991–2001). *Source:* World Bank, 2002.

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example, in 1997, East Timor exported about 500 tons to the United States, Europe, and Japan with increases expected in the following years (Saldanha and Da Costa, 1999).

Over the past decades, exports of primary products, such as coffee, sandalwood, cinnamon and candlenut, decreased substantially as a result of continuing mass movement of people and a monopoly in marketing of these products. Coffee exports declined by almost 3000 tons in the early 1980s, did not regain pre-invasion levels of 5000 tons per year until 1986, and then fell to 1000–4000 tons per year in the late 1990s (Fig. 6). During the 1971–1974 period, coffee exports averaged 5000 tons a year, consisting of 60% arabica and 40% robusta (Gonçalves *et al*., 1976). Variations to the total plantation area have contributed to the decline in coffee exports at different times.

A recent representative survey of coffee growers conducted by the World Bank (2001) in the major coffee producing areas concluded that most farmers would be prepared to invest more effort in production if it resulted in increased income. If they were given free saplings of good quality, they would be prepared to replant on a significant scale. Also, most indicated that they would welcome access to communal facilities for processing cherries and thus producing a better quality coffee bean. Almost all were ready to join an association or other cooperative entity if that were to facilitate access to better facilities.

Because of low inputs into coffee production and the favorable climate, East Timor's coffee can be certified as organic and is in demand, both for this reason as well as for its flavor characteristics. A campaign to inform farmers of the importance of organic certification would be desirable in order to increase the proportion of exports that can obtain the organic premium as this segment of the global market grows.

For the more immediate future, however, most income gains will be made by improving the quality of processing, a change that requires investment in rehabilitating and building new communal facilities, and the provision of good quality saplings and advice to farmers. With adequate financing arrangements, such as microfinance schemes, part of the cost of such additional infrastructure and services could be borne jointly by the farmers, with the state perhaps providing some form of catastrophe insurance.

Sandalwood

Prior to 1975, sandalwood was a high value-added crop for the East Timorese but most trees were destroyed due to over-exploitation in the 1980s. There is now no foreign exchange from sandalwood and production has continued to decrease very rapidly in the last decade.

Very little effort has been made to replant sandalwood, which was one of the most valuable commodities in the Portuguese era. Sandalwood and sandalwood by-products also declined from 1981 onwards. Exports of sandalwood declined dramatically from 244 tons in 1981 to one ton, four years later, with no wood since exported, possibly due to its extinction (Fig. 7). As a result of the decline in sandalwood, extraction of oil also declined and oil exports dropped from eight tons in 1981 to less than two tons in 1996. The export of sandalwood powder fluctuated significantly, indicating that extraction was from remaining stored wood. As in the case of

Figure 6. Coffee Production and Export (1980–1997).
Sources: BPS (Timor Timur Dalam Angka) various issues; Kanwil Departemen Perdagangan various reports.

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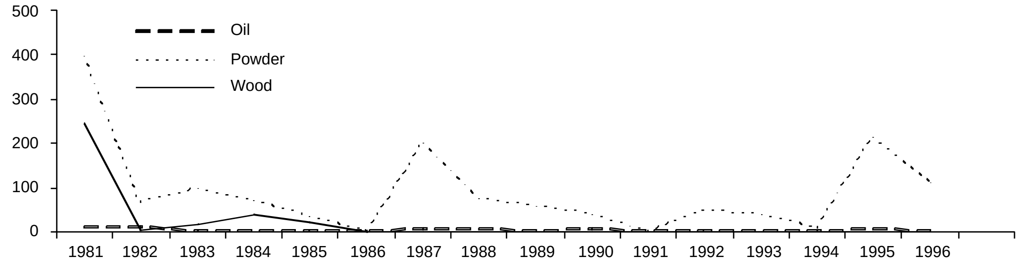

Figure 7. Volume of Exports of Sandalwood and its Products (1981–1996).
Sources: BPS 1992; Brahmana and Emanuel, 1996; BPS, 1998.

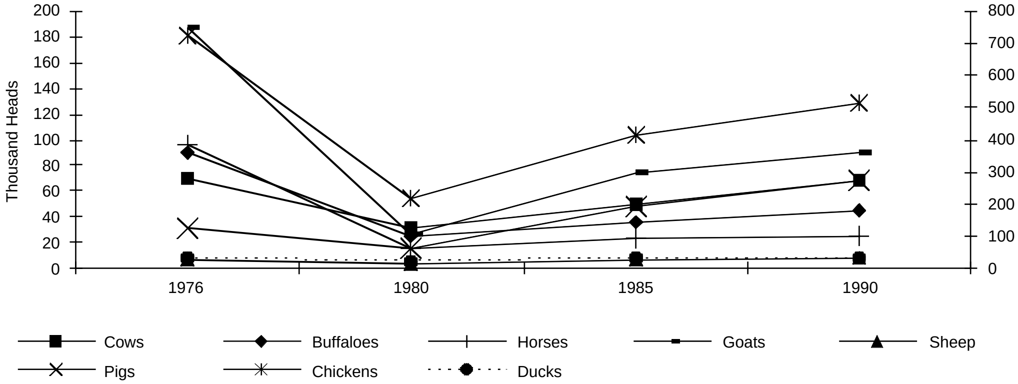

Figure 8. East Timor: Livestock Population 1976, 1980 & 1990.
Sources: BPS, 1992a; BPS, 1986; Soesastro, 1991.

coffee, the government ensured that PT. Denok and its associates controlled the export of sandalwood and its products in the 1980s and there was little opportunity for competition to develop.

It was the lure of vast sandalwood forests that first attracted the Portuguese to Timor in the 16th century but only a few stands now remain and logging of the species is strictly forbidden. The highly-prized sandalwood encourages illicit trade, with cargo believed to be heading for sale in Indonesian West Timor. Recent events have revealed large stockpiles of sandalwood in Baucau, which are being intercepted by authorities (ABC News online, 23 September 2002).

Equally, other vital commodities such as candlenut and cinnamon also suffered as a result of the Indonesian invasion in 1975, as well as the lack of investments and incentives to farmers. For example, candlenut exports plummeted from 945 tons in 1981 to 461 tons in 1986. Cinnamon exports also declined dramatically from 256 tons in 1981 to five tons in 1987 (Brahmana and Emanuel, 1996).

Livestock

Another important sub-sector of East Timor's national economy and household economic resource, livestock production, was also negatively affected by the invasion and annexation. The 1976 livestock figure of 848,000 head declined to 109,677 head in 1980 (Fig. 8), resulting in a sharp decline in the population-livestock ratio from 0.7 in 1972 to 0.1 in 1980.[6] Although the declining trend was reversed in 1985, the ratio was still far below the pre-invasion level. Except for goats, sheep, and ducks, all other livestock numbers remained well below levels of 1976.

6 Estimates based on sources from the Indonesian Department of Agriculture indicate a worse situation. For example, according to Soesastro (1991), the livestock population fell from 1,350,000 in 1976 to 409,300 in 1980.

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Fisheries

East Timor has a large fishery potential with many valuable species, including tuna, skipjack, snapper and prawns. Around 10,000 families depend at least partly on fishing. Around half live around Dili or on Ataúro Island. Potential fisheries output has been estimated at around 600,000 tonnes per year, though probably less than 1% of this is currently harvested. The most common form of fishing vessels are dugout canoes and many other boats with outboard motors.

Future income from fisheries can be boosted by increasing investment in the national fishing capacity and by licensing foreign vessels. The main obstacle at present is the lack of internationally recognised fishing zones. This has created considerable uncertainty and also encouraged widespread irregular fishing that could be depleting important resources. One priority for the new government therefore will be to establish economic and fishing zones. This would enable the government to gain income from fishing licences of, perhaps, $2 million a year, as well as an income for the East Timorese Navy from charging fines.

The Department of Economic Affairs has outlined a fishing strategy for East Timor with fishing grounds about 33 times larger than in the past. Based on 25% of what the Indonesians are now taking in the area, the annual catch in this zone could be worth between $25 and $35 million (UNDP, 2002).

The fishing strategy must, however, consider such issues as sustainability and protecting the interests of traditional fishing communities. Government agencies, the fishing industry and local communities will need to work closely together to find ways to increase capacity and productivity. Since local fishing communities do not yet have sufficient technical capacity for large-scale fishing operations using trawlers and netters, the government will have to issue most of the licences to foreign operators.

The fisheries sub-sector is not well developed but may have the potential to improve food security and contribute to small-scale development and exports. East Timor has about 650 km of coastline but very little continental shelf, with depths of 200 m reached within 2–8 km of the shore and depths of 2000–3000 m within 20 km. Coastal resources are limited to a narrow stretch of steeply-sloping seabed.

The biggest problem in the fishing industry is lack of demand due to lack of purchasing power. The poor consume about 10 g of fish per head per week, while even the 'rich' consume only about 190 g according to the latest data (TLHS, 2001). The low local demand for fish is only likely to increase as overall incomes rise.

A recent UNDP study (2001) that focused also on marine needs and priorities in East Timor concluded that East Timor's marine ecosystem, if used in a planned and non-destructive manner, has considerable potential to support economic development and sustain the population. Using figures from other similar areas of marine waters, the study estimated that, even after providing East Timor's population with a minimum recommended annual fish consumption of 13 kg per capita, exports could still be sustained.

Once East Timor delimits its exclusive economic fishing zone, offshore resources will be available for larger-scale commercial exploitation, either by East Timorese fishers or preferably through licensing arrangements with foreign fishing vessels. Experience in other Pacific Island countries indicates that East Timor's pelagic resources would include not only small species such as Indian mackerel, scad, sardines and small tuna but also high-value species of large tuna (World Bank, 2002)

MAFF's Fisheries Division has developed a strategic plan that aims to sustain East Timor's aquatic resources, establish a profitable private sector-based fishing industry that maximises sustainable economic returns, and asserts jurisdiction and control over the marine resources in the seas surrounding East Timor. The government's role is to be limited to providing the enabling business environment and framework within which the sector's private fishing and associated businesses will operate.

External assistance at this stage should be channeled towards developing the regulatory and legal framework for inshore fisheries management and investment in offshore fishing. Enforcing fishing regulations through partnerships between government, communities and private operators (co-management arrangements) and recognition of user rights for coastal communities have proven effective in many Asian-Pacific countries.

Information for this section was drawn partly from the UNDP Report (2001) and the World Bank study (2002).

Prospects offered by external events

An economy with a small and skewed natural resources base and with limited financial resources should actively engage in trade if it wishes to develop its economy rapidly. The growing interest often found in small island economies is opening up trade and so offering the prospect of improved opportunities for the expansion of domestic production and exports of primary and other products (Selwyn, 1975; Legarda, 1984). As stated in the National Plan, the East Timor development strategy

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aims to integrate the country's economy with regional and international economies to improve opportunities for markets.

In the interest of East Timor, the most important aspect is to progressively allocate resources (ideally through technical assistance of the funding agencies) to conduct research (empirical analysis) on the advantages and disadvantages of joining the multilateral trading system, the World Trade Organisation (WTO) and other regional organisations. The stronger disciplines and greater certainty associated with the WTO should boost investment both directly and through encouraging continued and greater openness of national economies (Anderson and Pangestu, 1995). Other sub-regional organisations such as the EU-ACP partnership[7] potentially offer great benefits for East Timorese agricultural exports if East Timor can meet the requirements.

Conclusion

One of the clearest messages from recent policy developments is that the world is becoming much more integrated as a consequence of various multilateral, regional and unilateral reform programs being implemented simultaneously. For East Timor this means new export market opportunities abroad as well as increased import competition on the domestic market. Given that half of the workforce is still in agriculture and the vast majority of the poor in East Timor still live in rural areas, the effects on agriculture of the country's structural and policy changes in the future will have major effects on real income, growth, poverty alleviation, and environmental degradation. How East Timor's agricultural development proceeds depends on the rate of overall economic growth and accompanying structural adjustments that would result if there were no policy changes on market or policy shocks at home and abroad. Such changes could alter East Timor's terms of trade as well as agricultural policy developments at home.

Sound economic policies and an innovative private sector are critical if the economy is to be shifted onto a sustainable development path. The government of East Timor can nurture the growth of the private sector by providing competitive tenders to local firms, by encouraging joint ventures with foreign companies and by developing extension services to advise farmers and exporters on market opportunities. East Timor's agricultural strategy should be geared towards rural development. This could include encouraging manufacturing sector activities in rural areas in order to generate employment opportunities and the processing of raw materials to increase value adding and contribute to export revenues and poverty reduction.

Efforts to encourage investment in rural infrastructure would have benefits for other areas, not only for agricultural production. With better transport and communications infrastructure and better-educated workers, East Timor's rural areas would be more attractive to investors in low-skill, intensive manufacturing and related service activities. This would boost the off-farm earnings of farm households, allowing a more efficient and fuller use of the rural workforce, particularly during non-peak seasons. In agricultural areas with fertile soils and favourable climatic conditions (such as exist on the southern coast of East Timor), intensification will require competitive markets, good management practices and timely information. Complementary improvements can also be made through public and private investments in agricultural research to encourage new technologies for sustainable development.

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[7] The ACP–EC Partnership Agreement (more commonly referred to as the Cotonou Agreement), was signed by 77 countries from Africa, the Caribbean, the Pacific and the European Community on 23 June 2000 in Cotonou, Benin. It represents a historical step in the long relations between these two groups of countries and a milestone in the definition of development policies and north-south relations on a global scale. In fact, with 93 signatories, the agreement constitutes the world's largest cooperative grouping for development and involves close to one billion people from half the sovereign states on the planet.

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Agriculture, small countries and globalisation[1]

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Abstract

This paper focuses on market globalisation. The first section provides an overview of the nature of small economies and discusses why small countries need to be open to international trade and to participate actively in globalisation; the second section discusses agriculture in small countries; the third section discusses challenges for small countries in globalisation; and the conclusion provides some recommendations for small countries opening up to international markets.

Introduction

IN TODAY'S world, no country can avoid globalisation. According to Low (2001) there are three types of globalisation — market globalisation, direct globalisation, and non-market globalisation. This paper focuses on market globalisation, which involves the free movement of goods, labor, capital, and technology.

Small countries are characterised by small domestic markets and concentrated exports. This often forces them to open up their economies and participate in international trade in order to achieve economies of scale. However, concentrated exports in one or two commodities make small countries vulnerable to price shocks on the international market.

Therefore, on the one hand, globalisation is good for small countries in that it enables them to trade with the world to promote growth and raise income (Frankel and Romer, 1999). On the other hand, globalisation carries risks for small countries because of concentrated exports.

What about agriculture in small economies? For small countries, the role of agriculture tends to be small in absolute terms because of limited land for farming. However, in small developing countries, agriculture still plays a major role in the economy.

The first section of this paper provides an overview of the nature of small economies and discusses why small countries need to be open to international trade and to participate actively in globalisation; the second section discusses agriculture in small countries; the third section discusses challenges for small countries in globalisation; and the conclusion provides some recommendations for small countries opening up to international markets.

Small country economies and international trade

Countries can be classified according to size as small, medium or large. Although there is no consensus in the literature about which size indicator to use to distinguish countries, many authors use population, which is the practice followed in this paper.

Other authors, for instance Jalan (1982), use income, geographical area, and population to measure size. However, geographical area and income do not reflect size accurately. Income measures whether a country is rich or poor, while geographical area does not represent favourable, productive or habitable size; some countries have a large area but more than 50% is desert (Australia). One needs to admit that population is a relative concept and varies over time (Perkins and Syrquin, 1989). The growth rate of population across countries is different and those with a high growth rate will surpass the low growth countries

[1] An early version of this paper titled "Globalisation: a View from a Small Country" was presented at the ASEAN People's Assembly, Sanur, Bali, 1 September 2002.

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leading to a change in both absolute and relative size of nations over time.

Based on population, countries in the world have been divided into five categories: micro-states, small states, medium states, large states, and super states (Table 1). The number of small states according to this classification is 39 (20.8%). Together with micro-states, these countries constitute about 27% of the total countries in the sample. Large and super states represent about 30% of the sample. This gives an almost bell-shaped curve distribution of countries in the world centred on the medium states (Md-s), which comprise almost 50% of the countries in the sample.

Selected social and economic indicators of small countries, classified by region, are presented in Table 2. St. Lucia in Latin America is the smallest country with 160,000 people. Two Pacific nations have populations close to that of St. Lucia, namely Samoa and Vanuatu. In Africa, population size of most countries is relatively high compared to the Pacific and Latin America. The country with the smallest population is Cape Verde with 412,000 people, more than three times that of Samoa, Vanuatu, or St. Lucia. In Africa, a number of countries, such as Botswana, Gambia and Mauritius belong to the mid-size group of countries with populations of more than one million.

Table 1. Classification of Countries by Size and Population 1998.

Nation states	Population (million)	Number of states	Share of countries (%)	Population 1998 (000)	Share of population (%)
Micro-states	Mc-s $<$ 0.1	13	6.9	540.2	0.01
Small states	0.1 $\leq$ S-s $\leq$ 2	39	20.8	24,384	0.43
Medium states	2 $<$ Md-s $\leq$ 15	80	42.6	512,509	8.99
Large states	15 $<$ L-s $\leq$ 100	46	24.5	1,652,097	28.99
Super states	Sp-s $>$ 100	10	5.3	3,509,550	61.58
World		188	100	5,699,080	100.0

Source: Adapted from Saldanha (2001). Figures are computed from 2000 World Development Indicators CD-ROM, World Bank for 1998 figures.

Table 2. Selected Indicators of Small Countries by Regions of the World, 1980–1998.

Country	Area (000) sq mil	Population 1998 (000)	Population growth (%)	GDP (US$/head)	GDP growth (%/head)
Pacific	6.2	400	1.9	1306	0.40
Fiji	7.1	827	1.2	1982	0.23
Samoa	1.1	176	1.6	1255	0.17
Solomon Islands	11.0	415	2.9	712	0.75
Vanuatu	5.7	182	2.0	1276	0.46
East Timor	9.1	812	1.7	417	3.3
Sub-Saharan Africa	41.6	960	1.7	2658	1.60
Botswana	231.8	1562	1.4	4328	4.86
Cape Verde	1.6	412	1.2	1521	2.70
Comoros	0.8	531	2.0	769	–1.00
Equatorial Guinea	10.8	432	2.5	916	0.97
Gabon	103.3	1181	1.6	5291	–0.26
Gambia, The	4.4	1216	1.6	1689	–0.10
Guinea-Bissau	13.9	1161	1.6	765	1.04
Mauritius	0.7	1159	0.8	5830	4.23
Swaziland	6.7	988	2.7	2812	1.97
Latin America	52.8	567	1.1	4671	1.12
Barbados	170.0	266	1.3	7049	0.73
Belize	8.9	236	1.7	3719	1.55
Guyana	83.0	857	0.5	2236	1.14
St. Lucia	0.2	160	1.1	3379	1.84
Trinidad & Tobago	2.0	1317	0.9	6971	0.35

Source: Adapted from Saldanha, 2001. Figures: World Bank, 2000; IMF, 2000; and Timor Timur Dalam Angka, 1996.

Small countries in Latin America have relatively high per capita income levels compared to those in Africa and the Pacific. Barbados and Trinidad and Tobago have per capita incomes of $7049 and $6971 respectively. The African countries, on average, have a higher income per capita than the Pacific. The poorest country of the entire group is East Timor with a per capita income of only $471.

Small countries tend to react favorably to globalisation through openness to international trade. Their small domestic markets, small pools of human resources, and less diversified natural resources pose great challenges to economic development. Some small countries are particularly isolated and vulnerable to natural disasters. Large countries, on the other hand, can choose whether or not to open to international trade because they can promote trade within the country to raise incomes (Frankel and Romer, 1999). (However, large countries also benefit by opening their economies. Sachs and Warner (1995) show that open economies perform better than closed economies. Therefore, opening the economy is important to promote economic growth and development, independent of country size.) Small countries have no option except to open and look for benefits from international trade.

Globalisation has brought increased trade and capital flows. While openness to the world economy can be a source of many economic benefits, an economy characterised by limited diversification and dependence on a single export such as bananas, sugar, textiles or tourism to generate foreign exchange earnings, can find itself vulnerable to adverse external shocks.

By relying on a policy of opening up coupled with the availability of human resources to manage good policies, small countries can achieve high economic growth (Blazic-Metzner and Hughes, 1993).

Small states often have greater capacity and elasticity to adjust because they can spread the fruits of economic growth more widely among their populations than larger states with comparable levels of per capita income. In addition, with shorter lines of internal communication, these small countries can often adjust more rapidly to changing conditions (Robinson, 1960).

Agriculture in small countries

Regardless of the size of the state, the role of the agricultural sector is relatively small (see Table 3 for selected economic indicators of countries by category of country). Agriculture accounts for the largest proportion in the medium-size states with a 21% share in GDP. ‘Openness’ and services are large relative to GDP even in large countries. One clear difference between categories is that the share of services in GDP is large for micro-states and smaller as size increases — the share of the service sector is 64.8% of GDP in micro-states, while in small countries it is 48%, which is slightly higher than for medium and large states.

Although the role of agriculture is relatively minor in smaller states (10.5%), when small countries are disaggregated by regions of the world, agriculture is not as insignificant as indicated. Some small countries in Africa have an agricultural sector GDP as high as 52.5% (Guinea-Bissau). The share of agriculture in small countries of the Pacific region is about 22% of GDP. However, in Latin America, the share of agriculture in GDP can range from 21.8% in Belize to 29% in Guyana (Table 4).

This evidence raises two important points: 1) that small countries in Latin America are more advanced than those in Africa and the Pacific; and 2) that many

Table 3. Selected economic indicators of countries by size, 1980–1998.

Category of State	Population growth (%)	GDP ($ million)	GDP growth (%)	Openness (%)	Services (%)	Agriculture (%)
Micro-states	0.75	301.1	6.44	27.11	64.8	10.50
Small states	2.03	4,030.4	5.94	21.87	48.0	16.32
Medium states	1.87	30,118.5	4.21	18.40	43.4	20.89
Large states	2.01	239,300.8	5.08	19.15	46.0	18.20
Super states	2.52	1,827,374.5	8.69	31.8	43.5	18.00

Notes: All figures are averages of five-year averages over the period 1980–1998; population growth figures are based on decade averages over the period 1960–1998.

Services are averages of five-year averages for 1980–1995; value added of wholesale and retail trade (including hotel and restaurants), financial services, and transport. **Openness** is the ratio of total trade (export + imports) to GDP. **Agriculture** is value added of agricultural sector. (Adapted from Saldanha 2001. Calculated from World Development Indicators, World Bank, 2000).

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of the small countries in Latin America and the Pacific are islands compared to those in Africa. This correlates with a small share of the agricultural sector in GDP.

The economy of small countries tends to be concentrated on a few products. In the agricultural sector, production often comes from plantations and cash crops (cloves, sugar, banana, cocoa etc). This exposes small, agriculturally-based countries to two different risks. First, having concentrated exports, they are vulnerable to international shocks, especially price shocks. Second, agricultural production bears its own risk because production is not as certain as producing manufacturing goods. A number of factors, like weather and irrigation, play an important role in agricultural production. Island countries can be very vulnerable to natural disasters and agricultural production can be an especially risky business.

Table 4 also shows growth rates, openness, and the role of the service sector in the various country categories. The growth rate of small states is close to 6.5%, which is lower than the growth rate of super states (8.69%). However, the high growth rate of super states is driven by the high growth of China, which has been as high as 13.5% per year. Removing China lowers the average growth rate of the super states closer to or lower than the growth rate of small countries. The super states in Table 4 are those countries with populations of more than 100 million people, such as China, India, USA, Russia, Pakistan, Japan, Pakistan, Bangladesh, Brazil, and Mexico. Except for China, these countries have grown at less than 6% a year. The best performer of micro-states, in terms of growth, is Antigua and Barbados, which grew by 9.6% per year in the same period.

In terms of per capita income growth, small countries in Africa show contradictory performances. Botswana, Mauritius, and Cape Verde grew by 4.8%, 4.2%, and 2.7% respectively. However, Gabon and Comoros experienced negative growth (Table 2). Small countries in the Pacific, except East Timor which grew at 3.3%, had growth below 1%. Small countries in Latin America performed better than those in the Pacific, growing at around 1.5% a year.

How did some small nations manage to attain high economic growth? There are a number of reasons. The first possibility is the lucky accident of being endowed with valuable natural resources, often developed by foreign firms. Every small nation has some advantage in natural resources — whether it be location, coastline, minerals, forests etc. The capacity to build on this natural resource depends on the nation’s social and economic institutions. Because of small population, and hence possibly

Table 4. Characteristics of Small Countries by Regions of the World, 1980–1999.

Country	Services (%)	Agriculture (%)	Openness (%)	CVI	Island
Pacific	48.1	21.9	114	9.5	
Fiji	57.3	20.0	85.3	8.9	yes
Samoa	38.0	22.4	75.8	7.4	yes
Solomon Islands	na	na	168.3	8.4	yes
Vanuatu	97.1	23.2	124.8	13.3	yes
East Timor	70.5	25.2	57.9	na	yes
Sub-Saharan Africa	45.8	25.0	105	7.4	
Botswana	43.7	5.3	113.3	10.2	no
Cape Verde	64.3	11.6	115.3	5.0	yes
Comoros	50.2	37.9	74.4	5.4	yes
Equatorial Guinea	21.8	49.3	90.1	7.0	yes
Gabon	40.4	7.7	101.6	6.2	yes
Gambia, The	55.1	31.1	100.8	9.3	yes
Guinea-Bissau	34.0	52.5	66.0	na	yes
Mauritius	57.3	11.9	126.0	6.5	yes
Swaziland	45.5	17.5	154.9	9.6	no
Latin America	56.8	14.1	109	6.6	
Barbados	73.9	4.7	95.6	5.7	yes
Belize	52.5	21.8	84.1	6.7	yes
Guyana	37.8	29.0	133.9	8.0	yes
St. Lucia	67.5	12.7	152.9	7.5	yes
Trinidad & Tobago	52.4	2.3	78.4	5.3	yes

Note: CVI = Composite Vulnerability Index.

greater homogeneity and closer internal ties, it may be easier to make the social adjustments needed to take advantage of the potentialities of modern technology and economic growth (Katzenstein, 1995).

Small and micro-states could be expected to have more open economies than large countries due to their small domestic markets. But this is not the case. Openness in super states is, on average, 31.8% of GDP compared to 21.9% in small states and 27.1% for micro-states (Table 3).

However, when we disaggregate small countries by region, the pattern of openness becomes clearer (Table 4). At the regional level in Africa, the Pacific and Latin America, on average, small countries have an openness of more than 100% of GDP. Some countries have openness ratings as high as 168% (Solomon Islands), 155% (Swaziland), or 152% (St. Lucia). But, other small countries in these regions are relatively closed, such as East Timor with 58% of GDP, Guinea-Bissau with 66% and Trinidad and Tobago with 78%.

Given the prevalence of export-led strategies of development, various areas of specialisation which have been attempted or suggested for island countries are plantations and cash crops (cloves, sugar, banana, cocoa etc), fishing, mining (oil, bauxite, phosphate, nickel, manganese, etc), manufacturing and processing (Dommen and Hein, 1985).

Investment does not necessarily follow openness and an economy accessing external financial resources may become exposed to the consequences of events on international financial markets. However, capital movements may depend more on economic policies than do trade movements, and access to external financial resources (loans, grants and transfers) may offer insurance during adverse periods.

With the implementation of the Uruguay Round agreements, and following the expiry of the Lomé IV Convention in the year 2000, small states may find themselves increasingly marginalised in this more competitive trade environment.

Challenges for small countries in the global economy

Countries need to be open to reap the benefits of globalisation and this can pose challenges to small countries. Two important points which need to be taken into account when opening up and participating in globalisation are income volatility and distributive effects.

Income volatility

The opening up of economies exposes small countries to volatility in annual growth. Given the large share of trade in GDP of small countries, volatility of terms of trade shocks can also be transmitted to volatility of income growth. Since the growth of income in small countries depends on trade, the fluctuations, or decline, of prices on the international market will affect the growth of income.

As well, exports by small states are likely to be more specialised than those of large states, in terms of both products exported and export markets (Kuznets, 1960; Armstrong and Read, 1998). As a result, the average prices of small state exports and imports may be more volatile than in countries with more diversified trade patterns. Diversification is a good option for small countries to insure against volatility on the international market. However, options for diversification may be limited because of limited land, which also limits natural resource endowment. Sometimes small countries are islands (Table 4) which can be prone to natural disasters or depend on a single commodity like bauxite or bananas. This alone poses challenges for insuring against volatility of that single dominant price on the international market.

To avoid trade shocks, it is important to allow countries to share risks with the rest of the world. This can be done by holding claims on assets located outside the country's borders, where returns are not correlated with returns to domestic assets (Easterly and Kraay, 2001).

Distributive effects

In an ideal world, globalisation will produce benefits for all people in a country, especially for small countries with small populations compared to larger countries. However, globalisation forces a reallocation of resources and some groups within a country may experience painful adjustments. Therefore, globalisation produces winners and losers. Losers will try to make their voices heard and reduce the speed of globalisation.

To address this problem, it is important to introduce compensatory policies to minimise social tensions and help the losers adjust when a country opens up to globalisation. These measures can include special training programs for the unskilled who are displaced, especially those who are displaced in sectors which benefit least from the new order and who are forced to enter into new sectors or markets.

It is also important to provide assistance to access capital for those who are displaced and must start afresh. This is especially true for small and medium

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companies that cannot compete in the regional or global market because of capital constraints.

Conclusion

The role of the agriculture sector varies across countries in the world. Small countries in Africa tend to have a larger share of GDP compared to those in Latin America and the Pacific. For all, globalisation is not necessarily a bad thing. Small countries can reap the benefits of international trade, and thus globalisation, because of economies of scale. However, two conditions need to be taken into account. First, small countries need to insure against volatility in the international market by diversifying the risk through holding assets abroad. Second, they need to undertake compensatory policies for those who are disadvantaged due to openness and globalisation. These policies can involve training to raise workers' skills and productivity and the provision of access to the capital market.

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III
Seeds of Life

Photographer: Brad Collis

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An introduction to the ACIAR project 'Seeds of Life–East Timor'

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Abstract

This paper provides an introduction to the ACIAR Seeds of Life project in East Timor, which has the goals of 1) improving food security for East Timor through the introduction, testing and distribution to farmers of improved germplasm of the major food crops and, 2) enhancing the capacity of Timorese scientists and technicians to independently develop and manage crop improvement programs for the benefit of village farmers and the nation.

The major staple crops being tested are irrigated rice, rainfed lowland rice, upland rice, maize, cassava, beans (red beans, soybean, mungbean, cowpea), sweet potato, potato, and peanut (groundnut). The main project activity has been the testing of 10–20 potentially adapted lines of these crops across four or five differing environments of East Timor. Trials in the first two years were conducted at Aileu, Baucau, Los Palos, Maliana and Maubisse in 2000–2001 and Aileu, Fatumaca, Betano and Loes in 2001–2002. Sites and experimental methods are described in the paper. Observations and measurements were made assessing growth, yield, stress tolerance and acceptability (taste).

It was very encouraging that some introduced varieties/lines of irrigated rice, maize, cassava, beans and sweet potato produced yields which were much higher than local check varieties. This indicates the appropriateness of the project approach to test widely for better adapted germplasm for East Timor. The increased yields possible with better-adapted material should bring strong benefits when extended and taken up by East Timorese village farmers.

Detailed reports on the trials, the performance of the crops and some suggestions on the best adapted lines are provided in the five papers that follow on maize, rice, sweet potato, peanut, and cassava and beans.

Introduction

EAST TIMOR, which comprises the eastern half of the island of Timor, is about 300 km long and 100 km wide. The climate is semi-arid. Along the north coast there is a short 3–4 month wet season of 800–1000 mm from December to March and a long, hot dry season. It is wetter along the south coast, with a 1000–1500 mm wet season, sometimes bimodal, from December to June. The wet season is wetter (1500–2000 mm) and longer (6–8 months) along the central mountain range, which rises to almost 3000 m. However, rainfalls are typically unreliable and unpredictable and short- and long-term droughts are common. Soils are sedimentary, with high clay contents and pH is generally alkaline, although some older formations are slightly acidic. There are five major land/soil formations (Aldrick, 1984a; Aldrick, 1984b; Aldrick and Anda, 1987) and six major agro-climatic zones (ARPAPET, 1996; Keefer, 2000).

East Timor has 850,000 inhabitants and, with a GDP/capita of US$400, is one of the poorest countries in the Asia-Pacific region and one of the poorest 10 countries in the world. Some 85% of the population live in rural areas, where people rely on subsistence agriculture for their livelihoods and have little capacity to participate in the cash economy.

Farming families generally grow corn as the major staple crop with other crops such as sweet potato, cassava, peanut, beans, pumpkins, rice, taro

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and yams also prominent. In some areas wild forest foods such as yams, tubers and beans may be harvested. Food insecurity remains a major problem. There are food shortages each year during the three to six month period prior to crop harvest in March–April and there can be widespread famines in occasional years when there is a major drought and the wet season fails. The extent and duration of hungry periods depend mainly on the amount of maize and other crops harvested and stored from the previous year. Increasing crop yields in a sustainable manner can help alleviate food shortages and is a key priority for agriculture in East Timor.

The country, formerly a Portuguese colony and Indonesian province, voted for independence in August 1999. In the few weeks following the independence vote, there was widespread and extensive damage of infrastructure and institutions, displacement of people, and disruption to farming activities as Indonesian troops and militia withdrew and the United Nations became established. In many towns, most schools, offices, shops and houses were destroyed. Damage was less in rural areas, but farming and markets were severely disrupted with massive losses of livestock and planting materials. Since this time, there has been a shortage of well-adapted planting material of staple crops. Emergency seed brought in during 1999–2000 was not necessarily well adapted to local conditions and locally-used material often lacks vigor and purity. There is a recognised need to reinvigorate the planting material of the major crops.

ACIAR developed the Seeds of Life project in August–October 2000 in response to these cropping issues with the goals of 1) improving food security for East Timor through the introduction, testing and distribution to farmers of improved germplasm of the major food crops; and 2) enhancing the capacity of Timorese scientists and technicians to independently develop and manage crop improvement programs for the benefit of the nation and for village farmers.

The project is consistent with the major aims of the agricultural sector in East Timor, which are to support a rural population of healthy, well-fed adults and children with access to a balanced intake of carbohydrate and protein and the capacity to produce and market surpluses which contribute to national food security and a cash economy. The overall strategy promotes not only the production of rice and maize, but also of protein-rich legumes in cropping systems which are sustainable and relevant to upland, non-irrigated areas where the majority of the farmers depend on dryland crops.

The proposal was developed quickly in September–October 2000 with excellent cooperation from all potential collaborators, to try and ensure testing could begin in the 2000–2001 wet season. This was achieved with the workplan being agreed and seed for testing introduced at the first project meeting in Dili in November 2000. A highlight of the first meeting was the launch of the project on 16 November 2000 by Xanana Gusmao.

It was agreed that the project would run from 2000 to 2003 to cover the 2000–2001, 2001–2002 and 2002–2003 wet seasons. The Memorandum of Understanding (MOU) for the project was signed in December 2000 by CGIAR institutes and between April and June 2001 by the East Timor Transitional Administration/United Nations Transitional Administration for East Timor (ETTA/UNTAET), ACIAR and ET partners

Collaborators

The project is a collaborative effort between the Division of Agricultural Affairs of ETTA/UNTAET, which since independence on 20 May 2002 has become the Ministry of Agricuture, Forestry and Fisheries (MAFF), and ACIAR, with participation from several Non Government Organisations [World Vision International (WVI), Catholic Relief Services (CRS), Australian Volunteers International (AVI)] and Centers of the Consultative Group of International Agricultural Research (CGIAR) including the International Rice Research Institute (IRRI), the International Maize and Wheat Centre (CIMMYT), the International Centre for Tropical Agriculture (CIAT), the International Potato Centre (CIP) and the International Centre for Research in the Semi-Arid Tropics (ICRISAT).

Personnel involved in implementing the project are:

MAFF: G. San Valentin, F. Benevides, D. Da Silva, A. Da Costa, J. Soares
AVI/ACIAR: B. Palmer, B. Monaghan
ACIAR: C. Piggin
WVI: P. Kapukha, D. Tupa
CRS: A. de Oliveira
IRRI: E.L. Javier, M.C. Toledo, V. Lopez, R. Reano
CIMMYT: F. Gonzalez
ICRISAT: S. Nigam, A.G.S. Reddy, D. Yadagiri
CIAT: R. Howeler, K. Hartojo
CIP: U. Jayasinghe, A. Setiawan

Objectives

The specific objectives of the project are:

- To evaluate under a range of soils, land forms and climatic conditions in East Timor the adaptation of a range of lines of rice, maize, cassava, beans (including red beans, soybean, mungbean,

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cowpea), potato, sweet potato and peanut supplied by IRRI, CIMMYT, CIAT, CIP, and ICRISAT

- To identify and multiply lines with improved environmental adaptation and tolerance to biotic (pests, diseases) and abiotic (drought, low fertility) stresses
- To improve farmers' access to high-quality seeds of the best-adapted cultivars
- To gather crop performance base data over a range of environments for future developmental programs on increasing farm productivity
- To build capacity of East Timorese Government institutions and staff in evaluation, production and distribution of improved germplasm.

Expected outputs

Expected outputs from the project over three years are:

- information on best-adapted lines
- knowledge of farmer preferences from on-farm testing and tasting
- seed increase and distribution to farmers of 'released' varieties
- increased capacity of MAFF and NGO staff to identify, investigate and solve problems.

Crops

The project is addressing the major staple crops of East Timor, with new and potentially better-adapted germplasm supplied by the CGIAR institutes as follows:

IRRI — Irrigated rice, rainfed lowland rice, upland rice

CIMMYT — Maize

CIAT — Cassava, beans (red beans, soybean, mungbean, cowpea)

CIP — Sweet potato, potato

ICRISAT — Peanut (groundnut)

Methodology

The main project activity has been the testing of 10–20 potentially adapted lines of each of the main crops across 4–5 differing environments of East Timor. Trials were conducted in Aileu, Fatumaca, Los Palos, Maliana and Maubisse in 2000–2001 and Aileu, Fatumaca, Betano and Loes in 2001–2002. Observations and measurements were made assessing growth, yield, stress tolerance and acceptability (taste).

Generally, crops were established and managed according to standard CGIAR institute recommendations and normal farmer practice. The main deviation was that all crops received a low basal dressing of fertiliser of 15:15:15 $N:P_2O_5:K_2O$ to reduce site differences in fertility and allow reasonable crop growth and better expression of genetic differences. It was considered that there is no point in conducting comparisons where nutrient availability is so low that crops fail. In general, the fertility of soils in East Timor is very low, so that crop growth and yields can be very poor and differing yield potentials may not be expressed. At some locations, two or three lines of maize were grown without fertiliser as extra treatments to quantify fertiliser responses and allow some comparison of sites.

This is not to suggest that fertilisers will become universal in East Timor. But reasonable yields can only be achieved and maintained if adequate soil nutrients are available. Farmers have opportunities to influence fertility of cropping areas through selection of garden locations with better soils, use of manures and legume rotations, or purchase of fertilisers through local traders if they have available funds. And, it is possible that use of fertilisers will increase in East Timor with agricultural development.

Locations and character of project trial sites

In 2000–2001, trials were conducted on five sites at Baucau and Lautem in the east (under the guidance of CRS), Bobonaro in the west and Aileu and Maubisse in the central highlands (under the guidance of WVI). The experimental program started late for two reasons; firstly, the wet season was unexpectedly early and, secondly, some of the material was unavoidably late arriving in East Timor. Nevertheless, the 2000–2001 trials allowed valuable experience and information to be obtained on crop performance and difficulties conducting trials in the East Timorese environment. Many trials yielded useful technical data and have supported information for more rigorous trials in 2001–2002.

The locations used for the second and third seasons were Fatumaca in the district of Baucau in the east, Aileu in the central highlands, Betano in the district of Manufahi in the south and Loes in the district of Liquica in the west (Fig. 1). The Fatumaca site is on the Agricultural Training Centre run by the Silesian Order and is conducted with the guidance of Father Eligio Locetelli, with assistance from CRS under the management of Dr Brian Palmer. The Aileu site, conducted on property rented by the Portuguese Mission, is managed by Dr Brian Palmer using locally appointed farm staff. The Betano site, located on MAFF property, is managed by Mr Brian Monaghan in conjunction with MAFF staff and locally employed laborers. The Loes site, located on land under MAFF control, is managed by Dr Gene San Valentin in conjunction with MAFF staff and locally appointed laborers.

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Aileu site

This site is located near the town of Aileu and is at an elevation of about 950 m on an alluvial terrace. The area is renowned for high intensity rain showers and so the plots were positioned on raised beds to encourage adequate drainage (Fig. 2). All operations were carried out by hand.

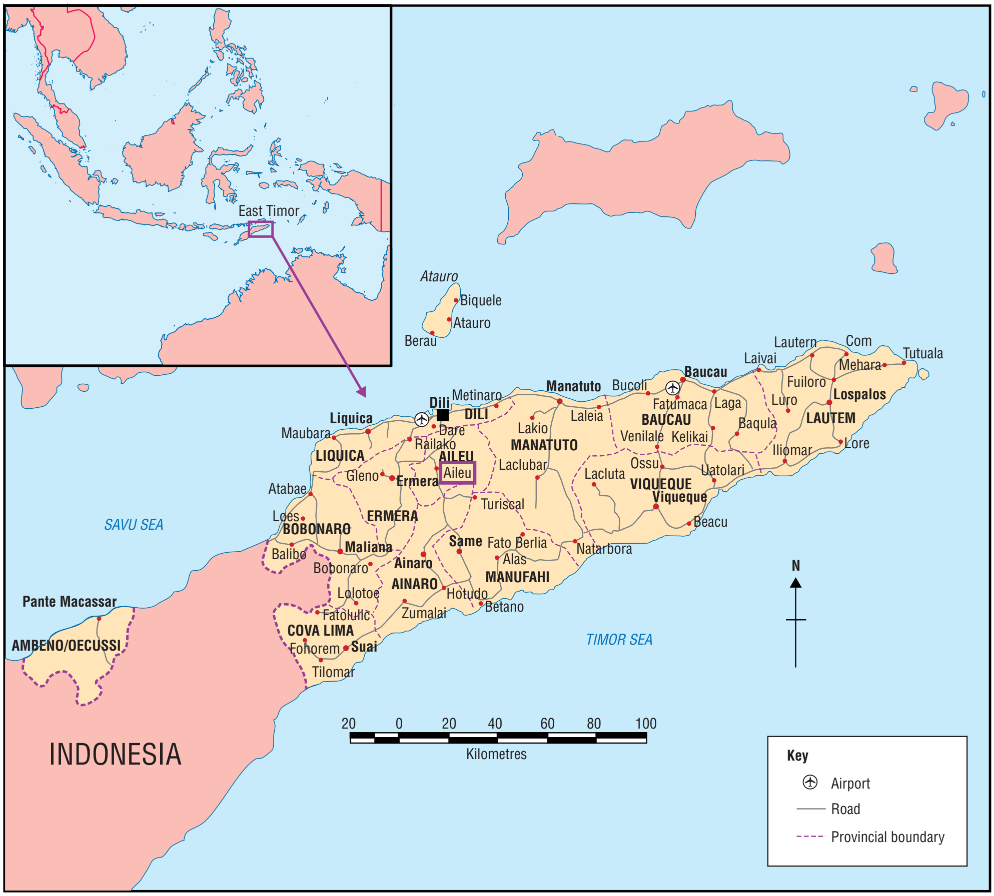
The major upland food crops grown by farmers in the area are maize and vegetables with minor amounts of cassava and sweet potato grown in home gardens. Soil fertility is extremely low (Fig. 3) and major responses to low levels of fertiliser inputs are observed. The Aileu site is representative of the central highlands.

Fatumaca site

This site at Fatumaca is a raised coral derived from coraline limestone, well structured with no evidence of waterlogging, and representative of the eastern region It is located on a plateau about 500 m above sea level. The soil appears deficient in major nutrients, particularly phosphorus owing to its relatively high iron content (probably a ferrusol). The location has had a history of cropping with fertiliser application. The site was cultivated using a reversible disc plow and rotovation. The major crops grown by farmers in the area are maize and groundnuts with minor amounts of cassava and sweet potato grown in home gardens.

Loes site

The soil at this site is a coarse-textured, old alluvial terrace located near Liquica close to the Bobonaro and Ermera districts; it is well drained and at an elevation of about 100 m. The soil fertility is low and the most common fertiliser used is urea, although



*Fatumaca (Baucau), **Betano (Manufahi), ***Aileu (Aileu), ****Loes (Liquica)

Figure 1. Location of experimental sites (2002–2003).

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Figure 2. Aileu location prior to planting.

No fertiliser

Local maize (white)

Plus fertiliser

Figure 3. Maize at Aileu. Photographer: Brian Palmer

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Figure 4. Average rainfall data.

deficiencies of phosphorus and potassium are suspected. The major upland food crops grown by farmers in the area are maize and cassava with minor amounts of groundnut, mungbean, upland rice and sweet potato. Large areas of irrigated rice grow next to the river Loes.

Betano site

This site is located south of the town of Same on the south-central coast and is at an elevation of just above sea level on recent alluvial deposits. The area has a longer wet season, with rains continuing into May–July (Fig. 4). All operations were carried out by hand.

The major upland food crops grown by farmers in the area are rice and maize with minor amounts of cassava and sweet potato grown in home gardens. Soil fertility is low and major responses to low levels of fertiliser inputs are observed. There are suggestions that the site is alkaline with induced iron deficiency. The Betano site is representative of the south coastal area.

Rainfall

On average, the wet season occurs between late November/December and April in lowland northern areas, with extended rains from May to July in the south (Betano) and in October in the central highlands (Aileu). There is very little rain between July and October. However, rainfall is extremely variable, and short dry periods are common in the wet season. There are also some years when the wet season fails. Long-term rainfall at the 2001–2002 sites is presented in Figure 4.

Crop performance 2000–2002

Overview of crop trial results

Some introduced varieties/lines of all crops except potato and red beans gave outstanding yields, which were much higher than local check varieties. These are highlighted below, and confirm the appropriateness of the project approach to test widely for better adapted germplasm for East Timor. The increased yields possible with better adapted material should bring strong benefits when extended and taken up by East Timorese village farmers. Potato and red beans proved difficult to grow well in the trials, probably because of the need for different planting times and/or management from the other crops.

In 2000–2001, after a rushed start, good, analysable data was obtained from 12 of the 35 trials,

Figure 5. Rice field near Bacau. Photographer: Eric McGaw

which were conducted at Los Palos, Baucau, Aileu, Maubisse, and Maliana. Yields of some introduced material were much higher than local controls for maize (3 vs 1.8 t/ha), sweet potato (24 vs 4 t/ha), peanut (4 vs 2 t/ha), and cassava (35 vs 6 t/ha). These are quite remarkable increases from better adapted material.

In 2001–2002, in trials at Baucau, Aileu, Betano, and Loes, local maize varieties had an average yield of 1.3–1.5 t/ha over the four sites, whilst CIMMYT lines SWS001Y-3 and SW5 had average yields of 3.8 and 3.5 t/ha. At Baucau, local sweet potato yielded 1.1 t/ha whilst the eight introduced CIP lines all yielded above 8 t/ha. At Baucau, local peanut yielded 2.8 t/ha whilst ICRISAT lines 93269, 95322, 95278 and 93261 yielded over 3.5 t/ha. At Loes, local peanut yielded 2 t/ha whilst 94063 yielded 3.4 t/ha. At Betano, ten test entries of irrigated rice had significantly higher yields than the local variety (3.49 t/ha), with PSB RC 74 having the highest yield (8.1 t/ha), followed by IR 72 (7.34 t/ha), and PSB RC 4 (6.90 t/ha).

Detailed reports

Detailed reports on the first two years of testing have been produced for rice by IRRI, maize by CIMMYT, peanut by ICRISAT, cassava and beans by CIAT, and sweet potato by CIP. These are reproduced in the five papers that follow in this proceedings and describe the experimental crop trials conducted in the 2000–2001 and 2001–2002 wet seasons in terms of: trials and activities; data collected and findings; interim conclusions on crop performance and 'best-bet' lines.

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Challenges and opportunities for maize research in East Timor — results of variety identification during the 2000 and 2001 cropping seasons

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Abstract

The Seeds of Life — East Timor project funded by ACIAR with the Ministry of Agriculture Forestry and Fisheries of East Timor was initiated in 2000 with the main goal to improve food security in East Timor through the introduction, testing and distribution to farmers of improved germplasm of major food crops. CIMMYT supplied improved, stress tolerant, high yielding maize varieties for testing in different agro-climatic conditions of East Timor. Testing during two growing seasons resulted in the identification of several varieties of different maturity and grain color with good adaptation to different regions in the country. During the first growing season (2000–2001), despite the difficulties of establishing and conducting research in the country, it was possible to obtain preliminary results from one early and one late-maturity variety trial, evaluated at Maliana and Aileu. In the early-maturity group, S97D145 and Lamuru varieties were 54 and 67% higher yielding than the local check, respectively. In the late-maturity group, LYDMR and SW5 varieties surpassed the local check by 66 and 87%, respectively on average. During 2001–2002, one trial, containing early and late maturity varieties, was conducted at four locations. Among the late varieties, SW5 confirmed its good adaptation and yield potential, exceeding by 125% the best local check on average. Similarly, S97D145 surpassed the best local check by 106%. In addition, the three full-season varieties SWS00351-1, SWS00352-2 and S99TLWQ-HG AB produced over 1.5 t/ha more than the local check. S99TLWQ-HG AB is a white QPM (Quality Protein Maize) variety with added nutritional value. The new, early yellow variety SWS001Y-3 was also in the top-performing group at each location with an average yield of 3.76 t/ha. Varieties SW5, S97D145 and the new varieties identified in 2001–2002 are proposed for multilocation testing and initial seed multiplication. Stresses identified during these two years include low fertility, drought, northern leaf blight and post-harvest pests. Main challenges for future activities include identifying the best variety for such a diverse climate and soil conditions, establishing a system for screening and releasing varieties on a continuous basis, establishing a good seed multiplication and delivery system and reducing post-harvest losses. Despite all the challenges, the current situation offers a unique opportunity to increase overall productivity by replacing the low-yielding local varieties with the improved germplasm that meets the yield and other qualitative traits required by farmers.

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Introduction

THE SEEDS of Life project funded by ACIAR with the Ministry of Agriculture Forestry and Fisheries of East Timor and with involvement of five centres of the Consultative Group for International Agricultural Research (CGIAR) was initiated in 2000 with the main goal to improve food security in East Timor through the introduction, testing and distribution to farmers of improved germplasm of major food crops. CIMMYT supplied improved, stress-tolerant, high-yielding maize varieties for testing in different agro-climatic regions of the country. Maize and rice are the major staple food crops in East Timor but due to the lack of suitable land for rice cultivation, maize covers the largest area of any crop.

In spite of the small size of East Timor, the country has about five major soil formations and six major agro-climatic zones, making it difficult to identify varieties with the best adaptation and performance for the whole country. In addition, poor infrastructure for research and lack of trained researchers are other constraints for the rapid identification and dissemination of improved germplasm.

Variety selection and trial designs

Initially, variety selection was based on information available in CIMMYT records, from input of experienced researchers in the region, and from site similarity information available. The first group of varieties, which were included for testing, was formed with popular varieties from Indonesia, important varieties in Asia and varieties that performed well in environments similar to East Timor (Tables 1 and 2). For the first season, it was considered desirable to separate varieties based on maturity. One early and one late trial were assembled with 12 and 10 entries, respectively. One local check was included in each trial.

Table 1. Early varieties tested in East Timor (2000–2001).

Entry	Variety name	Origin	Description
1	S98DEY-1	CIMMYT	Early yellow, DMR
2	S97D145	CIMMYT	Early yellow, DMR
3	POP145C5	CIMMYT	Early yellow, DMR
4	POP31C5	CIMMYT	Early yellow, DMR
5	S98D031	CIMMYT	Early yellow, DMR
6	POP49(Y)	CIMMYT	Early yellow, DMR
7	S98D145	CIMMYT	Early yellow, DMR
8	S98D147	CIMMYT	Early yellow, DMR
9	Lagaligo	Indonesia	Indonesia variety
10	Lamuru	Indonesia	Indonesia variety
11	CTS991044	CIMMYT	Yellow hybrid, DMR
12	Local check	East Timor	Farmers' variety

Table 2. Late varieties tested in East Timor (2000–2001).

Entry	Variety name	Origin	Description
1	S98D28-2	CIMMYT	Late yellow DMR
2	S98DAMATL	CIMMYT	Late yellow DMR
3	LYDMR	CIMMYT	Late yellow DMR
4	S98DSW1	CIMMYT	Late yellow DMR
5	SW1	Thailand	Most important variety in Asia
6	KS6	Thailand	Thai variety
7	SW5	Thailand	Thai variety with DMR
8	BISMA	Indonesia	Indonesian variety
9	CTS993004	CIMMYT	Yellow hybrid, DMR
10	Local check	East Timor	Farmers' seed

The number of entries varied each year but both trials used a randomised complete block design with three replications. Plots contained two rows each 5 m long. Distance between rows was 0.75 m and distance between hills 0.50 m. Three seeds per hill were planted and later thinned to two seedlings per hill.

During the 2001–2002 season, only one trial was assembled for practical purposes. Differences in plant height and maturity are taken into account by having more rows per plot and harvesting central rows. Eighteen varieties and two local checks were included in the trial (Table 3). In addition to the best entries from trials conducted in 2000–2001, a few more entries were included based on recent data available and based on farmer's preference. Among the new entries, there is a group of five QPM varieties with enhanced protein quality.

Table 3. Early and late varieties tested in East Timor (2001–2002).

Entry	Variety	Origin	Description
1	SW1	Thailand	Most important variety in Asia
2	SW5	Thailand	Thai variety with DMR
3	LYDMR	CIMMYT	Late yellow DMR
4	SWS00351-1	CIMMYT	Late yellow DMR
5	SWS00351-2	CIMMYT	Late yellow DMR
6	SWS00352-1	CIMMYT	Late yellow DMR
7	SWS00352-2	CIMMYT	Late yellow DMR
8	SWS00300	CIMMYT	Late white DMR
9	P300C1	CIMMYT	Late white DMR
10	S97D145	CIMMYT	Early yellow DMR
11	ACS00147	CIMMYT	Early yellow DMR
12	SWS001Y-3	CIMMYT	Early yellow DMR
13	S99100	CIMMYT	Early white DMR
14	S99TLWQ1	CIMMYT	Late white QPM
15	S99LWQ-HG-B	CIMMYT	Late white QPM
16	S99TLWQ-HG-AB	CIMMYT	Late white QPM
17	S99TLYQ-HGAB	CIMMYT	Late yellow QPM
18	S99TLYQ-HGA	CIMMYT	Late yellow QPM
19	LOCAL 1	East Timor	Local variety
20	LOCAL 2	East Timor	Local variety

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This was also a randomised complete block design with three replications. Plots comprised four, 5 m long rows. The distance between rows varied from 0.75 to 1.0 m and the distance between hills also varied but plant densities remained the same.

Results 2000–2001

Despite the difficulties of establishing and conducting research in the country, it was possible to obtain preliminary results from Maliana and Aileu where both early and late trials were conducted. Four other locations were lost, mainly due to animal damage and poor soils. Even at Maliana and Aileu, the quality of data was not as good as expected because of the erratic plant populations, but it was felt that data and visual observations reflected which were the best entries and that data could be used for preliminary selection — especially that from Maliana. Plant stand was used as a covariate to adjust for the effect of low plant densities in all cases. Invariably, plant stands of the local variety were lower than the experimental material, an indication of the poor germination due to poor seed quality resulting from the storage conditions used by farmers.

Table 4. Mean grain yield (t/ha) of early varieties evaluated in trial SLP. EVT at Maliana (2000–2001).

Entry	Variety name	Origin	No. of Plants	Yield	% of check
1	S98DEY-1	CIMMYT	56	2.38	142.5
2	S97D145	CIMMYT	47	2.75	164.7
3	POP145C5	CIMMYT	60	2.75	164.7
4	POP31C5	CIMMYT	57	1.93	115.6
5	S98D031	CIMMYT	50	1.80	107.8
6	POP49(Y)	CIMMYT	63	2.06	123.4
7	S98D145	CIMMYT	64	2.25	134.7
8	S98D147	CIMMYT	71	1.40	83.8
9	Lagaligo	Indonesia	57	1.92	115.0
10	Lamuru	Indonesia	63	3.01	180.2
11	CTS991044	CIMMYT	57	2.76	165.3
12	Local check	East Timor	31	1.67	100.0
				Mean:	2.22
				CV:	13.33
				l.s.d. (0.05) =	0.50

* Covariance analysis was done using a number of plants as covariates.

Table 5. Mean grain yield (t/ha) of early varieties evaluated in trial SLP. EVT at Aileu (2000–2001).

Entry	Variety name	Origin	No. of Plants	Yield	% of check
1	S98DEY-1	CIMMYT	25	2.42	131.5
2	S97D145	CIMMYT	24	3.23	175.5
3	POP145C5	CIMMYT	35	2.92	158.7
4	POP31C5	CIMMYT	32	1.81	98.4
5	S98D031	CIMMYT	35	1.53	83.2
6	POP49(Y)	CIMMYT	36	1.37	74.5
7	S98D145	CIMMYT	29	1.43	77.7
8	S98D147	CIMMYT	24	1.35	73.4
9	Lagaligo	Indonesia	25	1.20	65.2
10	Lamuru	Indonesia	35	2.55	138.6
11	CTS991044	CIMMYT	32	2.57	139.7
12	Local check	East Timor	22	1.84	100.0
				Mean:	1.97
				CV:	41.7
				l.s.d. (0.05) =	1.40

* Covariance analysis was done using number of plants as covariates.

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Table 6. Combined grain yield (t/ha) of early varieties evaluated in trial SLP. EVT at two locations in East Timor (2000–2001).

Entry	Variety name	Origin	Maliana	Aileu	Combined	% of check
1	S98DEY-1	CIMMYT	2.38	2.42	2.39	133
2	S97D145	CIMMYT	2.75	3.23	3.00	167
3	POP145C5	CIMMYT	2.75	2.92	2.85	158
4	POP31C5	CIMMYT	1.93	1.81	1.87	104
5	S98D031	CIMMYT	1.80	1.53	1.69	94
6	POP49(Y)	CIMMYT	2.06	1.37	1.72	95
7	S98D145	CIMMYT	2.25	1.43	1.68	93
8	S98D147	CIMMYT	1.40	1.35	1.33	74
9	Lagaligo	Indonesia	1.92	1.20	1.55	86
10	Lamuru	Indonesia	3.01	2.55	2.78	154
11	CTS991044	CIMMYT	2.76	2.57	2.67	148
12	Local check	East Timor	1.67	1.84	1.80	100
		Mean	2.22	2.00	2.1	
		CV:	13.3	41.7		
		l.s.d.(0.05)	0.50	1.40		

* Covariance analysis was done using number of plants as covariate.

Data for the early maturity trial is presented in Tables 4–6. Lamuru from Indonesia and varieties from Population 145 had the best performance and ear appearance at Maliana with 64–80% more yield than the local check (Table 4). The same trend was observed at Aileu, where these varieties yielded 38–75% more than the check (Table 5). Entry 11 is a hybrid included as reference, which also performed well at both locations. On average, S97D145 and Lamuru varieties were 67 and 54% higher yielding, respectively, than the local check (Table 6).

Data from the late maturity trial is presented in Tables 7–9. At Maliana (Table 7), S98D28-2 had the highest yield but also showed more plants with bad husk cover. It was followed by LYDMR, which had 32% more yield than the check. The three Thai varieties (KS5, SW1 and SW5) also yielded 13–19% better than the check. Yields at Aileu were better. Here Bisma was the highest yielding entry (3.82 t/ha), but its pale yellow color and semi-dent kernel texture makes it undesirable. LYDMR and SW5, on the other hand, had excellent color, flint kernels, and yielded 3.3 and 2.8 t/ha, respectively (Table 8). On average, LYDMR and SW5 varieties surpassed the local check by 66 and 87%, respectively (Table 9) and showed excellent grain quality and plant health.

Table 7. Mean grain yield (t/ha) of late varieties evaluated in trial SLP. EVT at Maliana, East Timor (2000–2001).

Entry	Variety name	Origin	No. of Plants	Yield	% of check
1	S98D28-2	CIMMYT	48	2.96	137.0
2	S98DAMATL	CIMMYT	46	2.47	114.4
3	LYDMR	CIMMYT	59	2.86	132.4
4	S98DSW1	CIMMYT	51	2.36	109.3
5	SW1	Thailand	36	2.59	119.9
6	KS6	Thailand	56	2.46	113.9
7	SW5	Thailand	65	2.51	116.2
8	BISMA	Indonesia	64	1.91	88.4
9	CTS993004	CIMMYT	59	1.88	87.0
10	Local check	East Timor	38	2.16	100.00
				Mean: 2.42	
				CV: 13.03	
				l.s.d. (0.05) = 0.84	

* Covariance analysis was done using a number of plants as covariates.

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Table 8. Mean grain yield (t/ha) of late varieties evaluated in trial SLP. EVT at Aileu, East Timor (2000–2001).

Entry	Variety name	Origin	No. of Plants	Yield	% of check
1	S98D28-2	CIMMYT	36	2.78	243.9
2	S98DAMATL	CIMMYT	37	3.46	303.5
3	LYDMR	CIMMYT	35	3.30	289.5
4	S98DSW1	CIMMYT	44	3.69	323.7
5	SW1	Thailand	26	1.94	170.2
6	KS6	Thailand	33	3.38	296.5
7	SW5	Thailand	27	2.80	245.6
8	BISMA	Indonesia	45	3.82	335.1
9	CTS993004	CIMMYT	21	3.65	320.2
10	Local check	East Timor	14	1.14	100.00
				Mean: 2.99	
				CV: 27.56	
				l.s.d. (0.05) = 0.68	

* Covariance analysis was done using a number of plants as covariates.

Table 9. Mean grain yield (t/ha) of late varieties evaluated in trial SLP. EVT at two locations in East Timor (2000–2001).

Entry	Variety name	Origin	Maliana	Aileu	Combined	% of check
1	S98D28-2	CIMMYT	2.96	2.78	2.8	170
2	S98DAMATL	CIMMYT	2.47	3.46	2.9	175
3	LYDMR	CIMMYT	2.86	3.30	3.1	187
4	S98DSW1	CIMMYT	2.36	3.69	3.0	178
5	SW1	Thailand	2.59	1.94	2.2	133
6	KS6	Thailand	2.46	3.38	2.9	177
7	SW5	Thailand	2.51	2.80	2.8	166
8	BISMA	INDONESIA	1.91	3.82	2.9	172
9	CTS993004	CIMMYT	1.88	3.65	2.9	172
10	Local check	East Timor	2.16	1.14	1.66	100
		Mean	2.42	3.00	2.7	
		CV	13.03	27.56		
		l.s.d. (0.05)	0.84	0.681		

* Covariance analysis was done using a number of plants as covariates.

Results 2001–2002

A special mention should be made about the conduct of trials during the 2001–2002 season. In general, the trial at each location had good plant stands and good weed and insect control. It was evident that the extra effort in managing and monitoring trials resulted in better quality of data (low CVs and better expression of high-yielding varieties). At Betano, some plots were damaged by animals. These plots were detected early in the season and taken out from the analysis of the experiment. Checks for this location were missing.

No serious diseases were observed during the season. At Aileu there was a low incidence of northern leaf blight caused by *E. turcicum*. At the same location, some plants showed symptoms of what appear to be sugarcane mosaic virus.

Table 10 shows rankings of all varieties at each location. It shows relative performance of each variety at different sites. For example, entry 12 (SWS001Y-3) that ranked first overall, was also on the top five entries at each of the four sites. Entry 12 was a new entry this year and was included from the encouraging results in other countries in Asia. Entry 2 (SW5) confirmed its good adaptation and yield potential. It was the top entry at Baucau and among the best entries at Aileu and Betano. Only at Loes was it not among the top entries, but yield was not significantly different from the best local check, Kalinga, a popular variety in Indonesia. Entries 7 (SWS00352-2) and 4 (SWS00351-1) ranked third

Table 10. Ranking for grain yield (t/ha) of maize varieties by location and overall means across four locations of varieties evaluated in SLP trials in East Timor (2001–2002).

Entry	Pedigree	Origin	Location				Overall Means	
			1	2	3	4	Grain yield	Rank
1	SW1	SW99E 2039-1	3	14	17	17	2.54	13
2	SW5	KU, Thailand	1	6	6	11	3.04	2
3	LYDMR	SW99E 2035	9	17	9	2	2.78	6
4	SWS00351-1	SW01D 1024	7	8	3	10	2.85	4
5	SWS00351-2	SW01D 1025	5	13	10	16	2.71	9
6	SWS00352-1	SW01D 1026	2	10	13	20	2.59	11
7	SWS00352-2	SW01D 1027	6	5	11	3	2.99	3
8	SWS00300	SW01D 1030	16	12	18	13	2.23	18
9	POP300C1	SW00L 3025	10	9	15	6	2.57	12
10	S97D145	SW98L 3006	14	1	2	19	2.76	7
11	ACS00147	SW00L 3019	13	4	12	9	2.70	10
12	SWS001Y-3	SW00L 3003	4	3	1	5	3.44	1
13	S99100	SW00L 3006	18	2	14	1	2.81	5
14	S99TLWQ1	TUM00B 5271-7	11	18	16	7	2.27	17
15	S99TLWQ-HG B	COT01A 267-35-61	12	15	8	14	2.48	15
16	S99TLWQ-HG AB	COT01A 267-62-138	8	7	7	15	2.74	8
17	S99TLYQ-HG AB	COT01A 268-44-87	15	11	4	8	2.50	14
18	S99TLYQ-HG A	COT01A 268-1-23	17	16	5	12	2.33	16
19	Local check 1		20	19		4	1.53	19
20	Local check 2		19			18	1.32	20

No.	Location	District	Zone
1	Fatumaca	Baucau	Eastern
2	Aileu	Aileu	Central highland
3	Betano	Manufahi	Southern coast
4	Loes	Liquica	Western

and fourth, respectively. These varieties are derived from the first cycle of selection of two new heterotic late populations. Entry 13 (S99100) is a new white early variety that showed excellent performance at Aileu and Loes. Even though it ranked 18 at Betano, it yielded over 50% higher than the best check. Other varieties that had good overall performance include entry 3 (LYDMR), entry 10 (S97D145) and entry 16 (S99TLWQ-HG-AB).

Table 11 shows mean grain yield at each location and combined yield. It also shows b values for each entry as an indication of their relative stability (values closer to one mean the variety has more stability across environments). Among the selected varieties from 2000–2001, SW5 confirmed its good adaptation and yield potential, exceeding by 98% the best local check on average. Similarly, LYDMR and S97D145 surpassed the best local check by 80%. Among the new entries, SWS001Y-3 was the top performer, outyielding the best check by 124%. The three full-season varieties SWS00351-1, SWS00352-2 and S99TLWQ-HG AB, along with the early variety S99100, produced over 1.0 t/ha more than the local check. S99TLWQ-HG AB is a white QPM (Quality Protein Maize) variety with added nutritional value.

Conclusions

Testing during two growing seasons resulted in the identification of several varieties of different maturity and grain color, with good adaptation to different regions in the country. Varieties SW5, S97D145, LYDMR and the new varieties identified in 2001–2002 are proposed for multi-location testing and initial seed multiplication. Enough seed is being provided for evaluation of selected varieties in yield trials during 2002–2003, as well as for unreplicated on-farm tests and seed multiplication. This last activity will require intensive training of East Timorese researchers in Nepal, India or another location where CIMMYT is conducting seed multiplication. Hands-on training is also required in trial design, trial management and data collection.

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Table 11. Mean grain yield (t/ha) by location and overall means across four locations of varieties tested in SLP trials (2001–2002).

Entry	Pedigree	Origin	Location 1	Location 2	Location 3	Location 4	Overall Means: Grain yield	Overall Means: b value	Overall Means: Rank
12	SWS001Y-3	SW00L 3003	3.58	4.03	3.67	2.47	3.44	1.17	1
2	SW5	KU, Thailand	4.14	3.54	2.67	1.81	3.04	1.51	2
7	SWS00352-2	SW01D 1027	3.30	3.65	2.42	2.57	2.99	0.96	3
4	SWS00351-1	SW01D 1024	3.26	3.48	2.80	1.84	2.85	1.31	4
13	S99100	SW00L 3006	2.02	4.10	2.09	3.04	2.81	0.86	5
3	LYDMR	SW99E 2035	3.08	2.70	2.54	2.80	2.78	0.00	6
10	S97D145	SW98L 3006	2.17	4.10	3.22	1.53	2.76	1.83	7
16	S99TLWQ-HG AB	COT01A 267-62-138	3.10	3.50	2.63	1.74	2.74	1.41	8
5	SWS00351-2	SW01D 1025	3.57	3.13	2.48	1.67	2.71	1.25	9
11	ACS00147	SW00L 3019	2.52	4.02	2.36	1.91	2.70	1.66	10
6	SWS00352-1	SW01D 1026	3.65	3.23	2.33	1.26	2.59	1.67	11
9	POP300C1	SW00L 3025	2.67	3.27	2.04	2.28	2.57	0.86	12
1	SW1	SW99E 2039-1	3.59	3.05	1.86	1.64	2.54	1.31	13
17	S99TLYQ-HG AB	COT01A 268-44-87	2.15	3.20	2.71	1.94	2.50	0.89	14
15	S99TLWQ-HG B	COT01A 267-35-61	2.58	2.96	2.60	1.78	2.48	0.90	15
18	S99TLYQ-HG A	COT01A 268-1-23	2.12	2.71	2.69	1.81	2.33	0.61	16
14	S99TLWQ1	TUM00B 5271-7	2.59	2.29	2.00	2.27	2.27	0.10	17
8	SWS00300	SW01D 1030	2.13	3.15	1.85	1.78	2.23	1.11	18
19	Local check 1		1.02	2.04		2.55	1.53		
20	Local check 2		1.32			1.54	1.32		
	Mean		2.73	3.27	2.50	2.01			
	CV (%)		8	7	11	14			
	l.s.d. (0.05)		0.62	0.70	0.91	0.97			
	l.s.d. (0.01)		0.83	0.94	1.22	1.30			

No.	Location	District	Zone
1	Fatumaca	Baucau	Eastern
2	Aileu	Aileu	Central highland
3	Betano	Manufahi	Southern coast
4	Loes	Liquica	Western

Among the stresses identified during these two years, low fertility, drought, northern leaf blight and post-harvest pests are the most important. Main challenges for future activities include identifying the best variety for such a diverse climate and soil conditions, establishing a system for screening and releasing varieties on a continuous basis, establishing a good seed multiplication and delivery system and reducing post-harvest losses. Despite all the challenges, the current situation offers the unique opportunity to increase overall productivity by replacing the low-yielding local varieties with the best-adapted germplasm that meets the yield and other qualitative traits required by farmers.

Selection of better rice for East Timor

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Abstract

The objectives of the rice component of ACIAR's 'Seeds of Life — East Timor' project are to identify rice varieties with good yield potential, tolerant to major abiotic and biotic stresses, and with acceptable grain qualities for various rice ecosystems and to help in the spread of selected varieties. The three activities being conducted are researcher-managed variety trials, farmer-managed variety trials and seed production. Seed production is an essential component in improving crop productivity. Limited amounts of quality seed will be produced at IRRI and will reach the farmers through on-farm trials. For the irrigated lowland trials, many test entries performed consistently better than the local check at trials at Maliana, Betano and Faulara. These varieties then went on to be evaluated in farmers' fields in the 2002–2003 wet season. The rainfed lowland variety trial failed in 2001–2002 due to the failure of the cropping season. The upland rice trial conducted in 2000–2001 had a very poor stand due to excessive rain and poor soil. Varietal differences were noted in a trial at Lisadila for agronomic traits. The best performing varieties were entered in on-farm variety trials in the following wet season. Once a variety is released, the farmers should be able to obtain quality seeds from government seed farms. Thus, there is a need to train agricultural technicians on rice seed production.

Introduction

THE VOTE for independence in East Timor in September 1999 was followed by widespread destruction of infrastructure, displacement of people, and disruption of agricultural and market activities. Returning farmers need substantial help to rebuild crop production. The ACIAR project: Seeds of Life — East Timor was established to help the East Timorese farmers. Its goal is to improve food security through the introduction and distribution of improved germplasm of various food crops, and training of East Timorese agricultural technicians. The International Rice Research Institute is one of the participating CGIAR centers in the project, responsible for the rice component. The objectives of this component of the project are to identify rice varieties with good yield potential, tolerant to major abiotic and biotic stresses, and acceptable grain qualities for various rice ecosystems, and to help in the spread of selected varieties.

Rice component activities: an overview

Three interrelated activities are being conducted. These are researcher-managed variety trials, farmer-managed variety trials and seed production. A

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researcher-managed trial has 10–15 test materials evaluated in small plots. It may or not be replicated and is conducted at a few sites for at least one year.

The best entries in researcher-managed trials are further evaluated in farmer-managed trials which are unreplicated and have big plots (100 sq m/variety). A farmer is given two to four test entries which he grows using his own resources and management practices. The objectives of a farmer-managed trial are: 1) to know the performance of promising/released varieties in farmers' fields; 2) to allow farmers to select the best variety under their own management practices; 3) to obtain feedback from farmers regarding the varieties; 4) to serve as a source of good seed for use by farmers; and 5) to serve as a demonstration field for promising/released varieties.

It is not enough that a farmer has selected the right variety for his farm. They should have quality seed (genetically pure and viable). Thus, seed production is an essential component in improving crop productivity. In East Timor, where there is no seed industry, the government should have a viable system of seed production and distribution. In the rice component of this project, limited amounts of quality seed will be produced at IRRI and delivered to farmers through on-farm trials. It will be used for further seed increase in government seed production farms. Some technicians will be trained in seed production.

Materials and methods

The target environments for rice varietal testing are irrigated lowland (13,000 ha), rainfed lowland (6000 ha) and upland (3000 ha) ecosystems. Replicated yield nurseries were composed for each ecosystem. The irrigated lowland nursery had 14–15 test entries, rainfed lowland had 11, and upland had 12 for the 2000–2001 and 2001–2002 cropping seasons. An observational nursery for the rainfed lowland ecosystem in high elevations was also composed with 11 test entries for the 2001–2002 cropping season. The test entries originated from IRRI, Philippines; University of the Philippines at Los Banos [UPLB], the Philippine Rice Research Institute [PhilRice]), Indonesia, India and South Korea (Table 1). They were selected based on their yield performance, grain quality and reactions to insect pests and diseases in the Philippines. Most of the entries were developed by IRRI, UPLB and

Table 1. Test entries for rice variety trials and their origin (2000–2002).

Entry	Origin
Irrigated lowland	
B2983B-SR-85-3-2-4	Indonesia
B7003D-MR-3-1-3	Indonesia
IR36	IRRI
IR 50	IRRI
IR 60	IRRI
IR 62	IRRI
IR 64	IRRI
IR 72	IRRI
PSB RC 10 (IR50404-57-2-2-3	IRRI
PSB RC 20 (IR57301-195-3-3)	IRRI
PSB RC 32	Philippines
PSB RC 4	IRRI
PSB RC 54 (IR60819-34-2-1)	IRRI
PSB RC 58	Philippines
PSB RC 74	Philippines
Upland	
B3632F-TB-1	Indonesia
B6144	Indonesia
B6149F-MR-7	Indonesia
C22	Philippines
IET1444	India
IR43	IRRI
IR57924-9	IRRI
KMP34	India
PSBRC1	IRRI
PSBRC5	IRRI
UPLRI-5	Philippines
UPLRI-7	Philippines

Entry	Origin	
Rainfed lowland		
CAMOR	Indonesia	a
DJAMADI	Indonesia	a
IR36	IRRI	ab
IR66	IRRI	ab
LEMO BESAR	Indonesia	ab
PSB RC12	Philippines	ab
PSB RC14	Philippines	ab
PSB RC60	IRRI	ab
PSB RC68	IRRI	ab
PSB RC70	IRRI	ab
SARANG BARUNG	Indonesia	ab
PSB RC42	Philippines	b
IR68333-R-R-B-19	IRRI	c
IR71121-35-1-1-1-2	IRRI	c
IR73305-14-2-2	IRRI	c
IR73689-19-1	IRRI	c
IR73689-31-1	IRRI	c
IR73689-76-2	IRRI	c
IR73691-14-1	IRRI	c
PSB RC92	Philippines	c
PSB RC94	Philippines	c
PSB RC96	Philippines	c
SR18518-BF4-B-12-1-2	Korea	c

a: entries in yield nursery, 2000-2001
b: entries in yield nursery, 2001-2002
c: entries in observational nursery

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PhilRice. Many of them are commercial varieties in the Philippines and if any are found to be adapted to East Timor conditions, it will be easy to import a large quantity.

The farmer's best local variety for each ecosystem was used as the check variety. The nurseries were given to cooperators along with field books describing how trials should be conducted (field layout, crop establishment, and data collection).

In the 2000–2001 cropping season, the irrigated lowland rice trial was conducted on one site, the rainfed lowland trial on three sites, and the upland trial on two sites. In the following cropping season, the irrigated lowland rice variety yield trial was conducted on two sites, and upland and rainfed lowland rice trials on one site each.

Results and discussion

Irrigated lowland

The irrigated lowland trial was conducted at Maliana in the 2000–2001 cropping season. The entries were laid out using a systematic arrangement for all replications instead of the recommended randomised complete block design. Thus, the trial was treated as an observational nursery and yield data were not collected. Most test entries looked better than the local check.

The outstanding performance of many test entries over the local check was confirmed in the 2001–2002 cropping season at Betano and Faulara (Table 2). The local check variety had the lowest yield at Betano. Ten test entries had significantly higher yields than the local variety (3.49 t/ha). PSB RC 74 had the highest yield (8.1 t/ha), followed by IR 72 (7.34 t/ha), and PSB RC 4 (6.90 t/ha). The top three test entries flowered early and had intermediate height. At Faulara, five test entries had significantly higher and one had a significantly lower yield than the local check variety (2.89 t/ha). PSB RC 54 (4.75 t/ha), B7003D-MR-3-1-3 (4.59 t/ha), and PSB RC 58 (4.43 t/ha) had the highest yields. The best test entries across sites were PSB RC 74, PSB RC 58, PSB RC 54, and PSB RC 20. They consistently had significantly higher yields than the local check variety at both sites. Their performance was better than IR 64, a widely accepted variety in East Timor. They, along with PSB RC 32, will be evaluated in farmers' fields in the 2002–2003 wet season.

Rainfed lowland

Results of the yield trials at Aileu and Maliana in 2000–2001 are given in Table 3. At Aileu, not a single test entry produced more yield than the local check variety. The farmer cooperator indicated that the trial was exposed to low temperatures at certain stages of growth. However, a number of test entries showed some potential at Maliana.

Table 2. Agronomic characteristics of entries in the irrigated lowland rice variety trial conducted at Betano and Faulara (2001–2002).

Entry No.	Designation	Betano			Faulara	Mean Yield (t/ha)	Rank
		DTF[a] (no.)	Height (cm)	Yield (t/ha)	Yield (t/ha)		
1	B2983B-SR-85-3-2-4	87	115	6.24*	3.71	4.97	2
2	B7003D-MR-3-1-3	95	106	4.92	4.59*	4.75	2
3	IR 50	82	82	4.75	3.90	4.32	
4	IR 60	84	81	6.17*	2.08	4.12	
5	IR 62	86	85	5.09	4.17*	4.63	2
6	IR 64	87	92	5.91*	2.63	4.27	
7	IR 72	80	87	7.34*	3.84	5.59	2
8	PSB RC 10 (IR50404-57-2-2-3	81	79	6.69*	2.34	4.51	
9	PSB RC 20 (IR57301-195-3-3)	80	90	5.90*	4.12*	5.01	1
10	PSB RC 32	78	106	6.90*	3.60	5.25	2
11	PSB RC 4	89	85	5.46	1.23#	3.35	
12	PSB RC 54 (IR60819-34-2-1)	90	94	6.57*	4.75	5.66	1
13	PSB RC 58	90	101	5.60*	4.43	5.01	1
14	PSB RC 74	80	95	8.10*	4.27*	6.19	1
15	Nona Portu (local check)	—	—	3.49	2.89	3.19	
	l.s.d.			2.05	1.18		

[a] DTF = days to flowering; * = significantly higher than the check; # = significantly lower than the check.

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Table 3. Yield (t/ha) of entries in a rainfed lowland rice variety trial conducted at Aileu and Malina (2000–2001).

No.	Designation	Aileu	Maliana	Mean	Rank
1	Camor	2.85#	2.57	2.71	
2	Djamadi	3.92	2.25	3.08	2
3	IR36	3.12#	2.62	2.87	4
4	IR66	2.68#	2.17	2.43	
5	Lemo Besar	2.17#	2.32	2.24	
6	PSB RC12	1.58#	2.32	1.95	
7	PSB RC14	3.73	1.98	2.86	5
8	PSB RC60	3.63	1.53	2.58	
9	PSB RC68	3.43	1.73	2.58	
10	PSB RC70	3.82	2.72	3.27	1
11	Sarung Barung	2.93#	2.93	2.93	3
12	local check	4.62	2.27	3.44	
	l.s.d. (5%)	1.42	1.08		

The trial in the 2001–2002 cropping season failed. The rainfed observational nursery for low temperature areas was not sown. The yield trial will be repeated in 2002–2003 and the top five entries (PSB RC 70, Djamadi, Sarang Barung, IR 36, and PSB RC 14) will be evaluated in farmers' fields.

Upland rice

The upland rice trial conducted in the 2000–2001 cropping season had a very poor stand due to excessive rain and poor soil. Varietal differences were noted in the 2001–2002 trial at Lisadila for many agronomic traits (Table 4). Yield data was not reliable because lots of grains were lost due to bird damage. Farmers made a visual evaluation of the varieties in the trial and in larger, but unreplicated, plots in an adjacent area. UPL Ri-7 and C22, products of the UPLB breeding program, were ranked number one and two, respectively. These two varieties have been released in other Asian countries. Two Indonesian varieties (B6144 and B6149F-MR-7) and one IRRI variety (IR 43) were ranked third. These five varieties will be entered in on-farm variety trials during the 2002–2003 wet season.

Tentative workplan for 2002–2003

Researcher-managed varietal testing will continue in 2002–2003. The composition of all nurseries will be the same as last year. The yield trial sites are Loes (three ecosystems) and Betano (irrigated lowland ecosystem). If feasible, a rainfed lowland rice observational nursery will be established in Aileu. IRRI will send the nurseries to East Timor in mid November 2002.

Farmer-managed variety trials will be conducted in the coming wet season. The five best lines identified in each ecosystem yield nursery will serve as test entries. On-farm trials for irrigated lowland will be established in eight sub-districts; rainfed lowland in three sub-districts and upland in two sub-districts (Table 5). Each sub-district will contain two sites for a given ecosystem on-farm trial. Each site will have one to five farmer-cooperators — one if the cooperator is willing to evaluate five varieties and five cooperators if each is only interested in evaluating one variety. The suggested variety plot size is 100sq m (1 kg seed). IRRI will send seeds to East Timor in December 2002. The results of the researcher and farmer-managed trials will be the basis for variety recommendation.

Table 4. Agronomic characteristics of entries in an upland rice variety trial at Lisadila (2001–2002).

Entry No.	Variety	DTF (no.)	Height (cm)	Yield (t/ha)	Remarks	Farmer rating
1	B3632F-TB-1	84	135	0.98	Resistant to blast, very susceptible to stemborer (SB)	
2	B6144	83	134	0.73	Moderately resistant to SB	Good
3	B6149F-MR-7	84	125	0.58	Moderately resistant to SB	Good
4	C22	94	118	1.02	Moderately resistant to SB	Better
5	IET1444	82	100	0.35	Very susceptible to SB	
6	IR43	93	87	1.54	Very susceptible to SB	Good
7	IR57924-9	87	115	0.96		
8	KMP34	83	86	1.27	Resistant to blast	
9	PSBRC1	94	122	0.96	Resistant to blast, Moderately resistant to SB	
10	PSBRC5	87	122	1.79	Resistant to blast, Susceptible to SB	
11	UPLRI-5	92	120	0.58	Intermediate resistance to SB	
12	UPLRI-7	86	109	1.21	Moderately resistant to SB	Best

DTF = days to flowering.

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Figure 1. Rice farmers harvesting. Photographer: Eric McGaw

Table 5. Target sites for on-farm variety trials to be conducted in the 2002–2003 cropping season.

Ecosystem	District	Sub-district
Irrigated lowland	Bobonaro	Atabae and Maliana
	Liquisa	Faulara
	Baucau	Vemase and Venalale
	Manufahi	Betano and Same
	Viqueque	Viqueque
Rainfed lowland	Manatutu	Manatutu
	Dili	Metinaro
	Bobonaro	Maliana
Upland	Liquisa	Lisadila
	Viqueque	Viqueque

Once a variety is released, the farmers should be able to obtain quality seeds from government seed farms. Thus, there is a need to train agricultural technicians in rice seed production. Seed production training may be done in East Timor in 2003.

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Performance of some CIP sweet potato clones under East Timorese conditions

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Abstract

Results are presented from the sweet potato trials conducted in Aileu, Maubisse, Fatumaca and Bobonaro during 2000–2001. The results indicate that clones introduced to East Timor performed exceptionally well under the local conditions. The highest yielding among the introduced clones were also among the most palatable according to the local taste. One clone (CIP clone 9), which did not perform well, had excellent vegetative growth during the dry season and could be used as animal feed and as a crop to prevent erosion. The experiment is ongoing and, because of variability in taste preference and yields in different locations, selection of materials to be exposed at farm level should be properly considered. It is expected that farmers will be able to pinpoint the clones of preference to grow in their location in the near future.

Introduction

THIS paper reports the results of the sweet potato trials conducted in East Timor through Seeds of Life — ET. Sweet potato is the seventh most important food crop, based on total world production (FAO, 2002). It has a unique ability to grow on marginal lands with few, if any, inputs such as fertilisers. Although it is a nutritious crop with high vitamin levels, it is more notable as a food security crop than for its nutritional value. Past experience has shown that it is a crop which can sustain populations during times of crisis. This was seen immediately after the Second World War in Japan (Anon., 2000), after the devastating earthquake in 1990 in Northern Luzon, and after the civil disturbances in Rwanda a few years ago. Except for a few areas or countries, such as Irian Jaya, Indonesia and Papua New Guinea where it is a staple food, sweet potato is consumed to a limited extent as a fresh root. Generally, sweet potatoes are given a low priority in the human diet and also on the research agenda of many developing countries. Because of its low value on the market, sweet potato is usually grown by resource-poor farmers in marginal lands. However, the importance of this crop has recently increased because of the high demand for sweet potato starch on the Asian market. Cultivation of sweet potato is considered to be environmentally friendly because of the low inputs required, especially for nitrogen, and its ability as a fast-growing crop to cover the land and prevent erosion. Sweet potato has a unique ability to grow under shady conditions and is an ideal ground cover for inter-cropping.

Recent research in Japan indicates that consumption of sweet potatoes can suppress stomach diseases caused by *Escherichia coli*, *Staphylococcus* and *Bacillus cereus* (Yoshimoto, et al. 2001). The high flavonoid content of sweet potatoes (especially the purple fresh varieties) give them strong antioxidant properties (Lu et al., 2001). The phenolic content of sweet potatoes is three times higher than that of blueberry (Cevallos and Zevallos, 2001). Other components such as anthocyanins, dietary fibre and

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calcium have advantages of reducing cardiovascular diseases (Yamakawa and Yoshimoto, 2001).

Due to their high anthocyanin content, sweet potatoes are used to obtain natural food coloring agents which are considered superior to synthetics. New varieties of sweet potatoes with a high starch content are attractive to the food industry for preparation of noodles, pastries and cakes. Sweet potato also forms an important component of biodegradable plastics.

In the past, sweet potato has been considered a poor, subsistence food but, as indicated above, it has many uses in food processing, health and manufacturing and is a very useful dual-purpose crop in developing countries for subsistence and to generate cash incomes.

Materials and methods

Advanced materials for the trials were selected from germplasm available at the CIP Regional Office for East, South East Asia and The Pacific (ESEAP), Bogor Indonesia. Research conducted with the germplasm available in Indonesia over many years made it possible to select appropriate clones which had a high chance of adaptation under East Timorese conditions. Sweet potato cuttings of selected clones were air shipped to East Timor for trials at two different times in two different batches. The first batch, which comprised nine clones, were mainly selected for adaptation, fresh consumption and high dry matter content. The second batch was selected for adaptation, yellow flesh color and sweetness. Table 1 shows the clones introduced to East Timor.

The trials were conducted in Alieu, Fatumaca, Maliana and Maubisse. The clones were tested in a randomised complete block design with two replicates during 2000–2001 and three replicates for 2001–2002. During the first year, only two trials could be conducted because planting materials were lost during shipment. Crops were harvested by hand, four months after planting and farmers, village families and extension officers participated in a simple palatability test. The simple questionnaire included phrases such as “I like,”, “I don’t like,” and “other comments”. More than 25 people took part in the palatability tests, the number varying depending on the number of people in the village.

Results

The results presented here are from the first batch of sweet potato clones that was sent to East Timor in 2000–2001. No data are yet available for the clones sent in 2001–2002. Despite some missing data, yields were compared by analysis of variance.

Table 1. The CIP — ESEAP sweet potato clones tested in East Timor.

No.	CIP number	Local Code	Remark
Batch I			
1	B053-9*	CIP-1	Fresh; L; M
2	AB94001.8	CIP-2	HDM; L; M
3	AB95012.4	CIP-3	Fresh; M; H
4	AB94078.1	CIP-4	HDM; L; M
5	AB94079.1	CIP-5	HDM; L; M
6	BB96001.2	CIP-6	HDM; L; M; H
7	BB97020.1	CIP-7	Fresh; M; H
8	BB96110.8	CIP-8	Fresh; L
9	F0043	CIP-9	Fresh; L
Batch II			
10	BB97258.2	CIP-10	L; M; Fresh; skin — orange; flesh — dark orange
11	BB97257.11	CIP-11	L;H; Fresh; skin — orange; flesh — orange
12	AB97016.1	CIP-12	M; skin — red; flesh — pale yellow.
13	BB96010.12	CIP-13	HDM; H; skin — yellow; flesh — yellow
14	BB96609.7	CIP-15	M; Fresh; skin — red; flesh — intermediate orange
15	BB96611.4	CIP-17	
16	BB97251.6	CIP-18	

1. Fresh — fresh consumption.
2. HDM — high dry matter.
3. L,M,H — adapted to low, medium, high elevation based on CIP — ESEAP database.
4. Released by Indonesian government under the official variety name Jago.

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Aileu

In 2000–2001, all introduced sweet potato clones except CIP 9 yielded higher than the local control check, although the differences were not always significant (Table 2). The outstanding clone in this location was CIP 8, which yielded 28 t/ha, while clones 1, 2, 3, 4, 5, 6, and 7 were statistically similar, yielding 10+ t/ha. Although CIP clone 9 did not produce any roots, it had luxurious vegetative growth and remained green even under water-stressed conditions. In 2001–2002, yields were 7–15 t/ha for introduced clones. The local variety had a very high yield and appeared to be a CIP line so no comparisons were made. In the taste test in 2000–2001, there was no suggestion that introduced lines were less acceptable than the local varieties.

Table 2. Storage root yield in 2000–2001 and 20001–2002 and palatability taste test data in 2000–2001 at Aileu (869 m asl).

Clone	Yield 2000–2001 (t/ha)	Yield 2001–2002 (t/ha)	Taste test***
CIP-8	23.0 c*	10.6 bcd	8
CIP-4	17.4 Bc	11.8 d	1
CIP-6	16.0 Bc	7.7 a	6
CIP-2	15.2 Bc	8.9 ab	3
CIP-7	12.8 Ab	9.5 abc	7
CIP-1	10.2 Ab	15.2 c	4
CIP-5	10.1 Ab	11.2 cd	10
CIP-3	9.9 Ab	7.5 a	2
Local M	6.9 ab		9
CIP-9	2.7 A		5
Local P**		15.4 e	

* Means do not differ if followed by the same letter (Duncan 5%).

** Local P was probably a cutting of a CIP line introduced in 2000–2002.

*** 1 — most palatable; 10 — least palatable.

Fatumaca

In 2000–2001, all introduced clones except for CIP 1 and 9 performed better than the local variety. Among the introduced clones, CIP 2, 6 and 7 gave similarly high yields and were more productive than CIP clones 3, 4, 5 and 8 (Table 3).

In 2001–2002, all introduced clones except CIP 1 yielded more than the local controls, with CIP 2 and 7 yielding more that 12 t/ha. CIP 9 was not included in the Fatumaca trial. In 2001–2002, all clones yielded 8–10 t/ha, much higher than local varieties which only yielded about 1 t/ha.

Table 3. Storage root yield in 2000–2001 and 2001–2002 at Fatumaca.

Clone	Yield 2000–01 (t/ha)	Yield 2001–02 (t/ha)
CIP-7	12.6 e*	8.9 bc
CIP-2	12.1 de	8.6 bc
CIP-6	9.9 cde	9.2 bc
CIP-5	8.7 cd	9.6 c
CIP-8	7.3 c	8.1 b
CIP-3	7.1 c	8.1 b
CIP-4	6.5 bc	8.8 bc
CIP-1	3.2 ab	8.3 bc
Local M	1.9 a	1.1 a
CIP-9	0.0 a	
Local P		1.0 a

* Means do not differ if followed by the same letter (Duncan 5%).

Maliana

During 2000–2001, all introduced clones except CIP 9 yielded more than the local variety. CIP 8 yielded an outstanding 19.1 t/ha (Table 4). Taste tests showed that many of these introduced lines were very acceptable to the local villagers, with six rated higher than the local variety. There were no trials conducted at Maliana in 2001–2002.

Table 4. Storage root yield and palatability taste test data at Maliana (298 m asl) in 2000–2001.

Clone	Yield 2001 (t/ha)	Taste test **
CIP-8	19.1 e*	6
CIP-6	14.0 d	2
CIP-4	13.3 cd	9
CIP-7	12.8 cd	4
CIP-3	12.6 cd	1
CIP-2	12.2 cd	8
CIP-5	8.4 bc	10
CIP-1	4.8 ab	3
Local M	3.2 a	7
CIP-9	0 a	4

* Means do not differ if followed by the same letter (Duncan 5%).

** 1 — most palatable; 10 — least palatable.

Maubisse

Due to unavoidable circumstances it was only possible to harvest one replicate of the trial in 2000–2001 (Table 5).

Table 5. Storage root yields at Maubisse (1354 m asl) in year 2000–2001.

Clone	Yield 2001 (kg/plot)*	Harvested plants/plot
CIP-6	18.4	20
CIP-4	15.2	17
CIP-8	15.2	19
Local M	14.9	18
CIP-5	14.5	15
CIP-7	14.3	19
CIP-1	12.3	18
CIP-2	12.3	20
CIP-3	6.9	11
CIP-9	4.7	14

Note: * Only one replication or plot was harvested.

Adaptation of introduced sweet potato in East Timor

Trial results consistently showed that all CIP clones introduced into East Timor generally grew well and outyielded the local varieties (Fig. 1). These results were constant in different localities over two years. The greatest difference between the local and introduced clones was at Fatumaka during the second year, when the introduced clone yields were about eight times higher (Fig. 1).

There was also great variability in the performance of the introduced clones at different locations and at different times, illustrating a strong genotype × environmental effect. The highest yielding clone was usually different at different sites and times. It was interesting that CIP 9 did not produce any edible storage roots under any conditions tested, although vegetative biomass production was high.

It was only possible to conduct palatability tests in two localities (Aileu and Maliana) during 2000–2001. The results (Tables 2 and 4) indicate very clearly the variation in taste preferences in the two localities for the introduced clones. However, there was no suggestion that introduced lines were unacceptable or unpalatable, with eight CIP lines at Aileu and six CIP lines at Maliana preferred over the local varieties. The highest preference for taste did not match the highest yield, but preferred clones were, nevertheless, also very productive. (Figs 2 and 3).

The second batch of clones sent to East Timor was specifically selected for high carotene to combat blindness in children caused by vitamin A deficiency. Results from these lines will be available in 2002–2003.

Discussion

CIP clones introduced into East Timor performed exceptionally well under local conditions. However, the highest yielders among the introduced clones were not the most palatable according to the local taste panels. When selecting clones for further field testing, in addition to yield, palatability, as judged by the local community, should also be given a high priority. Ideally, a balance of yield and palatability should be sought; although yield is particularly important if selection is targeted at processing.

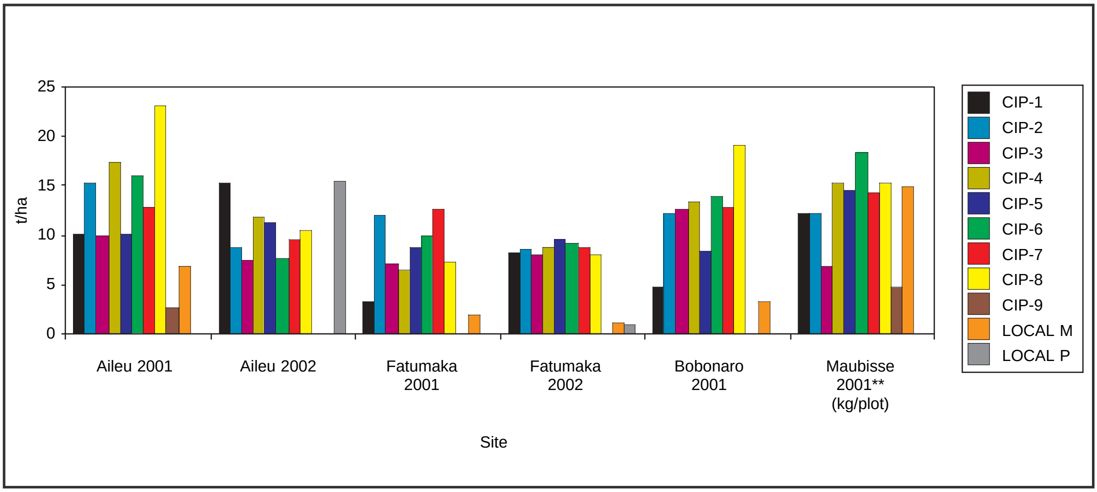

Figure 1. Overall production of sweet potato clones at four sites in East Timor.

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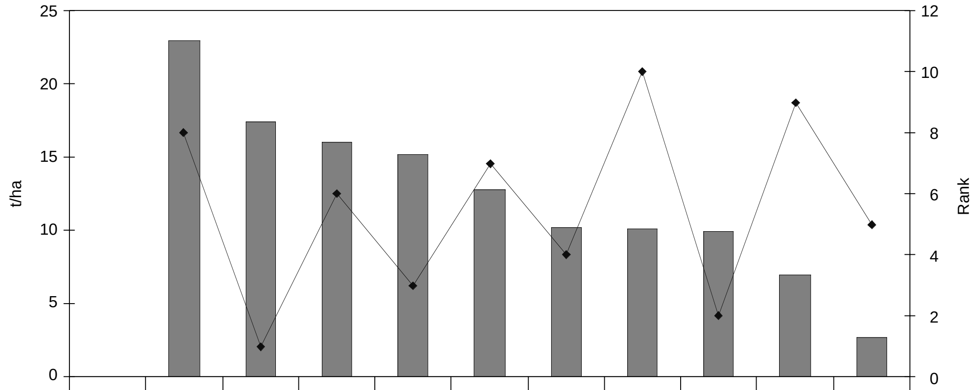

	CIP-8	CIP-4	CIP-6	CIP-2	CIP-7	CIP-2	CIP-5	CIP-3	Local M	CIP-9
yield (t/ha) Aileu	23	17.4	16	15.2	12.8	10.2	10.1	9.9	6.9	2.7
taste test rank	8	1	6	3	7	4	10	2	9	5

Figure 2. Storage root yield and taste test data for sweet potato clones in Aileu in 2000–2001.

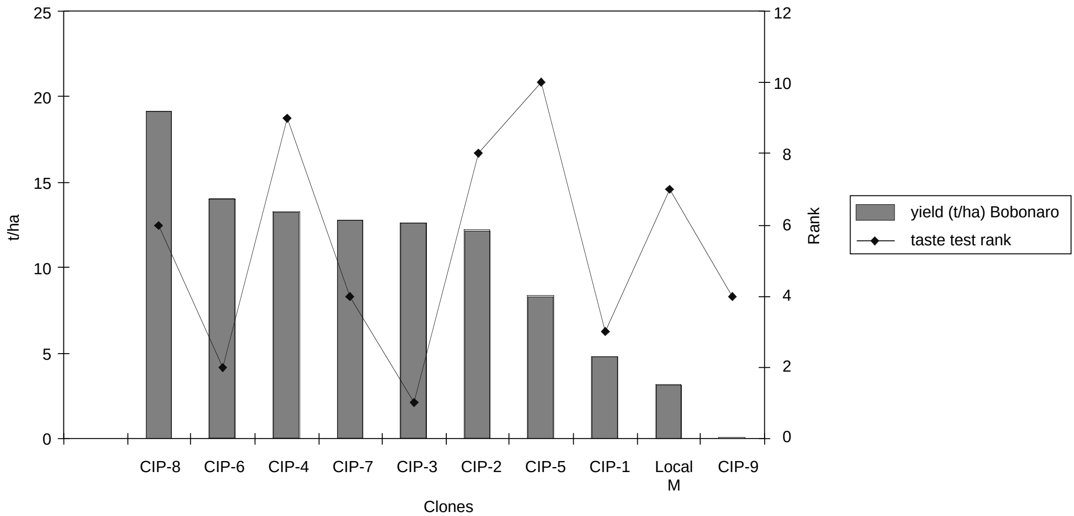

Figure 3. Storage root yield (2001) and taste test of sweet potato clones in Maliana.

Although CIP clone 9 did not perform well for tuber yield, it had excellent vegetative growth even during the hot summer when there was a lack of water. This clone could be used as a leafy vegetable or for animal feed. Due to its rapid growth and tendency to cover the land in a short time, it can be used as a cover crop to reduce erosion.

Second year results were consistent with those obtained during the first season, except for a few differences in yield which were probably due to the use of better quality and physiologically younger planting materials. This gives confidence that there are several CIP lines which have robust high yields and are acceptable to villagers in each locality.

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Figure 4. Sweetpotato weighing 4.6 and 3.1 kg. Photographer: Eric McGaw

Whilst it would be wise to conduct further trials to clarify these between year differences, there is an urgent need for increased food production and it is recommended that on-farm trials and demonstrations of the better adapted clones are undertaken immediately with farmer involvement to promote uptake and achieve villager benefits. Farmers generally like to observe and experience newly introduced varieties for several seasons before planting them widely, even if they are officially released varieties. Release of varieties by local departments of agriculture without considering farmer opinions has proven unsuccessful in many countries and has resulted in poor adoption of newly released varieties. Results from on-farm trials will be useful for the local government to select the most suitable varieties for official release.

The production of seed (planting materials) of selected clones should start immediately. Since it is a gradual process involving the bulking up of roots and vines, appropriate sites for production should be sought. It is also important to consider that the poor performance of the local variety which was used as a local check in these trials may not be because of poor adaptation but perhaps because of degeneration. Therefore, for the future, local varieties should be cleaned up through tissue culture and given back to farmers to increase variety options for farmers and to conserve local biodiversity of the crop. Clean up capacity will be important in the future to ensure better CIP lines remain productive.

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Groundnut: ICRISAT and East Timor

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Abstract

Although it is widely grown in small plots as an upland crop with little or no inputs, groundnut is not a major crop in East Timor. The cultivars that are grown have low yield potential and there is a great potential to increase the cultivation of groundnut in the country. Under the ACIAR 'Seeds of life — East Timor' project, new groundnut cultivars were introduced and trialled in the 2000–2001 and 2001–2002 seasons at a number of locations. Many of the introduced varieties outperformed the local variety at all the locations. As well as stimulating the local food and oil processing industry, increased groundnut production would provide an opportunity to export the produce to neighboring countries in the region. To enable a sufficient supply of good quality seed of the improved varieties farmers should be encouraged to produce and save their own seed. For this to happen, they need training in seed production and processing as the seed crop requires different handling than the commercial crop.

Introduction

GROUNDNUT (*Arachis hypogaea* L.) is an annual legume, which provides a rich source of high-quality, edible oil (45–50%), easily digestible protein (23–25%), minerals, and vitamins. It ranks 13th among the food crops and annual oilseed crops in the world. Its high oil and protein contents serve important needs for food, energy, and industrial uses. Groundnut haulms provide excellent fodder for animals. Groundnut cake, obtained after extraction of oil, is used in the animal feed industry and also in human food preparations. Groundnut shells are used as fuel and as filler in animal feeds and fertilisers. They can also be used in making cardboards. Cultivation of groundnut helps to improve soil fertility as it leaves behind a substantial amount of nitrogen in the soil. The crop is cultivated under diverse growing conditions ranging from subsistence to high-input–mechanised agriculture. It can be grown as a sole crop, intercrop, or mixed crop.

Groundnut, which probably originated in the region of southern Bolivia and north-western Argentina, is grown in more than 100 countries on about 25 M ha with a total production of 33 M t and an average productivity of 1.3 t/ha. Over the past 12 years, the annual growth in area has averaged 1.8%, in production 3.3%, and in productivity 1.5% (FAO, 1999). Asia remains the largest producer of this crop, while China, India, and the USA are the leading groundnut producing countries in the world.

Cultivated groundnut has two subspecies *hypogaea* and *fastigiata,* which, in turn, have two (*hypogaea* and *hirsuta*) and four (*fastigiata, vulgaris, aequatoriana,* and *peruviana*) botanical varieties, respectively. Groundnut has several wild relatives, some of which are cross-compatible with the cultivated varieties, while others are not. These wild relatives of cultivated groundnut harbor resistance genes for many abiotic and biotic stresses that affect groundnut productivity. In Asia, these stresses include drought, rust, late leaf spot, early leaf spot,

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aflatoxin, collar rot, and stem and pod rots (all fungal diseases), bud necrosis and peanut stripe virus diseases, bacterial wilt, and *Spodoptera*, leaf miner, red hairy caterpillar, aphids, thrips, and white grub (all insect pests) (Nigam et al., 1991).

Groundnut improvement at ICRISAT

Two different approaches are adopted in groundnut improvement at ICRISAT. For subsistence farming, the emphasis is on reducing the yield losses caused by abiotic and biotic stresses through resistance breeding. For high-input farming, the emphasis is placed on improving yield potential and confectionery qualities. In the former, incorporation of genetic resistances may entail some cost of yield potential, but resistant cultivars give higher realized and stable yields under limited or no input farming. As inputs are no limitation in the latter, attempts are made to improve yield potential and seed quality to ensure higher realized yield with better seed quality.

There are several agronomic and end-use specific traits, which determine the adaptation and end use of new varieties. In oil types, crop duration, pod yield, pod shape, shelling outturn, and seed dormancy are important agronomic considerations. Additional agronomic traits that are required in confectionery types include seed mass, seed color, shape, and size, and percentage of sound mature seeds. The quality considerations in confectionery types include oil content, oleic/linoleic fatty acid ratio, protein content, sugar content, blanchability, taste and flavor, and pesticide residues. The first two traits are also important in oil types.

Conventional breeding dominates the genetic enhancement scene in groundnut. New breeding tools such as genetic transformation and marker-assisted selection are just emerging in the crop. Single and complex crosses are made among desired parents to generate segregating populations for selection of plants with the desired combination of traits. The pedigree method of selection is most widely used. In interspecific hybridisation, where genes from wild *Arachis* species are harnessed, chromosome doubling, embryo rescue, tissue culture, and back crossing are utilised (Singh et al., 1990). The selection environment reflects the near target-farming situation.

The breeding materials developed at ICRISAT — early-generation bulks, advanced-generation breeding lines, country-specific populations, and regional and international trait-specific trials — are made available to national programs on request for direct introduction or further *in situ* selection and release of cultivars. National programs in collaboration with ICRISAT have so far released 63 improved groundnut cultivars in 32 countries. Thirty-seven more varieties in 12 countries are likely to be released soon.

Groundnut in East Timor

No reliable area or production statistics of groundnut in the country are available. Although it is widely grown in small plots as an upland crop with little or no inputs, it is not a major crop in East Timor. The crop is generally free from abiotic and biotic stresses except for iron chlorosis and a moderate intensity of foliar diseases (rust, late leaf spot, and early leaf spot). Nondescript cultivars with low yield potential are grown and the produce used for direct consumption. There is great potential to increase the cultivation of groundnut in the country. Opportunities exist for its export to the Southeast Asia region. Further, introduction of legumes in cropping systems will help to stabilise the productivity of cereal-based cropping systems. However, it is essential to introduce new high-yielding cultivars to promote groundnut cultivation in the country. In the short term, introduction of improved, advanced-generation genetic materials and their subsequent evaluation for local adaptation and high yield would be a desirable approach to make the new cultivars available to farmers.

Following this approach, ICRISAT, under an ACIAR-funded and coordinated project, 'Seeds of life — East Timor', introduced into East Timor 15 advanced varieties in the 2000–2001 season (Table 1) and five more advanced varieties in the 2001–2002 season (Table 2). These 15 advanced varieties were evaluated in replicated trials at various locations during the 2000–2001 and 2001–2002 seasons in the country (Tables 1 and 3). Many introduced varieties outperformed the local variety at all the locations. Considering the vast agroclimatic variation in the country, the locations were grouped into three clusters; <1000 mm rainfall (Table 4), 1000–1500 mm rainfall (Table 5), and >1500 mm rainfall (Table 6).

The first ranking variety at each location and the first three varieties in each cluster are listed in Table 7. A careful perusal of Table 7 identified four varieties, ICGV# 94063, 93269, 95278, and 95248 which often yielded 2–3+ t/ha of kernels and were worthy of further on-farm testing across the country and for initial seed increase. Local check varieties, in contrast, yielded 1–2 t/ha. The five varieties introduced in the 2001–2002 season were evaluated separately at one location (Table 2). These varieties were selected for introduction after a visit to farmers' groundnut fields during the 2000–2001 cropping season. These varieties gave an outstanding

Table 1. Performance of groundnut genotypes in a multilocation trial, East Timor, 2000–2001.

Genotype	Pod yield (t/ha)				
	Maubisse	Aileu	Maliana	Mean	Rank
ICGV 95278	1.19 (5)[a]	2.19 (3)	3.39 (2)	2.26	1
ICGV 94040	0.69 (13)	1.50 (13)	3.94 (1)	2.05	2
ICGV 93269	0.69 (12)	1.53 (11)	3.33 (3)	1.85	3
ICGV 93277	0.66 (14)	1.69 (8)	3.11 (4)	1.82	4
ICGV 92120	1.08 (6)	2.22 (2)	2.17 (10)	1.82	5
ICGV 94002	1.42 (2)	1.83 (5)	2.19 (9)	1.82	6
ICGV 94037	1.06 (8)	1.72 (7)	2.64 (6)	1.81	7
ICGV 95248	1.50 (1)	2.25 (1)	1.56 (15)	1.77	8
ICGV 94106	1.28 (4)	1.36 (15)	2.53 (7)	1.72	9
ICGV 93261	1.33 (3)	0.78 (16)	2.94 (5)	1.69	10
ICGV 94016	0.75 (11)	1.89 (4)	2.28 (8)	1.64	11
Local	1.08 (7)	1.64 (10)	2.03 (12)	1.58	12
ICGV 95322	0.89 (9)	1.75 (6)	1.67 (14)	1.43	13
ICGV 95299	0.81 (10)	1.47 (14)	2.00 (13)	1.43	14
ICGV 94063	0.61 (15)	1.53 (12)	2.08 (11)	1.41	15
ICGV 95353	0.56 (16)	1.69 (9)	1.31 (16)	1.19	16
Mean	0.98	1.69	2.38		
CV(%)	68.6	41.3	28.7		
l.s.d.	1.16	1.21	1.16		
			l.s.d. (Genotypes)	0.88	
			l.s.d. (Location)	0.38	

[a] Figure in parentheses refers to the rank at the location.

performance of 4–6 t/ha of pods. Three of these varieties, ICGV# 87123, 88438, and 86590, were selected for seed increase and multilocation on-farm trials in the country.

Table 2. Performance of newly introduced groundnut genotypes, East Timor (2001–2002).

Genotype	Major trait(s)	Pod yield (t/ha)
ICGV 86590	Foliar diseases resistance	3.92*
ICGV 86564	Large-seeded (Confectionery)	3.80
ICGV 88438	Large-seeded, tolerance to iron chlorosis (Confectionery)	4.61*
ICGV 89214	Large-seeded, tolerance to iron chlorosis (Confectionery)	4.04
ICGV 87123	Medium-duration	5.76*

* Selected for seed increase and farmer participatory on-farm variety selection trials.

Potential for groundnut and East Timor's future needs

From the results of limited trials conducted in 2000–2001 and 2001–2002, it is abundantly clear that groundnut has an excellent potential to perform in East Timor and help in increasing the income of poor farmers. Increased groundnut production would not only stimulate the local food and oil processing industry but would also provide an opportunity to export the produce to neighboring countries in the region which are currently the net importers of the commodity. Groundnut cake obtained after extraction of oil would support the local animal feed industry. These activities will lead to increased employment opportunities at the local level. Good quality groundnut free from aflatoxin and chemical residues is in great demand on the international market and commands a premium price. The food use of groundnut will grow in future. However, to produce premium quality groundnut, it is important that there is a change from subsistence agriculture to assured input growing conditions. Particularly, the crop should not suffer moisture stress at the podding stage as its produce becomes vulnerable to aflatoxin contamination under drought. As the crop is generally free from diseases and insect pest damage, opportunity exists to produce organic groundnut using decomposed organic matter for nutrient supply and natural plant products and biological agents for control of diseases and insect pests.

Because of the large agroclimatic variation in the country, it would be advisable to release agroclimatic zone-specific cultivars to harness their full potential for the benefit of farmers. The same would apply to cultural practices and production techniques.

Table 3. Performance of groundnut genotypes in a multilocation trial, East Timor (2001–2002).

Genotype	Kernel yield (t/ha)			Mean	Rank
	Baucau	Betano	Loes		
ICGV 94063	2.45 abcd	1.02 bcdef	3.43 e	2.30	1
ICGV 95278	2.54 bcd	1.03 bcdef	2.55 d	2.04	2
ICGV 95299	2.21 abcd[1]	1.49 fg	2.26 cd	1.99	3
ICGV 93269	2.72 d	1.15 cdefg	2.04 abcd	1.96	4
ICGV 93277	2.10 abc	1.14 cdefg	2.47 cd	1.90	5
ICGV 94002	2.15 abc	1.36 efg	2.18 bcd	1.90	6
ICGV 95248	1.73 a	1.71 g	2.05 abcd	1.83	7
ICGV 95322	2.84 cd	1.27 defg	1.36 a	1.82	8
ICGV 95353	2.19 abc	0.78 abcd	2.42 cd	1.80	9
ICGV 94016	1.86 ab	0.78 abcd	2.13 abcd	1.59	10
ICGV 92120	2.39 abcd	0.58 abc	1.73 abc	1.57	11
ICGV 94106	2.03 abc	0.55 ab	1.85 abc	1.48	12
ICGV 93261	2.15 bcd	0.31 a	1.91 abcd	1.46	13
Local	1.67 abc	0.64 abc	2.04 abcd	1.45	14
ICGV 94037	1.84 abc	0.84 abcde	1.47 ab	1.38	15
			l.s.d. (Genotypes)	0.657	
			l.s.d. (Location)	0.294	

Column means followed by the same letter are not significantly different ($P \leq 0.05$) according to Duncan's multiple range test.

Table 4. Performance of groundnut genotypes at <1000 mm rainfall locations, East Timor (2001–2002).

Genotype	Kernel yield (t/ha)		Mean	Rank
	Betano	Loes		
ICGV 94063	1.02 (8)[a]	3.43 (1)	2.23	1
ICGV 95299	1.49 (2)	2.26 (5)	1.88	2
ICGV 95248	1.71 (1)	2.05 (8)	1.88	3
ICGV 93277	1.14 (6)	2.47 (3)	1.81	4
ICGV 95278	1.03 (7)	2.55 (2)	1.79	5
ICGV 94002	1.36 (3)	2.18 (6)	1.77	6
ICGV 95353	0.78 (10)	2.42 (4)	1.60	7
ICGV 93269	1.15 (5)	2.04 (9)	1.60	8
ICGV 94016	0.78 (10)	2.13 (7)	1.46	9
Local	0.64 (11)	2.04 (10)	1.34	10
ICGV 95322	1.27 (4)	1.36 (15)	1.32	11
ICGV 94106	0.55 (13)	1.85 (12)	1.20	12
ICGV 94037	0.84 (9)	1.47 (14)	1.16	13
ICGV 92120	0.58 (12)	1.73 (13)	1.16	14
ICGV 93261	0.31 (14)	1.91 (11)	1.11	15

[a] Figure in parentheses refers to the rank at the location.

Table 5. Performance of groundnut genotypes at 1000–1500 mm rainfall locations, East Timor (2000–2001 and 2001–2002).

Genotype	2000–2001 Maliana Pod yield (t/ha)	2001–2002 Baucau Kernel yield (t/ha)	Rank[a]
ICGV 94040	3.94 (1)[b]	—	
ICGV 93269	3.33 (3)	2.72 (2)	1
ICGV 95278	3.39 (2)	2.54 (3)	2
ICGV 93277	3.11 (4)	2.1 (10)	3
ICGV 93261	2.94 (5)	2.15 (8)	4
ICGV 92120	2.17 (10)	2.39 (5)	5
ICGV 94106	2.53 (7)	2.03 (11)	6
ICGV 94063	2.08 (11)	2.45 (4)	7
ICGV 95322	1.67 (14)	2.84 (1)	8
ICGV 94037	2.64 (6)	1.84 (13)	9
ICGV 94002	2.19 (9)	2.15 (9)	10
ICGV 95299	2.00 (13)	2.21 (6)	11
ICGV 94016	2.28 (8)	1.86 (12)	12
Local	2.03 (12)	1.67 (15)	13
ICGV 95353	1.31 (16)	2.19 (7)	14
ICGV 95248	1.56 (15)	1.73 (14)	15

[a] Assumes equal shelling outturn for all the genotypes at Maliana.

[b] Figure in parentheses refers to the rank at the location.

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Figure 1. Brian Palmer and workers in a field of groundnuts. Photographer: Eric McGaw

Table 6. Performance of groundnut genotypes at >1500 mm rainfall locations, East Timor (2000–2001).

Genotype	Pod yield (t/ha)		Mean	Rank
	Maubisse	Aileu		
ICGV 95248	1.50 (1)[a]	2.25 (1)	1.88	1
ICGV 95278	1.19 (5)	2.19 (3)	1.69	2
ICGV 92120	1.08 (6)	2.22 (2)	1.65	3
ICGV 94002	1.42 (2)	1.83 (5)	1.63	4
ICGV 94037	1.06 (8)	1.72 (7)	1.39	5
Local	1.08 (7)	1.64 (10)	1.36	6
ICGV 94016	0.75 (11)	1.89 (4)	1.32	7
ICGV 95322	0.89 (9)	1.75 (6)	1.32	8
ICGV 94106	1.28 (4)	1.36 (15)	1.32	9
ICGV 93277	0.67 (14)	1.69 (8)	1.19	10
ICGV 95299	0.81 (10)	1.47 (14)	1.14	11
ICGV 95353	0.56 (16)	1.69 (9)	1.13	12
ICGV 93269	0.69 (12)	1.53 (11)	1.11	13
ICGV 94040	0.69 (13)	1.50 (13)	1.1	14
ICGV 94063	0.61 (15)	1.53 (12)	1.07	15
ICGV 93261	1.33 (3)	0.78 (16)	1.06	16

[a] Figure in parentheses refers to the rank at the location.

The non-availability of good quality seed of improved varieties of groundnut in required quantities remains a bottleneck in most of the developing countries. Farmers should be encouraged to produce and save their own seed. However, for this to happen successfully, they should be given training in seed production and processing as the seed crop has different handling requirements than the commercial crop.

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Table 7. Summary analysis of 2000–2001 and 2001–2002 performance of groundnut genotypes, East Timor.

Location	<1000 mm rainfall		1000–1500 mm rainfall		>1500 mm rainfall	
	Betano	Loes	Maliana	Baucau	Maubisse	Aileu
Best performer	ICGV 95248	ICGV 94063	ICGV 94040	ICGV 95322	ICGV 95248	ICGV 95248
Overall						
1	ICGV 94063*		ICGV 93269*		ICGV 95248*	
2	ICGV 95299*		ICGV 95278*		ICGV 95278*	
3	ICGV 95248*		ICGV 93277*		ICGV 92120*	

* Selected genotypes for seed increase and farmer participatory on-farm variety selection trials underlined: ICGV# 94063, 93269, 95278, and 95248.

Evaluation of cassava and bean germplasm in East Timor

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Abstract

Cassava (*Manihot esculenta* Crantz) is the third most important food crop in East Timor, after maize and rice. It is mostly planted in backyards or in small plots near the house. Plants are pulled up when needed and the peeled roots are eaten after boiling. Most local varieties have good eating quality but low yields and starch contents. The average cassava yield in the country is reported as 4 t/ha, one of the lowest in Asia. Two introductions of cassava varieties, mostly from East Java, Indonesia, were tested in 2000–2001 and 2001–2002, respectively. Data from one trial indicate that high yields of up to 35 t/ha can be obtained with promising breeding lines developed by RILET in Malang, compared with yields of about 14 t/ha for two local varieties. Similar trials conducted in 2002, although not yet harvested, indicate the superior growth of some other breeding lines from RILET, which seem to have exceptional tolerance to low soil zinc and iron. Yields up to 25 and 38 t/ha were obtained in Baucau and Aileu, respectively, compared with 10–15 t/ha for the local varieties.

Bean (*Phaseolus vulgaris*) germplasm from Africa and Latin America has also been evaluated, but no data are yet available. Several varieties of other pulses, including mungbean (*Vigna radiata*), soybean (*Glycine max*), and cowpea (*Vigna unguiculata*), were introduced from Indonesia, Thailand and Australia. In general, the Indonesian varieties seem to be best adapted to the soil and climatic conditions of East Timor. The mungbean varieties Murai, Merpati, Perkutut and Kenari all outyielded the local mungbean variety; while the soybean variety Kawi consistently showed the highest yield among the tested soybean varieties, and the cowpea variety KT-5 was superior to KT-9 and the local varieties Hitam and Merah.

Introduction

AFTER the vote for independence of East Timor in August 1999, a large part of the population was displaced to West Timor or fled into the mountains. This massive disruption of normal agricultural activities resulted in the loss of seed of local varieties. Although large amounts of seed were imported from other countries in time for the 2000 planting season, much of it was of poor quality and/or the varieties were not well adapted to local soil and climatic conditions. In order to improve food production and reduce poverty, ACIAR requested the collaboration of five future harvest centres in Asia to help introduce and evaluate promising germplasm of rice, maize, cassava, potato, sweet potato, peanut, beans and other pulses. This paper describes the evaluation of cassava, beans and other pulse crops during the first two years of the project, i.e. 2000–2001 and 2001–2002.

Cassava and bean production

In terms of both production and area, cassava (*Manihot esculenta* Crantz) is the third most important crop in East Timor, after maize and rice (Table 1). Cassava is used mainly for direct human consumption, the peeled roots are boiled with little or no prior processing. For this reason, most of the local varieties are “sweet” with a low cyanogenic potential. Some cassava may also be used for on-farm pig feeding, to what extent is unknown. There is no processing of cassava roots into starch or other industrial products.

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Table 1. Agricultural production in East Timor (1997).

Food crops	Production (tonne)	Yield (t/ha)	Estimated area[a] (ha)
Field crops			
Maize	106,600	1.8	59,222
Rice	52,000	2.7	19,259
Cassava	66,500	4.0	16,625
Sweet potato	16,200	3.9	4,154
Peanut	3,200	1.0	3,200
Soybean	1,200	0.8	1,500
Tree crops			
Coconut	9,900	0.2	49,500
Coffee	9,700	0.2	48,500
Candlenut	690	0.2	3,450
Cocoa	42	0.08	525
Cloves	12	0.05	240

Source: Central Bureau of Statistics Indonesia, 1998.
[a] Calculated from total production and yield.

Table 2 shows the names and principal characteristics of the local cassava varieties. Many of them are likely to be the same variety but with different local names. Most of them probably originated in Indonesia, but some may have been introduced by the Portuguese directly from Brazil.

While the local cassava varieties have been selected mainly for their excellent eating quality, they tend to have a low yield potential and relatively low dry matter (DM) content. In future it is expected that cassava will be grown not only for human consumption, but also for animal feeding and possibly for starch extraction. For this, varieties with higher yield and higher DM or starch content are required.

Cassava as a species is particularly well adapted to dry climates or to areas with unpredictable rainfall. Once established, cassava tolerates long (six to eight months) periods of drought. During the drought the plants may drop many leaves and new leaf production is limited, but once it starts raining again the plant can quickly mobilise the carbohydrates stored in the roots to re-establish a full leaf canopy and continue growth. Cassava as a species is very well adapted to acid soils, but not well adapted to high pH or saline soils. At high pH (above 7.5), especially in the presence of calcium or magnesium carbonates, cassava often suffers from micronutrient deficiencies, particularly zinc and iron, and occasionally manganese. However, varieties differ markedly in their ability to take up zinc or iron from soils that are very low in these nutrients, and varietal selection for tolerance to iron and zinc deficiency is probably a more practical solution to this problem than micronutrient applications.

Like cassava, beans (*Phaseolus vulgaris*) originated in Latin America, and most of the genetic variability exists in that continent. Unlike in Latin America, beans are not a staple food anywhere in Asia, but are consumed mainly as a snack food or dessert. However, in East Timor, beans are consumed as a staple food, and they constitute an important source of protein in the diet. This is probably due to the Portuguese, who brought beans from Brazil for that purpose. While in Latin America beans are generally grown, traded and consumed as a single variety, with a characteristic size, shape and grain color, in East Timor (and much of Africa), beans are generally sold on the market as varietal mixtures, with many different shapes and colors. It is likely that they are also planted as varietal mixtures, partially to reduce the incidence of pests and diseases. In Latin America, beans suffer from a host of insects and disease problems, but it is not known yet which of these are of importance in East Timor. Beans are particularly well adapted to cooler climates, i.e. elevations of 800 to 2000 m above sea level (asl) in the tropics. They require adequate soil moisture during establishment, vegetative growth and flowering, but prefer dryer weather during pod set and ripening. Beans are not well adapted to very acid soils and may suffer from aluminium toxicity when the aluminium saturation is above 20%. Beans also require fairly high levels of available P in the soil, but some varieties are quite tolerant of low soil P.

Other grain legumes (also known as pulses), such as mungbean (*Vigna radiata*), cowpea (*Vigna unguiculata*) and soybean (*Glycine max*) are grown in East Timor, mainly in home gardens or in small plots. The total area is probably less than 3000 ha. These three grain legumes are generally used for human consumption or for animal feeding (soybean) and are an important source of protein in the diet. While cowpea is well adapted to acid soils, neither mungbean nor soybean tolerate high levels of exchangeable aluminium and prefer fertile soils with a near neutral pH. All three legumes grow well at low elevation, while growth and production are reduced at lower temperatures found at higher elevation, such as above 800 m asl.

Germplasm evaluation

Most of the germplasm evaluation trials for the upland crops were conducted in Baucau and Los Palos in the east, Aileu and Maubisse in the central highlands, Betano along the south coast, and in Loes or Maliana in the western part of the country. Table 3 shows results of soil analyses of samples taken between November 2000 and March 2002 in four districts of East Timor, mainly from these experimental sites. According to these results, soils have a pH ranging from 4.9 to 7.5, i.e. most soils are

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Table 2. Names and characteristics of some local cassava varieties in East Timor.

Name[a] (meaning)	Characteristics	
	Top	Roots
1. Mentega (butter)	Red petioles, yellowish stem, dark green leaves and brownish shoot, branched	Brown skin, yellowish parenchyma
2. Nona Metam[b] (black girl)	Red petioles, big light-green leaves, less branched	Red skin, white parenchyma
3. Ermera[b]	Dark red-purple petioles, greenish-brown stem, green leaves and shoot	Red skin, white parenchyma
4. Puti (white)	Green petioles, light-green leaves, low branching	White skin, white parenchyma
5. Manu Tolu (yellow egg)		
6. Lesu (white)		
7. Autohan (han = eat)		

[a] Some of these may be the same varieties with different local names.
[b] Ermera and Nona Metam look very much like the Thai variety Hanatee.

Table 3. Chemical and physical characteristicsa of some soils in East Timor in 2000, 2001 and 2002.

Sample no.		Sample location and description	Date	Lab series
Baucau	–1	Don Bosco Technical School in Fatumaca; field of dark brown limestone-derived soil	Nov 00	S-33
	–2	Baucau experimental site at Fatumaca; red clay soil	Jan 02	S-107
Ainaro	–1	Near Maubisse; 80% slope, purple brown clay soil after burning	Nov 00	S-33
	–2	South of Maubisse; at 1300 masl, yellow clay with lime stones	Nov 00	S-33
	–3	South of Maubisse; same site, lower field, brown-red clay soil	Nov 00	S-33
	–4	Maubisse, Coffee Cooperative; Bobonaro clay	Oct 01	S-137
Aileu	–1	Aileu experimental site; dark purple soil	Jan 02	S-107
	–2	Aileu experimental site; in cassava trial	Mar 02	S-107
Manufahi	–1	Betano Extension Station; grey clay with rocks	Oct 01	S-137
	–2	Betano Experimental site; in cassava trial, yellow cassava	Mar 02	S-107
Liquisa	–1	Loes Transmigration Office; field behind office, silty loam	Oct 01	S-137
	–2	Loes Transmigration Office; rice fields; grey loam	Oct 01	S-137

		Chemical characteristics															Physical characteristics			
			%	ppm	me/100 g					%	%	ppm					%			
Sample no.		pH	OM	P	Al	Ca	Mg	K	Na	Al	Na	B	Zn	Mn	Cu	Fe	Sand	Silt	Clay	Texture[c]
Baucau	–1	5.6	3.3	6.2	0	15.41	0.98	0.28		0		0.48	0.32	209.7	0.24	0.6	20.0	25.0	55.0	clay
	–2	5.7	3.7	7.9	0	11.78	0.87	0.19	0.06	0	0.5	0.90	0.45	208.0	0.22	0.8	15.6	18.3	65.1	clay
Ainaro	–1	6.5	6.0[b]	28.5[b]	0	15.39[b]	3.20[b]	0.84[b]		0		2.00[b]	2.75	140.2[b]	1.01[b]	4.4[a]				
	–2	6.6	3.1	2.4[a]	0	16.17[b]	5.40[b]	0.51[b]		0		0.56	1.78	95.0	1.31[b]	8.8[a]	21.0	36.4	42.6	clay
	–3	6.6	3.3	2.3[a]	0	16.18[b]	5.51[b]	0.47[b]		0		0.56	1.87	126.7[b]	1.57[b]	15.2	26.3	33.7	40.0	c.l.
	–4	7.2[b]	3.1	8.6	0	26.80[b]	6.11[b]	0.54[b]	0.39	0	1.1	0.60	0.89[a]	142.8[b]	0.07[a]	15.1	19.8	29.9	50.3	clay
Aileu	–1	4.9	5.0[b]	5.3	0.94	3.20	1.35[b]	0.49[b]		16		0.90	1.37	28.8	0.32	49.9	38.4	27.8	33.9	c.l.
	–2	5.0	5.6	2.6[a]	1.77	2.51	1.09[b]	0.47[b]		30		0.89	1.28	22.1	0.32	47.6	24.0	31.8	44.2	clay
Manufahi	–1	7.0	3.0	111.1[b]	0	30.46[b]	1.57[b]	3.49[b]	0.44	0	1.2	1.03[b]	0.03[a]	1.0[a]	0.06[a]	0.3[a]	30.5	24.6	44.9	clay
	–2	7.5[b]	3.0	93.9[b]	0	31.67[b]	1.42[b]			0		1.54[b]	0.00[a]	0.3[a]	0.06[a]	0.0[a]	20.3	28.8	50.9	clay
Liquisa	–1	7.1[b]	3.4	138.3[b]	0	6.98[b]	1.88[b]	0.42[b]	0.40	0	4.1[b]	0.88	2.45	72.2	0.44	35.0	43.4	33.7	22.9	loam
	–2	7.2[b]	2.4	62.5[b]	0	7.55[b]	1.52[b]	0.17	0.40	0	4.1[b]	0.61	2.73	190.3[b]	3.74[b]	192.9[b]	8.1	76.6	15.3	si.l.

[a] low or very low levels.
[b] high or very high levels for cassava.
[c] s.l. = sandy loam; c.l. = clay loam; si.l. = silt loam.

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slightly acid to slightly alkaline. Most are relatively high in OM, very high in Ca, Mg and K and quite high in P except for a few sites in Aileu district. P deficiency could be a limiting factor for maize and pulses in the Aileu and Baucau sites.

High levels of aluminium and sodium do not appear to cause problems. The main problem, at least for cassava, is the extremely low levels of zinc and iron at the Betano (Manuhafi) and Don Bosco (Baucau) sites and, possibly, the low levels of copper and manganese at the Betano site. Other crops, especially peanut, are likely to be affected by iron deficiency at these two sites.

Cassava

In late 2000, vegetative planting material (stems) of 12 cassava varieties was introduced to East Timor, 10 from Indonesia and two eating varieties from Thailand. These were planted in replicated trials in Baucau, Los Palos, Maubisse and Maliana. Each variety was planted in plots of 5 by 5 m with nine plants of the test variety in the centre, and borders of a local variety. Plants were spaced at 1.0 by 1.0 m. There were generally three replications per trial. In some trials, 200 kg/ha of 15:15:15 N:P:K fertilisers were applied shortly after planting.

For a number of reasons no reliable data could be obtained in three of the four sites. Table 4 shows the results of the cassava trial at the Maliana site in Bobonaro district. Root yields varied from 6.9 to 35.4 t/ha, with a yield of 13.5 and 14.9 t/ha for the two local varieties Mentega and Nona Metan. Highest yields were obtained with the Indonesian breeding lines OMM90-3-100, SM477-2 and the released variety Malang 2. Most of the local eating varieties from Indonesia and Thailand had low yields of 10–20 t/ha. Planting material of the harvested plants was not properly marked and stored, and thus could not be used for further experimentation.

In October 2001 and in January 2002 new planting material was brought in from Indonesia, including some local varieties from the calcareous soil area of Yogyakarta, as well as breeding lines from the Research Institute for Legumes and Tuber Crops (RILET) in Malang, East Java. The planting material from Yogyakarta is still being multiplied in an extension station near Dili. The planting material from RILET was used to plant replicated trials at four sites, i.e. Baucau, Betano, Aileu and Loes. These were planted in January–February and harvested in November–December 2002.

During a brief visit in March 2002, the cassava trials were inspected in Baucau, Aileu and Betano. Plants were 2–2½ months old. In Baucau, on calcareous soils, many cassava varieties showed clear symptoms of zinc, and possibly iron, deficiency, while in some plots many stem cuttings had either not germinated or plants had died shortly after germination, most likely as a result of severe zinc deficiency. Other varieties, however, particularly CMM95-42-3, CMM96-36-269 and OMM96-01-69, were growing very well. Obviously, there were large varietal differences in tolerance to low zinc.

In Aileu, cassava grew quite well, but some varieties grew poorly. There were no symptoms of nutrient deficiencies, but some young plants grew poorly and had yellow–orange leaves, most likely due to low temperature. Again, the two lines from RILET, CMM95-42-3 and CMM96-36-269 showed excellent growth. The local variety *Puti* (with light green leaves and green petioles) grew very well and seems well adapted to low temperatures. Another local variety, also called *Puti* (with light-green leaves and red petioles) also seemed well adapted, in contrast to *Mentega*, which showed stunted growth at this high (960 m asl) elevation.

Table 4. Average cassava yield and plant stand of 14 varieties evaluated at the Maliana site of Bobonaro, East Timor (2000–2001).

Variety	Origin	Plant stand (%)	Root yield (t/ha)[a]
Hanatee	Thailand	58	15.9
Rayong 2	Thailand	17	6.9
Adira 1	Indonesia	83	9.5
Mentega	Indonesia	50	10.0
Ketan	Indonesia	92	14.7
Tambak Urang	Indonesia	83	14.5
Randu	Indonesia	96	22.1
Malang 2	Indonesia	96	27.8
UB ½	Indonesia	92	26.7
SM 477-2	Indonesia	100	28.9
SM 881-5	Indonesia	92	26.3
OMM 90-3-100	Indonesia	96	35.4
Mentega	East Timor	54	14.9
Nona Metam	East Timor	79	13.5

[a]Based on area (12 sq m) harvested.

In Betano, cassava was about two months old and growth was highly variable, with plants in many plots showing uniform yellowing of all leaves, typical of iron deficiency or salinity. Some leaves had border necrosis, which is also typical of severe iron deficiency or salinity. The two local varieties, Manu Tolu (= Mentega?) and Leso (= Puti?) showed severe yellowing of leaves, while many of the introduced varieties had poorly germinated or had died of iron and/or zinc deficiency. Again, the line CMM95-42-3 showed excellent growth without any symptoms of micronutrient deficiencies.

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Tables 5 and 6 show the results of two of these trials conducted in Baucau and Aileu, respectively (no yield data could be collected in Betano and Loes). Table 5 shows that nine of the introduced varieties had significantly higher yields than the two local varieties in Baucau; CMM 96-08-44 produced the highest yield of 25.3 t/ha, compared with 10–14 t/ha for the two local varieties. In Aileu (Table 6) five varieties were significantly higher yielding than the best of the two local checks; OMM 90-03-100 produced a yield of 38.8 t/ha, while CMM 96-08-44 produced 29.2 t/ha, as compared to 9.5 and 15.8 t/ha

Table 5. Results of a cassava variety evaluation trial conducted in Don Bosco Technical School, Fatomaca, Baucau, East Timor in 2002–03.

	Evaluation[1]				Plants harvested			Yield (t/ha)			
	I	II	III	Av.	I	II	III	I	II	III	Av. I+II[2]
1. CMM 96-27-76	2	1	3	2.0	–	–	–	–	–	–	–
2. SM 2361-1	1	1	2	1.3	6	6	0	26.0	19.7	0	22.85ab
3. CMM 96-08-19	2	3	2	2.3	–	–	–	–	–	–	–
4. CMM 96-08-44	3	1	3	2.3	7	7	1	25.6	25.0	20.0	25.30a
5. CMM 96-36-255	4	3	3	3.3	5	5	4	25.0	25.4	16.3	25.20a
6. CMM 96-37-275	2	3	3	2.7	3	5	3	14.7	14.4	8.0	14.55cd
7. CMM 90-36-224	1	2	1	1.3	1	2	–	18.2	20.0	–	19.10bc
8. OMM 96-02-113	2	3	1	2.0	5	–	–	16.4	–	–	–
9. CMM 96-36-269	4	5	5	4.7	2	4	8	21.6	21.0	18.5	21.30ab
10. OMM 96-01-69	4	3	5	4.0	7	5	–	23.7	19.0	–	21.35ab
11. CMM 95-14-13	2	3	4	3.0	6	4	–	9.7	13.8	–	11.75d
12. CMM 95-42-3	5	5	5	5.0	3	9	6	22.0	19.5	19.3	20.75ab
13. CMM 96-25-25	3	3	3	3.0	4	2	–	18.8	22.5	–	20.65ab
14. OMM 96-01-93	4	2	3	3.0	6	4	–	14.2	15.0	–	14.60cd
15. OMM 90-03-100	3	4	4	3.7	3	2	–	19.7	22.5	–	21.10ab
16. local Mentega	2	2	2	2.0	6	5	7	13.6	14.5	13.6	14.05d
17. local Putih	2	2	4	2.7	4	4	4	10.2	10.0	9.5	10.10d

[1] evaluated March 26, 2002; 1 = bad: 5 = very good growth.
[2] Duncan test at $\alpha = 0.05$.

Table 6. Results of a cassava variety evaluation trial conducted in Aileu, East Timor in 2002–03.

	Evaluation[1]			Plants harvested		Yield (t/ha)			Yield (t/ha)
	I	II	Av.	I	II	I	II	Av.[2]	Av. 2 sites[2]
1. CMM 96-27-76	2	1	1.5	2	7	11.0	12.6	11.80 de	11.80 de
2. SM 2361-1	2	1	1.5	4	–	15.8	–	–	22.85 abcd
3. CMM 96-08-19	4	3	3.5	7	7	18.9	16.3	17.60 cd	17.60 bcde
4. CMM 96-08-44	3	2	2.5	5	2	28.4	30.0	29.20 b	27.25 ab
5. CMM 96-36-255	4	3	3.5	9	8	10.9	16.9	13.90 de	19.55 abcde
6. CMM 96-37-275	3	3	3.0	4	5	22.5	24.0	23.25 bc	18.90 abcde
7. CMM 90-36-224	2	4	3.0	3	–	6.7	–	–	19.10 abcde
8. OMM 96-02-113	3	2	2.5	5	7	18.0	18.3	18.15 cd	18.15 bcde
9. CMM 96-36-269	4	4	4.0	7	8	31.7	25.8	28.75 b	25.02 abc
10. OMM 96-01-69	5	1	3.0	7	3	3.7	1.7	2.70 f	12.02 de
11. CMM 95-14-13	3	3	3.0	7	–	25.0	–	–	11.75 de
12. CMM 95-42-3	5	5	5.0	7	9	30.7	30.0	30.35 b	25.55 abc
13. CMM 96-25-25	3	2	2.5	7	8	24.3	28.8	26.55 b	23.60 abc
14. OMM 96-01-93	2	2	2.0	3	4	21.7	12.5	17.10 cde	15.85 bcde
15. OMM 90-03-100	4	2	3.0	7	7	44.7	32.9	38.80 a	29.95 a
16. local Mentega	4	3	3.5	8	7	14.0	17.7	15.85 cde	14.95 cde
17. local Putih	3	3	3.0	7	5	9.6	8.4	9.00 ef	9.55 e
18. local Mentega				4	8	15.5	21.4		
16.				–	6	–	10.0		

[1] evaluated March 27, 2002; 1 = bad: 5 = very good growth.
[2] Duncan test at $\alpha = 0.05$.

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for the two local varieties. Although these data are still preliminary and based on relatively few plants, the three trials harvested so far point to the high yield potential of OMM 90-03-100, followed by CMM 96-08-44, CMM 95-42-3 and CMM 96-36-269, which are all advanced breeding lines from RILET. Farmers involved in the harvest considered CMM 96-36-269, CMM 95-42-3 and SM 2361-1 the best to eat.

Beans (*Phaseolus vulgaris*)

In September 2000, a collection of 14 varieties was introduced from Africa, mainly from Uganda, Malawi and Kenya. These were planted at five sites: Baucau, Los Palos, Maubisse, Aileu and Maliana. For various reasons, none of these trials produced reliable results.

In December 2001, another 11 bean varieties were introduced from Colombia. These were supposed to be planted in April 2002 (after the maize harvest) at three sites: Betano, Aileu and Maubisse, but drought prevented them being planted. Planting was postponed until November 2002 and only at the Aileu site. Beans will be planted in five rows, each of 5 m length, at a spacing of 50 cm between rows and 5–8 cm between plants in the row.

Other pulses (mungbean, cowpea, soybean)

In September 2000, two mungbean, two soybean and two cowpea varieties were introduced from Indonesia; two cowpea varieties (for green pods) from Thailand, and one soybean variety from Australia. These were planted in replicated trials in Baucau, Los Palos, Aileu, Maubisse and Maliana. The three pulses were planted in the same trials but grouped together according to species. They were planted in plots of 5 by 2.5 m with 50 cm between rows and 10–20 cm between plants.

Reliable results could be obtained only from Los Palos. Table 7 shows that the varieties from Indonesia outyielded the local varieties as well as those from Thailand and Australia. Highest yields were obtained with the mungbean variety Kenari, the soybean variety Kawi and the cowpea variety KT-9.

In October 2001 another collection of mungbean, soybean and cowpea varieties was introduced from RILET in Malang. These were planted in replicated trials in Baucau, Aileu, Betano and Loes. In Baucau, plant growth was excellent with vegetative growth, possibly excessive. No yields could be obtained, however, due to heavy rain at pod ripening.

Table 8 shows that in Betano grain yields were very good, especially those of mungbean and soybean. There were no significant differences among mungbean varieties, but highest yields were obtained with mungbean variety Murai. Among soybean varieties, the Indonesian variety Kawi again outyielded the others and had a significantly higher yield than Burungrang. The commercial variety Willis had an intermediate yield, while the local variety Ked had a low yield of only 0.83 t/ha. Unlike the previous year, the cowpea variety KT-5 outyielded KT-9.

Table 7. Yields of mungbean, soybean and cowpea in Los Palos, Lautem district, East Timor (2000–2001).

Crop/variety	Dry grain yield (t/ha)	Origin
mungbean Sriti	0.835	Indonesia
mungbean Kenari	0.889	Indonesia
mungbean local	0.782	East Timor
soybean Kawi	0.578	Indonesia
soybean Burangrang	0.529	Indonesia
soybean Leichhardt	0.507	Australia
cowpea KT-5	0.671	Indonesia
cowpea KT-9	0.795	Indonesia
cowpea KVC-7	0.640	Thailand
cowpea BS-6	0.755	Thailand

Table 8. Results of the grain legume trial conducted in Betano, Manufahi district of East Timor (2001–2002).

Crop/variety	Dry grain yield (t/ha)
mungbean Murai	1.547a
mungbean Merpati	1.433a
mungbean Perkutut	1.294a
mungbean Kenari	1.435a
soybean Kawi	1.608a
soybean Malabar	1.300ab
soybeanWillis	1.146ab
soybean Burangrang	0.808b
soybean local ked	0.833ab
cowpea KT-5	0.672a
cowpea KT-9	0.589a

Numbers followed by the same letter are not significantly different at $P \leq 0.05$ according to Duncan's multiple range test.

In Aileu, the same collection of pulses grew well, but much less vigorously than in Baucau, probably due to the lower temperature at that high elevation. The commercial soybean variety Willis was rather weak, while some mungbean varieties showed yellowing and necrosis along leaf borders, most likely due to the cold. Results of this trial (Table 9) show that yields were much lower than in Baucau, probably due to poor adaptation to low temperature. Among mungbean varieties, the three Indonesian varieties Merpati, Perkutut and Kenari had significantly higher

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Figure 1. Mungbeans.

Figure 2. Cassava at Aileu.

Photographer: Eric McGaw

yields than the local mungbean variety. Among soybean varieties, the Indonesian variety Kawi again had the highest yield, but this was not significantly different from the local variety Ked. Among cowpea varieties, the Indonesian variety KT-5 yielded more than twice as much as KT-9, or the two local varieties Hitam (black) and Merah (red).

In Loes, the pulses grew vigorously, but no yield data could be obtained due to severe drought after flowering.

Table 9. Results of the grain legume trial conducted in the Aileu district of East Timor (2001–2002).

Crop/variety	Dry grain yield (t/ha)
mungbean Murai	0.269ab
mungbean Merpati	0.381a
mungbean Perkutut	0.332a
mungbean Kenari	0.314a
mungbean local	0.193b
soybean Kawi	0.878a
soybean Malabar	0.456cd
soybean Willis	0.561bc
soybean Barangrang	0.341d
soybean local ked	0.754ab
cowpea KT-5	0.773a
cowpea KT-9	0.384b
cowpea local hitam	0.302b
cowpea local merah	0.301b

Numbers followed by the same letter are not significantly different at $P \leq 0.05$ according to Duncan's multiple range test.

Conclusions

The cassava, bean and pulse trials conducted in East Timor in 2000–2001 suffered from many problems and limitations. Only one cassava and one pulse trial provided reliable results. In the second year of the Seeds of Life — East Timor Project, many of the problems experienced in the first year could be overcome, trials were better supervised, and the resulting data is therefore more reliable.

In the cassava trials some of the introduced breeding lines from Indonesia showed excellent growth in Baucau, Aileu and Betano, in spite of severely limiting iron and zinc concentrations in the soil in Baucau and Betano. These lines significantly outyielded the local cassava varieties Mentega and Merah.

The two pulse trials for which yield data could be obtained, indicate very high yields of mungbean and soybean in Betano, but much lower yields in Aileu, probably due to cold. Most introduced mungbean varieties, particularly Murai in Betano and Merpati in Aileu, significantly outyielded the local mungbean variety. Among soybean varieties, the Indonesian variety Kawi has consistently outyielded all other varieties, although the local variety Ked produced very good yields in Aileu. Among cowpea varieties, KT-5 outyielded all other varieties and had twice the yield of two local varieties in Aileu.

Seed and planting material of these varieties and crops should be kept, and replanted in order to confirm their superior performance during next year's trials, while seed and planting material of the most promising varieties should be quickly multiplied for on-farm testing with participation of local farmers.

IV
International Perspectives

Photographer: Eric McGaw

Drawing from the past to prepare for the future: responding to the challenges of food security in East Timor

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Abstract

This paper examines the challenges to food security in East Timor by drawing on information about the past history of agriculture on East Timor. The paper examines the repertoire of food crops on Timor from the pre-European contact period to the present, giving attention to the role of rice in a configuration of what is otherwise a predominantly 'dryland' agricultural system. The paper then outlines the various agro-climatic zones in East Timor and considers issues of the variability of rainfall, both seasonal and in terms of the ENSO cycle in these different growing environments. The paper concludes by considering the minimal requirements for food security planning in East Timor.

Introduction

FOR such a small nation, East Timor's agriculture is a remarkable amalgam of elements — a great variety of cultigens planted according to distinct farming traditions in diverse environments that are subject to considerable annual, as well as seasonal, climatic variability. Understanding something of East Timor's agricultural past provides a context for considering possibilities for the future. It also provides a basis for assessing contemporary issues of 'food security'. Finally, but importantly, it helps to establish an agenda for future research and thus further improved understanding of East Timor's agricultural potential.

This paper begins with a brief, general history of Timor's principal crops and their relative overall significance in present-day cropping systems. It then considers the diversity of conditions that local farmers face in East Timor and concludes with a number of observations on possible future requirements for food security planning.

The pre-European repertoire of food crops in Timor

It is possible to identify a repertoire of crops grown in Timor prior to the arrival of the Portuguese. The list of these crops is based on a combination of historical observations and comparative evidence from the region. (An understanding of the early botanical history of the eastern Indonesian region benefits from the extraordinary work of the 17th century Dutch naturalist, G.E. Rumphius, whose comprehensive six-volume study of the botany of eastern Indonesia was published after his death as the *Amboinsche Kruydboek* (1741–1755). This treasure trove of detailed information has proved a reliable baseline for all subsequent accounts of the botany of the region (see Heyne, 1950)). Timor possesses an entire suite of crops associated with the early migration of Austronesian populations and the spread of agriculture by these groups. The existence of Austronesian cognate terms (words related by their linguistic origin) for these crops among different Timorese populations[1] combined with indications of similar

[1] An initial survey of the lexical and ritual evidence on traditional agriculture can be found in Fox 1992. 'PAN' indicates that a particular term can be reconstructed to the level of Proto-Austronesian; 'PMP' indicates that a term can be reconstructed to Proto-Malayo-Polynesian, which constitutes the largest subgroup of Austronesian languages.

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patterns of cultivation found throughout much of eastern Indonesia provides some of the best evidence for the early establishment of these crops. (Occasionally, when new crops were adopted, the terms used to identify them became linguistically associated with the plants, which they have gradually replaced. Here, caution is required. So little research has been done on the ethnobotany of Timor, that linguistic designations, including the present set of Linnaean terms for these crops, may well prove to be misleading. In addition, given the history of agriculture on Timor, the whole range of local varieties of particular crops is a subject that needs much greater investigation.) The relative importance of these crops, however, has varied significantly in different parts of the island and in different periods. In historical terms, several previously important grain crops have receded to near insignificance and have been replaced by introduced crops. In short, the picture is one of considerable complexity and what follows is merely an outline.

The principal pre-European crops of Timor were 1) Job's tears (*Coix lachryma jobi L.*), 2) rice (*Oryza sativa L.*), 3) millet (*Panicum viride L./Setaria italica L.*), 4) mung bean/green gram (*Phaseolus aureus Roxb*.), 5) pigeon pea (*Cajanus cajan Millspaugh*.), 6) sesame (*Sesame orientale L*.) and 7) sorghum (*Andropogon sorghum Brot*.).

In addition, the Timorese planted in their gardens 8) onions and garlic (*Allium spp*) (not all varieties of onion now grown on Timor predate the arrival of Europeans. It is likely, for example, that shallot is a more recent introduction to the island), 9) ginger (*Zingiber officinale R*.), 10) turmeric (*Curcuma viridiflora*), 11) cucumber (*Cucumis sativus* L.), 12) sugar cane (*Sacchrum officinarum L*.), 13) banana (*Musa paradisiacal. L*.), 14) taro (*Colocasia esculenta*), and a variety of 15) yam (*Discorea elata L.*).[2]

It is possible, indeed probable, that various other beans and pulses should be included in this list but, for the moment, beans and pulses represent the least researched segment of Timorese agriculture. Some definite candidates for inclusion would be cowpea (*Vigna sinensis Endl./Vigna unguiculata*), rice bean (*Vigna umbellata*) and the lablab bean (*Dolichos lablab L*.). Similarly, if one were to expand this list to other food sources, a variety of fruit trees including jackfruit (*Artocarpus integra*) and mango (*Mangifera indica L*.) and useful palms including the Borassus (*Borassus flabellifer/sundicus Becc*.), Coconut (*Cocos nucifera L*.), Areca (*Areca catechu L*.), Gewang (*Corphya elata Roxb*.) and Pandanus (*Pandanus spp*) would need to be noted for their importance.

Not all of these crops reached Timor at the same time. Some were among the earliest crops grown in Timor while others came later. Sorghum, for example, was a relatively late arrival and was probably spreading through Timor at the time of European arrival. It is useful to consider some of these crops briefly.

*Job's Tears (PMP: *qaZelay)* Job's tears has no economic or cropping significance in East Timor today. This grain was once, however, of greater importance and may have been the earliest grain grown in Timor. A pierced seed of this cereal, apparently intended as an ornament, was discovered in excavations in the Baucau area dating back 5000 years (Glover, 1971). Job's tears thus provide a possible first hint of agriculture on the island. Interestingly, among the Kemak there is a continuing ritual significance assigned to Job's tears. In the ceremonies of the Kemak, Job's tears are 'called upon' to hold harvested rice grains to their stalks (Renard-Clamagirand, 1982). Similarly, Job's tears (and millet) are given prominence in the myths of the Bunak (Friedberg, 1980).

*Rice (PAN: *pajey)* Rice is almost certainly one of the earliest crops to be grown in Timor. But it was probably never as prominent a food crop as it is at present. Through most of the 19th and early 20th centuries, rice was grown in limited areas as a rain-fed or partially-irrigated crop. In some parts of Timor, rice is still grown on terraced fields and this form of cultivation may well have been more widespread than it is today. Rice was grown by 'run-of-river' irrigation and, on favourable sites, spring-fed irrigation was not uncommon. Only in the 20th century (and indeed only in the last quarter of the 20th century), with the construction of larger-scale irrigation systems, has rice taken on its present importance as a major food crop.

*Millet (PAN: *beCeng)* Millet (Foxtail Millet) is another one of the early grain crops of Timor that has dwindled to near insignificance in the 20th century. At one time, in the early history of Timor prior to the introduction of sorghum and maize, millet may have been the major subsistence crop of the Timorese. It is still grown in mixed gardens in some areas of Timor but for the most part the memory of millet is retained only in myth and ritual. Among the Kemak, for example, women who go out to harvest rice are supposed to wear sprigs of millet in their headbands to increase the fertility of the harvest; millet is also

[2] Throughout this paper, for consistency, the Latin terminology used in Heyne 1950 has been followed, with alternative designations, in a few instances, where there has been reclassification.

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hung in granaries to 'welcome' the harvested rice (Renard-Clamagirand, 1982). Bunaq myths recount the tale of three ancestors, one of whom planted a mixed garden of Job's tears and millet; another a garden only of millet while the third planted only rice (Friedberg, 1980)[3].

Mung Bean/Green Gram This is a food crop of both historical and contemporary significance about which there is still insufficient knowledge. Even the designation of this bean or gram as *Phaseolus aureus Roxb*. (see Purseglove, 1971) may be questioned. The Dutch botanical literature on Timor refers to it as *Phaseolus radiatus*, which distinguishes it from *Phaseolus mungo L*. (see Heyne, 1950). Others refer to it as *Phaseolus lunatus.*

This bean/gram is an important and widely grown crop throughout the region. It has a variety of cognate designations: Dawan, Timor: *fue(l)*, Roti: *fufue*, Savu: *kebui*, Manggarai: *wue*, Ende: *mbue*, Bima: *buwe*, Bugis: *buwe* (see Fox, 1992). The Tetun term for bean is *fore* and this particular bean is *fore mungo*. (On the island of Savu, mung bean is the major subsistence crop. In the 18th century, it was once exported in large quantities from the island of Roti (see Fox, 1977) but is now of lesser significance among a range of food crops.)

Mung bean has long been associated with the Tetun-speaking populations of Timor. Especially in southern coastal areas inhabited by Tetun farmers, this bean is a major crop. It is a significant crop in times of drought because it is generally planted in the late rainy season and is thus less dependent on catching the initial, and often irregular, rains of the west monsoon.

Pigeon pea Pigeon pea has never been as prominent as mung bean in the subsistence regimes of any Timorese populations. It can, however, be found widely intercropped in Timorese fields and gardens. This plant is known by similar cognate terms in much of Timor (Helong: *tulis*, Dawan: *tunis*, Tetun: *turis*).[4] The importance of pigeon pea in Timorese agriculture stems from its drought resistance. Although never bountiful, it is often available when other crops fail. The ethnobotany of pigeon pea, however, remains to be investigated.

*Sesame (PMP:*lenga)* Sesame is probably one of the oldest cultivated crops in Timor. It was probably introduced by early Austronesian-speaking settlers to the island. Cognates of the constructed proto-Austronesian term (**lenga*) are found widely in Timor: Dawan: *nene;* Tetun: *lena*.

Sorghum The introduction of sorghum began a process of change in the agriculture of Timor. The term *batar* in Tetun was originally used to refer to sorghum. It derives from an old Malay word for sorghum, *batari*, (itself possibly from Persian) and is related to cognate terms for this crop elsewhere in the region (Makassar: *batara*', Bugis: *bata*; Tana Ai, Flores: *watar*; Sumba: *wataru*). Historical evidence would suggest that sorghum came to Timor via trade-based connections in the region at sometime during the 15th or 16th centuries. In many areas of Timor, maize followed in the wake of sorghum.

When maize was introduced, the same term, *batar*, was applied to maize but linguistic distinctions were made between the two crops. In Tetun Terik, maize is referred to as *batar malae* 'foreign *batar*' and sorghum as *batar ai naluk*, 'long-stalked *batar'*.[5]

With the spread of maize, sorghum has lost much of its earlier importance. However, it is probably more drought tolerant than maize and, therefore, continues to be planted in the driest areas of Timor. Thus, for example, sorghum is still grown in mixed gardens in the coastal area of Maubara. Its potential for food security in times of drought cannot be overlooked.

'New world' crops that transformed Timor

Three crops, which originated in the Americas and were directly or indirectly introduced — perhaps it would be better to say, 'diffused' — via European contacts, have now completely transformed the agriculture of Timor.[6] These three crops are maize (*Zea mays L.*), pumpkin/squash (*Cucurbita spp*.), and cassava (*Manihot utililissima Pohl*). Together with mung bean, these crops now constitute the indispensable staples of the Timorese diet.

A whole variety of other important new world plants can also be added to this list: new world taro

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3 Claudine Friedberg has written extensively on Timorese agriculture from the perspective of the Bunaq who occupy the central border area between East and West Timor. She has also written a major ethnobotanical treatise on Bunaq utilisation of plants. See, in particular, Friedberg, 1974 and Friedberg, 1990.

4 This particular cognate, however, resembles cognates (as for example, Javanese/Malay: *turi*, Madurese: *toroy*) for *Sesbania grandiflora*, another drought-resistant plant that is also found on Timor.

5 Similar forms of linguistic assimilation of maize to sorghum are prevalent in the region (see Fox, 1992)

6 The pathways by which some of these plants reached eastern Indonesia, and Timor in particular, are by no means clear. Many of these plants were already established at the time that Rumphius prepared his masterwork. This is certainly the case for maize, pumpkin, sweet potato, peanuts, watermelon and tomato. Rumphius credits the Spanish for the introduction of maize and sweet potato into eastern Indonesia and designates Japan as the source of the diffusion of peanuts.

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(*Xanthosoma*) which is now interplanted with older forms of taro (*Colocasia*), sweet potato (*Ipomoea Batatas Poir*.), peanut (*Arachis hypogaea L.*), watermelon (*Citrullus vulgaris Schrad*.), papaya (*Carica Papaya L*.) which is generally eaten as a 'vegetable', different kinds of chili (*Capsicum annuum L./ Capsicum fructescens L*.) and tomato (*Solanum Lycopersicum L*.).

To this list could also be added yet more recent introductions: eggplant, Chinese and European cabbage and the potato, which is grown in some upland areas of the island.

While the repertoire of Timorese food plants is indeed considerable, the three plants that have so significantly changed the patterns of Timorese subsistence deserve further consideration.

Maize is the most important of these three because it is now the principal staple of the Timorese. The date of its introduction to Timor is uncertain, though it was beginning to spread on the island by the end of the 17th century. Although the Portuguese are sometimes credited with its introduction, there is no clear evidence of this. Early Portuguese accounts appear to confuse maize with sorghum, which was already well established in some coastal areas of Timor. The earliest Dutch reference to maize dates to 1672 in the form of a directive to Dutch Company officials in Kupang instructing them to introduce what was then called "jagung, Spanish or Turkish wheat" (*sjagon [jagung] Spaense ofte Turckse taruw*) to improve native agriculture. This reference seems to imply that maize was not yet being cultivated. However, by 1699, just a quarter century later, William Dampier reported that maize was growing in the Kupang Bay area of West Timor (Dampier, 1703).

If this is the appropriate date for the introduction of maize, the major agricultural transformation of Timor occurred in the 18th century with maize spreading from west to east. This agricultural revolution coincided with the growing dominance of the Portuguese-speaking Topass elite (extending from Lifao in Oecussi through the Noel Muti mountains to the south coast) who maintained a close association with the rulers of West Timor, supplying them with iron tools and flintlock weapons. It is this 'alliance' that transformed Timor beginning in the west (see Boxer, 1947; Fox, 1988).[7]

Once introduced, maize spread throughout the island of Timor to become the mainstay of the diet of most Timorese. Maize is planted to coincide with, and thus capture, the first precious rains of the west monsoon. The onset of these rains varies locally; rain can occur as early as October or be delayed until December. Mountainous areas generally receive rains well ahead of the coasts; as a result, maize planted in the uplands can be well advanced before planting even begins in the lowlands. Early rain, however, is no guarantee of its continuation. Hence all maize farmers must retain enough seed to replant, if initial attempts at planting fail. In dry years it is not unusual for farmers to be forced to three attempts at planting their crop. The irregularity and uncertainty of maize cultivation is a persistent concern of all Timorese farmers.

Pumpkin/squash[8] Despite the prevalence of pumpkin and squash as a source of subsistence among the Timorese, the importance of these plants is often overlooked. They are intercropped in virtually all Timorese fields and gardens. Yet there are hardly any reliable data on production and there is even less information on the botanical history and local ethnobotany of these critical food sources. Describing conditions in the Ambon region in the 17th century, Rumphius provides an excellent description of local pumpkin and reports that it was already a common food at the time (Heyne, 1950). What can be said of pumpkin and squash in Timor is that they are now an invaluable food source both in times of abundance and in times of scarcity.

Cassava In the 1870s, the botanist Teysman reported that cassava was hardly grown in Timor and that there was, at that time, no Timorese word for the plant. In the 1890s, only migrant Rotenese, at the western end of Timor, were reported to be planting cassava. During the Japanese occupation, however, there was a major effort to force the Timorese to plant cassava, a policy which the Dutch continued in West Timor and the Portuguese may also have encouraged. In effect, once introduced throughout Timor, cassava has been taken up and has now

[7] The fact that in West Timor there is a single large language group — the Dawan or Atoni Pah Meto — is the likely result of the expansion of this population (and its assimilation of other language-speakers) through its reliance on effective new tools, formidable new weapons and a new crop base — all initially gained by contact with Europeans, both Portuguese and Dutch (see Fox, 1988). With the transformation of their subsistence base, the Atoni Pah Meto were able to increase their local population density and were able to expand their territory by more voracious methods of slash and burn agriculture. No other comparable expansion of a particular language population occurred in East Timor.

[8] The literature on Timor uses the terms 'pumpkin' and 'squash' almost interchangeably for a variety of possible plants: *Cucurbita moschata Duch., Cucurbita pepo L.* and also *Curcubita Duch.* (see Mudita and Aspatria, unpublished draft for a discussion of current squash cultivation in Timor).

become one of the island's most important crops, particularly in times of drought.

Historical, as well as contemporary, evidence indicates a remarkable openness on the part of the Timorese to adopt and utilise new plant material. Their existing repertoire of food plants testifies to this fundamental attitude. Timorese openness — indeed eagerness to experiment with new seeds — is based on an understanding of the need to find suitable conditions for cultivation of specific food plants. As one Timorese farmer patiently explained to me after what was (to me at least) a spectacular failure of a new variety of maize, the initial failure of newly introduced seeds should not be viewed with discouragement since conditions in Timor are difficult and therefore it takes time for any new arrival to become adjusted.

Rice in the configuration of Timorese agriculture[9]

As a result of this openness to new food plants, Timorese agriculture consists of a curious configuration of crops. Timorese dryland agriculture with its reliance on maize, beans and squash — spiced, as it were, with chilies and tomatoes — resembles Mexican *milpa* cultivation, which is based on a similar mix of intercropped plants. The major difference from a kind of 'Mexican' cropping system lies in the importance of rice, cultivated both as a rainfed and as an irrigated crop.

Rice was certainly one of the early food plants cultivated in East Timor. Throughout the island, it is regarded as a food of high status. Although for many East Timorese, rice is not consumed on a daily basis, it is essential to serve to guests at feasts and ceremonies. In the second half of the 20th century, rice has been at the centre of a further transformation of Timorese agriculture.

In the mid-1960s, the Portuguese introduced a number of varieties of high-yielding rice that had just been developed at the International Rice Research Institute (IRRI) in Los Banos. As in other parts of Asia, Portuguese agronomists were able to demonstrate that IR8 and IR5 from IRRI were more productive, with or without fertiliser, than the local *indica* variety (of indeterminate pedigree) known as *Java* (see Gonçalves et al., 1974). Whereas all varieties responded to the application of fertiliser (nitrogen and phosphate), IR 8 produced yields between 4.3 and 5.5 tonnes per hectare in almost all areas. This was at least one tonne greater than that of the local variety. These yields were reported to be over ten times higher than those from rice planted by traditional methods on rainfed fields (see Metzner, 1977). The sites chosen for the rice trials in East Timor were located on the north-eastern coast of the island where, at that time, most irrigated rice agriculture was concentrated. These sites included Laclo and Lelaia (in Manatuto), Seiçal (in Baucau) and Laivai (in Lautem). All trials required the transplanting of seedlings, a practice that was itself an innovation. Metzner (1977), whose research focused on a transect from Baucau through Viqueque, reported that on the northern (Baucau) side of this transect: "Wet rice fields are predominantly located in the floodplain of the River Seiçal and along the western and eastern escarpment of the Baucau Plateau (Baucau-Sede), as well as in the foothill zone of Mt Mata Bian in Quelicai".

More significantly still, the new high-yield varieties were introduced to the Uato Lari plain in Viqueque on the south coast of the island, which had been opened up in 1965, via irrigation, for substantial agricultural development and increased settlement. Metzner, who conducted geographical research in East Timor in 1969, noted the remarkable speed with which the new rice varieties were taken up by the East Timorese — more rapidly, however, in the Uato Lari plain than in Baucau or other sites on the north coast. By 1969, Uato Lari was exporting to Dili almost twice the amount of rice that Baucau exported (see Metzner, 1977). Metzner attributed this "rice boom" to the new varieties of rice (IR5, IR8) and the adoption of rice transplanting techniques together with the use of fertiliser (nitrogen as ammonium sulphate).

These new experiments in rice agriculture were still in their initial stages when Indonesia took over the territory in 1975. At the time, Indonesia was itself involved in a massive national program of rice intensification (BIMAS) (see Fox, 1991), and soon transferred its rice development policies to East Timor. The result was a substantial investment in irrigation in pursuit of increased rice production throughout the territory. East Timor's landscape, with a number of important rivers emanating from the mountains and flowing to the coasts — north and south — made 'run-of-river' irrigation a relatively effective development strategy.

Whereas the Portuguese colonial government had concentrated its efforts in the eastern half of East Timor, the Indonesian government shifted development to the western half because in the late 1970s and early 1980s, there was greater local security in the west than further to the east.

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[9] This section and the following one draw on information from Hill and Saldanha (2001).

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The Indonesian push to increase irrigated rice agriculture was not without its difficulties. New areas for rice cultivation were developed and extended throughout East Timor but without sufficient local labour to achieve production levels that would assure food security. Farmers had to learn new skills and alter others to meet the needs for rice growing. Transmigrants from other areas of Indonesia, Bali in particular, were brought to East Timor to introduce exemplary skills and provide extra labour. Mechanisation was begun but was only partially successful. Water buffalo that had previously been relied upon for puddling rice fields declined in number but their replacement by small tractors was a mixed success. Maintaining these tractors and using them in Timor's difficult clay soils posed formidable problems. Bali cattle were introduced as traction animals with some success in the western regions but with far less success elsewhere.

The initial development of new irrigation was concentrated on the Maliana plain in Bobonaro district and these efforts resulted in a substantial increase in irrigated rice production. As a result, by 1982, according to official statistics, Bobonaro had twice as much land planted with irrigated rice as either Viqueque or Baucau. The district had the highest rice production in East Timor. By 1981, Bobonaro's rice yields per hectare were the highest in East Timor, which indicates the use of high-yield varieties of rice. By 1982, if official figures are correct, Bobonaro was producing as much rice as the rest of East Timor put together (BPS Kantor Statistik, 1982). In time, further efforts at developing irrigation were extended throughout the territory so that by 1997, rice production amounted to roughly two-thirds that of maize.[10]

Rice production is concentrated in the northern and the southern coastal areas on both the eastern and western sides of the island. Viqueque, Baucau and Manatuto are the main production areas in the east; Bobonaro, Covalima and Oecussi are, similarly, the main production areas in the west (Fox, 2001). These coastal areas thus benefit from rains that occur at higher elevations; they also gain from a fertile flood of silt that is brought down with the annual river flows. Yet, each year, these heavy river flows from the mountains play havoc with downstream irrigation systems. Damage to intake and headworks, serious erosion, heavy siltation and the undermining of concrete foundations all contribute to the need for regular, as well as immediate, repair. Under these conditions, production is always precarious and costs are relatively high. Nevertheless, rice cultivation is a critical component — an important niche component — of a diverse environment still dominated by dryland agriculture. It is this diverse environment that requires further consideration.

The agro-climatic zones of East Timor

Given its relatively small size, East Timor is comprised of a surprisingly diverse ecology. Much of this diversity is a product of the territory's complex landscape and variable seasonal rainfall. Based mainly on factors of altitude and rainfall, East Timor can be divided into six different 'agro-climatic' zones (ARPAPET, 1996) (Fig. 1). Although further differentiation among these zones is possible, and indeed necessary to a proper understanding of local agriculture, recognition of these zones provides a first step to comprehending East Timor's diversity.

The structure of these zones takes account of the fact that East Timor is divided by a mountainous spine that transverses the territory from west to east. In broad terms, 21% of East Timor is below 100 metres; 44% consists of land between 500 and 1000 metres; while the remaining 35% of land is over 1000 metres in elevation.

East Timor's mountains have a significant influence on the island's rainfall patterns. More rain falls in the mountains than on the coast. The south coast of East Timor has, in effect, a second period of seasonal rain. Whereas most of the north coast has its monsoon rain from December through February, the south coast enjoys additional rains in April, May and June. These rains can often be greater than the rains at the beginning of the year. As a result, the north coast is far drier than the south and the mountains have more rain than the coasts. These patterns are critical to agriculture and also to the patterning of local livelihood activities.

East Timor's six agro-climatic zones are set out in Table 1. It is important to realise that these zones do not necessarily define contiguous areas. A number of locations within each zone is listed and also the calculated extent of each zone. Figure 1 provides a better indication of the relative size of these zones.[11] It includes an indication of the principal catchment areas of East Timor. The dark line on this map distinguishes between these catchments.

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[10] Government figures for 1997 report total rice production at 110,540 tons and total maize production at 174,553 tons (BPS Kantor Statistik, 1997).

[11] Oecussi (Ambeno), the enclave of East Timor in West Timor, requires a separate map. Basically Oecussi's agro-climatic zones are similar to the rest of the north coast of Timor.

Table 1. Agro-climatic zones of East Timor.

	Altitude (m)	Rain (mm/ annum)	Months of Rain
1. North Coast Lowlands Maubara, Dili, Manatuto (147,045 ha: 10%)	<100	<1000	4–5
2. Northern Slopes Atabae, Dare, Baucau, Lautem (336,627 ha: 23%)	100–500	1000–1500	5–6
3. Northern Uplands Bobonaro, Ermera, Aileu, Venilale (290,553 ha: 20%)	>500	>1500	6–7
4. Southern Uplands Lolotoe, Same, Soibada, Ossu (215,021 ha: 15%)	>500	>2000	9
5. Southern Slopes Hatu-Udo, Baguia, Alas, Los Palos (304,981 ha: 21%)	100–500	1500–2000	8
6. South Coast Lowlands Suai, Natabora, Betano, Viqueque (166,700 ha: 11%)	<100	<1500	7–8

Source: ARPAPET (1996). See Fox, 2001:157.

The variability of rainfall and the ENSO cycle

Timor is located in an area that is strongly affected by the El Niño Southern Oscillation (ENSO) cycle. This means that Timor alternates, in seemingly erratic phases, between periods of drought and flood. Thus, for example, from March 1991 until April 1998 (except for a brief respite of some months in 1995–96), Timor suffered continuing dry El Niño conditions (see Fox, 1999). During 1997–98, these conditions became particularly severe. From May 1998 until recently, Timor experienced a succession of relatively good monsoonal rains associated with a continuing La Niña. Despite the flooding that occurs during La Niña phases, these periods are times of increased productivity when the land (and its people) replenish and revive. Unfortunately, for the past century, Timor has experienced more periods of El Niño drought than La Niña plenty. Moreover, not only are there indications that this pattern will continue, there are also indications that the severity of El Niño phases may increase.

A number of critical locations in East Timor are anomalous within the general zonal pattern outlined here. These anomalies have a great deal to do with the irregular pattern of mountains and their effect on rainfall. Often it is the seemingly anomalous areas of Timor that are historical sites of importance, consistently chosen by successive populations for their exceptional features.

Having outlined these agro-climatic zones and the area that each covers, it is salutary to point to several important exceptions where higher rains occur than would otherwise be expected. Thus, for example, Liquica, located in the North Coast Lowlands, at an altitude of only 25 m, has an average rainfall of 1349 mm, well above that of neighbouring Maubara. Similarly, Maliana (Northern Slopes) at 278 m has an average of 2053 mm of rain; again well above what might be expected at this altitude, as does Baguia (Southern Slopes) at 369 m with 2388 mm of rain and Viqueque (Southern Coast Lowlands) at 46 m with 1610 mm of rain.

Timor's complex topography leads to variability in rainfall from place to place, but there is also considerable variability in rainfall from rainy season to rainy season and even from month to month within any one rainy season. Table 2 shows the mean annual rainfall for 20 sites in East Timor at different altitudes, along with the highest and lowest rainfall recorded at each site. A year of very high rainfall can be followed by a year of very low rainfall, making it particularly difficult for local farmers to predict and prepare for the conditions that they must face in any one year.

A 'variability index' is used here to attempt to capture this potential inter-annual variability for each site. This is simply a ratio index of the highest to the lowest recorded rainfall. A high index number is an indication of high variability in rainfall from year to year. Based on this index, it is important to note the differences between sites but particularly the high variability in key agricultural sites: Bobonaro, Maliana, Dili, Fohorem, Manatutu and Lautem — all of which have variability indices that range from 3 (Bobonaro) to 6 (Manatutu).

Planning for food security: minimal requirements

Given the high probability that East Timor will face a variety of ENSO episodes in the future, one needs to ask what are the minimum requirements for planning. This does not refer to the response process to an emergency situation but rather the preparatory stage (or stages) that are minimally necessary to know when, where and how to respond to problems of food security.

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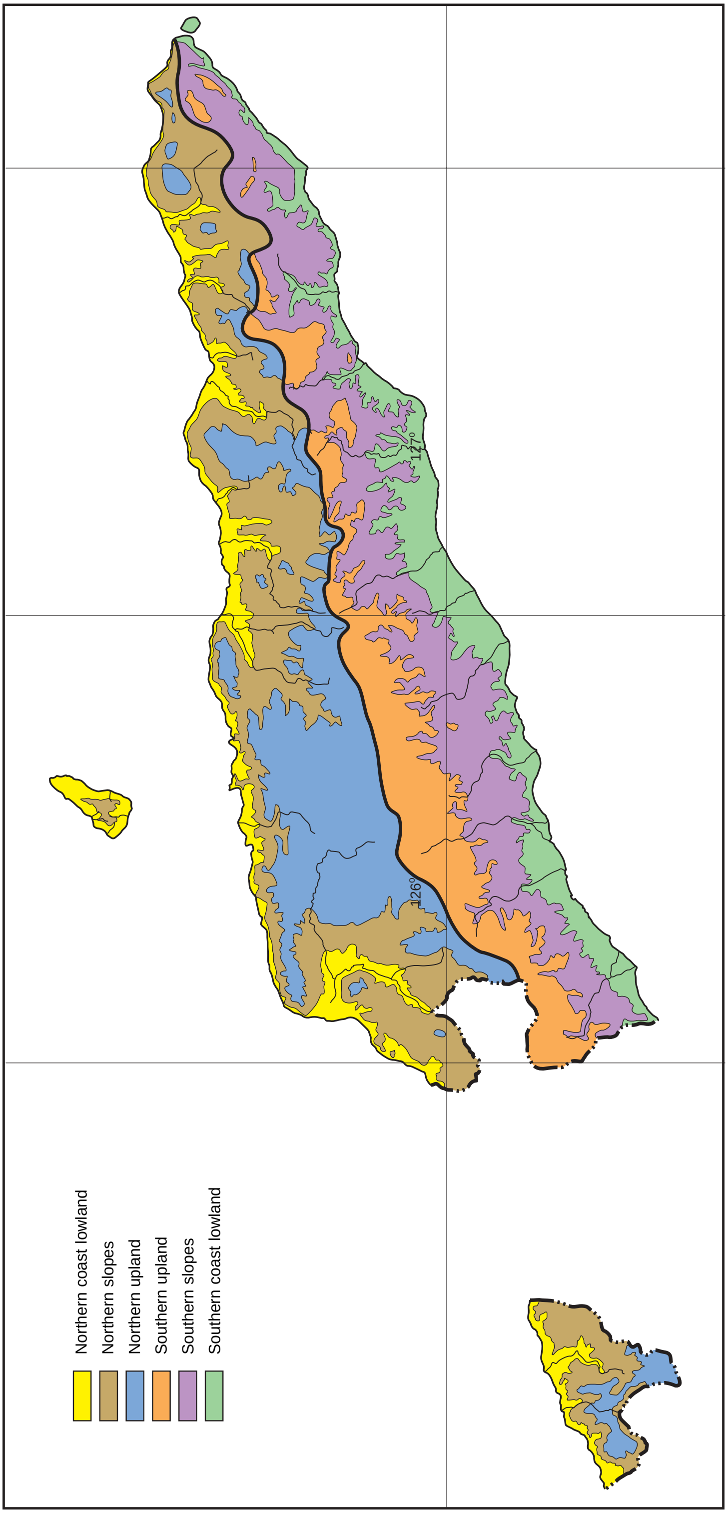

Figure 1. The Agro-Climatic Zones of East Timor.

Table 2. Rainfall patterns in East Timor.

Site	Altitude	Mean	Highest	Lowest	Variability Index
Ainaro	809	2753	3465	2033	1.7
Alas	280	1937	2922	1033	2.8
Baguia	349	2388	3354	1622	2.0
Baucau	527	1362	1467	831	1.7
Betano	7	1329	1797	846	2.1
Bobonaro	850	2349	5229	1760	3.0
Dare	498	1742	4985	869	5.7
Dili	4	954	2821	475	5.9
Ermera	1160	3008	3601	2079	1.7
Fatu Besi	1125	2944	4410	1742	2.5
Fasenda Algare	916	1934	2565	1200	2.1
Fohorem	599	1503	2755	495	5.5
Gleno	770	1765	2431	1078	2.2
Hato Builico	1908	2537	5310	1639	3.2
Iliomar	365	2063	3004	1120	2.7
Laga	65	787	1209	468	2.6
Lautem	174	1040	1428	405	3.5
Liquisa	25	1349	1754	889	1.97
Los Palos	394	1905	3622	1313	2.7
Maliana	278	2053	3170	647	4.9
Manatuto	4	583	1700	283	6.0
Maumeta Atauro	4	969	1285	366	3.5
Oe Silo	472	1568	2338	979	2.4
Ossu	698	1956	2605	1264	2.0
Oecussi	2	1084	1458	755	1.9
Same	544	3142	4087	1445	2.8
Soibada	700	2444	3274	1527	2.1
Suai	71	1327	1760	956	1.8
Tutuala	361	1536	2412	1124	2.1
Viqueque	46	1595	2308	1115	2.0
Zumalai	100	1329	2063	861	2.4

A first requirement is a network of meteorological stations to record rainfall throughout East Timor. At the time of writing, none of the previous rainfall stations have been restored. The existing database on rainfall can serve as a guide to rainfall patterns in East Timor but to know what is actually occurring, one needs a network of stations that record rainfall and report to a coordination centre where all data is lodged and examined.

The next requirement is a database on rural livelihoods. Virtually no reliable agricultural data are being gathered on a systematic basis for East Timor. Former Indonesian data collections, which are certainly valuable and indicative but not wholly reliable, still form the basis for agricultural planning. New databases on production are needed and, in addition, there is a need to build up a systematic picture of local patterns of livelihood. These patterns are invariably based on farmers' experience and understanding of local soil conditions and rain patterns as well as different historically developed cultural practices. These practices include a range of significant features such as household structures, marriage patterns, and the control, transmission and allocation of traditional land holdings, all of which have an influence on livelihood strategies.

Awareness of different traditional cropping patterns — mapped across the landscape of East Timor — would already be a major step in an appropriate direction. There are areas where droughts occur at greater regularity — parts of the north coast, for example — than elsewhere in East Timor. Similarly, there are areas of regular flooding which can often be as devastating as severe drought.

This basic knowledge is fundamental to planning for the future and with it one can shape a response program that will be adequate and appropriate to conditions in East Timor.

The goal for every nation is to be able to assure its citizens of a sufficient supply of food, even in times of agricultural adversity. This is by no means a simple proposition. For most countries, like East Timor, food security requires reliance on both internal production and reasonable market access to food supplies from elsewhere. In addition, it requires local distribution capacities and mechanisms for appropriate allocations. Local self-reliance figures prominently in times of shortage. Food security, however, must be based on the recognition that in times of adversity, when local populations lack the capacity to meet their own most basic food needs, national assistance is a primary task of good governance. For food security, there is the need for advanced planning to be able to recognise emerging problems and to be able to respond to crises as quickly and as effectively as possible.

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The role of *Leucaena* in swidden cropping and livestock production in Nusa Tenggara Timur Province, Indonesia[1]

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Abstract

The islands of Nusa Tenggara Timur province in eastern Indonesia lie in the rain shadow of Australia. They have a semi-arid climate with a short wet season from December to March, and a long, hot, dry season. Natural erosion can be quite severe when heavy rains at the start of the wet season fall on soil that has lost much of its vegetative cover over the long period without rain. Increasing population and the introduction and increase of swidden cropping, extensive wildfires, domestic livestock, and weeds in the late 1800s and 1900s accelerated the loss of natural vegetation and led to extensive land degradation over much of the province.

Between the 1930s and 1960s, villagers, government institutions and non-government organisations recognised that more sustainable fallow systems were needed, so the use of *Leucaena leucocephala* was developed and promoted in the province. Contrasting systems have since emerged and endured in the Amarasi and Sikka areas, providing excellent examples of village adoption and use of shrub legumes in village farming systems. The aim of this paper is to describe the background and nature of contrasting *Leucaena*-based farming systems in Amarasi and Sikka in NTT and to promote awareness that might be useful in utilisation of leucaena and other shrub legumes in East Timor.

The Amarasi system, which was developed in the 1930s, is based around the use of *Leucaena* as a fallow rotation for corn and as a food source for tethered cattle and housed goats. The Sikka system was developed in the 1960s and involves the use of contour rows of *Leucaena* to prevent erosion and to create indirect terraces. Crops such as corn, peanuts, and mung beans are grown on the terraces and mulched with *Leucaena* clippings. These extensive systems each cover about 50,000 hectares, or about 70% and 30% of the Amarasi and Sikka areas respectively. They have contributed substantially to farm production, wood supply, and stabilisation of the resource base.

The systems were placed under severe pressure and declined for several years after 1986, when the psyllid (*Heteropsylla cubana*) spread, multiplied, and devastated *Leucaena* over wide areas. This led to increased use of other tree legumes in the systems and a search for *Leucaena* species tolerant of the psyllid. Over time, however, the influence of the psyllid waned and, during the 1990s, *Leucaena* production and utilisation returned to near its previous levels.

This paper describes these contrasting systems and draws conclusions about the reasons for their success. They are examples of successful and robust cropping and livestock systems that have been widely adopted by farmers. Lessons from Amarasi and Sikka are valuable in considering the promotion and adoption of similar systems in other areas.

Introduction

NUSA TENGGARA TIMUR (NTT) province in eastern Indonesia comprises the eastern Lesser Sunda Islands of Timor, Flores, Sumba, Roti, Savu, and numerous smaller islands. The area of NTT is about 50,000 sq km and the total population is about three million (Fig. 1). Population densities range from 15 to 100 people per sq km. Conditions in NTT have been described by Ormeling (1955), Fox (1977), and Metzner (1982).

[1] Based on a paper published in the proceedings of the conference on "Indigenous Strategies for Intensification of Shifting Cultivation in Southeast Asia" in Bogor, Indonesia, 23–27 June 1997. ICRAF, IDRC and CIIFAD.

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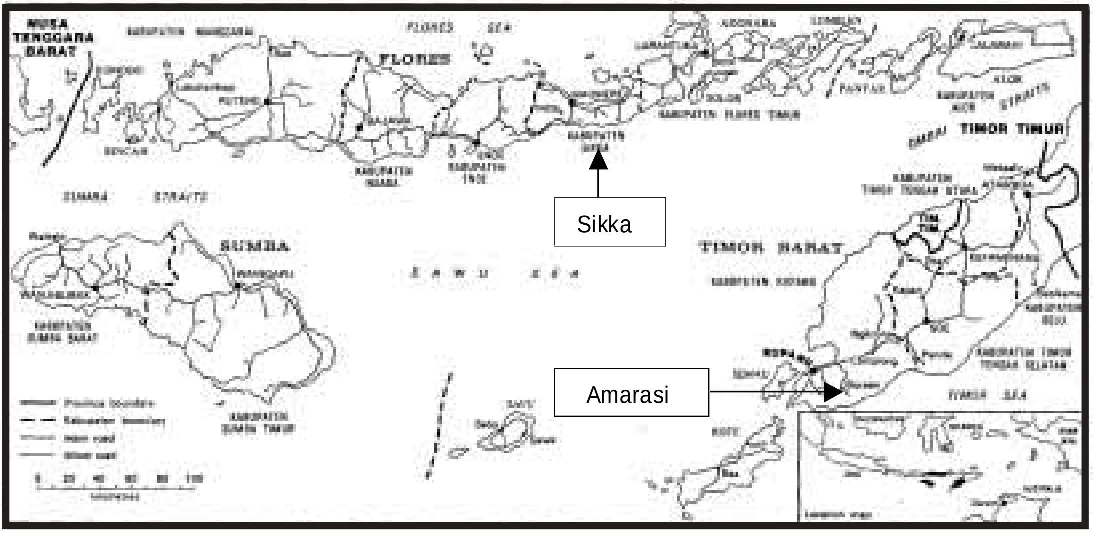

Figure 1. Towns, Kabupaten, and roads of Nusa Tenggara Timur Province, Indonesia.

Agriculture and climate

The islands rise from the sea to altitudes of up to 2500 m along central mountain ridges. Mountain areas are rugged and steep. Deep, eroded streams carry water from the mountains to wide, shallow rivers that flow along narrow plains to the sea. Most streams flow intermittently, raging after rains but without water for much of the year. The few big, permanent rivers flow strongly after rains and become trickles as the dry season progresses.

The soils of the outer southern arc of islands, including Timor, Roti, Sabu, and Sumba, have been derived from marine sediments. They are highly calcareous, with a soil pH between 8 and 9, with some soils being sodic (Aldrick and Anda, 1987). Poorly adapted crops and forages growing on these soils often exhibit zinc, iron and phosphorus deficiencies. Chemical properties of soils on the major land units in West Timor have been detailed by Aldrick (1984a, 1984b).

In contrast, the soils of the inner arc of islands, including Flores and Alor, are derived from recent volcanic activity and are generally more fertile than the soils of Timor (Aldrick and Anda, 1987). These soils are vulnerable to erosion, slightly acidic, with a pH of 5.5 to 6.0, low in N and P, and low in soil organic matter and water-holding capacity (Metzner, 1982).

Agriculture is dominated by the semi-arid climate, with an extreme dry season that usually extends from April or May until October or November. This is caused by south-east monsoon winds that are dry after blowing over the Australian continent. North-west monsoons bring rain from November or December to March or April. The timing and quantity of rainfall are characterised by extreme variation. Average rainfalls vary from 1000 to 1500 mm and generally increase with altitude. Wet season temperatures range from a maximum of 35°C to 38°C to a minimum between 22°C and 25°C. In the dry season temperatures range from a maximum between 22°C and 35°C and a minimum between 19°C and 22°C, with more extreme temperatures in elevated regions. Evaporation rates range from 4 to 9 mm per day with yearly totals of around 2000 mm. These are extreme conditions for plant growth, and McWilliam (1986) showed that total crop failure may be as frequent as one year in five.

Timorese subsistence life was traditionally based on hunting and gathering, with some cultivation of ancient crops such as sorghum, Job's tears, rice, millet, mung bean and cucurbits. According to Fox (1977), slash-and-burn cultivation commenced after the introduction of maize from the Americas by Dutch and Portuguese colonialists around the 1670s, and extensive grazing by large ruminants only occurred after the introduction of cattle in 1912.

Present day cropping is based on slash-and-burn cultivation of maize and cassava, with some sorghum, peanuts, mung beans, rice, sweet potatoes, pumpkins, and other vegetables. Most farmers cultivate up to a hectare of land under the shifting slash-and-burn system and also have up to half a hectare of permanent garden around their house. In the flatter areas, many farmers also grow irrigated rice, often

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quite distant from their homes. Management systems for these crops have been detailed by Pellokila et al. (1991). Tree or horticultural crops are of lesser significance. Management systems for fruits such as papaya, bananas, citrus, mangoes, pineapples, soursop, custard-apples, and jackfruit, and vegetables such as tomatoes, cabbages, beans, eggplant, and garlic, have been outlined by Chapman (1986), Baker (1988), and Pellokila et al. (1991). Many farmers raise cattle, buffaloes, goats, pigs, and chickens. Horses are also common. These livestock feed as scavengers under a free-range system, and management inputs are low. Livestock production systems have been described by Ormeling (1955), Ayre-Smith (1991), and Piggin (1991). Most crop produce is consumed on the farm. Livestock are a form of wealth and are usually only killed and eaten on traditional or festive occasions and contribute little to the nutrition of rural villagers. In some areas with improved access and management, farmers produce for expanding local, provincial and national markets.

Land degradation

Various authors have suggested that traditional slash-and-burn cultivation systems can carry a maximum of 30 to 50 people per sq km (Fox, 1977). Above this limit, there is often progressive degradation of the entire system with shortening of the fallow cycle, a succession from forest to grassland, and severe water imbalance. Over the last century, there has been severe and increasing land degradation throughout much of NTT due to the following factors:

- An increasing human population (see Table 1) which has depended largely on slash-and-burn agriculture with progressively longer crop and shorter fallow cycles, and consequent increasing deforestation and reduced forest regeneration. In 1983, 500,000 ha of land was being cropped in NTT by 420,000 small farm households. An estimated 70% of this land was under shifting cultivation (Barlow et al., 1991).
- An increasing cattle population and the introduction and spread of weeds like lantana (*Lantana camara*), which have reduced forest regeneration and placed increasing grazing pressure on grasslands.
- Extensive annual burning of forest and grassland vegetation in the long and extreme dry season, leaving the soil bare and unprotected.
- High intensity downpours of rain, which are a common occurrence in the short and variable wet season. These cause severe erosion of bare slopes that have been stripped of their vegetation by fires and consequent silting of streams and rivers.

Most of the forest in NTT has now been cut, grazed, or burnt from mountain areas. Floods and erosion are commonplace, but streams dry quickly because there is little remaining vegetation to catch and hold moisture in catchment areas.

Sustainable village systems

In several parts of NTT this severe land degradation has been arrested and reversed through the development, largely by local administrators and farmers, of stable swidden systems based on *Leucaena leucocephala*, commonly known as lamtoro, or *Leucaena*. One is in the Kecamatan (district) of Amarasi in West Timor, southeast of Kupang and centered

Table 1. Population, cattle numbers and area of Leucaena in NTT, Amarasi, and Sikka between 1930 and 1987[a].

		NTT (50,000 sq km)		Amarasi (740 sq km)		Sikka (1670 sq km)	
	Year	Total	No/sq km	Total	No/sq km	Total	No/sq km
Population	1930			16,800	23	123,000	74
	1950			17,600	24	131,500	79
	1970	2,260,000	45	25,000	34	188,000	113
	1980	2,737,000	55	30,000	41	215,000	129
	1987	3,087,000	62				
Cattle numbers	1915	234	0.005				
	1921	2,700	0.5				
	1948-52	108,000	2.2	500	0.7		
	1970-76	375,000	7.5	13,000	18	50	0.03
	1980-82	414,000	8.3	17,000	23	2,050	1.2
	1987	600,000	12			3,400	2
Leucaena (ha)	1955			440			
	1975					8,000	
	1982			50,000		20,000-43,500	

[a] *Source:* Piggin and Parera, 1985; Barlow et al., 1991.

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around Buraen. The other is in the Kabupaten (regency) of Sikka on the island of Flores (Fig. 1). It is interesting to trace the history of these somewhat contrasting systems and draw conclusions about the reasons for their success. They are examples of successful and robust cropping and livestock systems that have been developed and widely adopted by farmers. Experiences and lessons from these systems are valuable in considering the promotion and adoption of similar systems in other areas.

It wasn't until 1930 that organised scientific agrarian advice under central direction began in NTT. Significantly, the establishment of an agricultural extension service in Kupang was closely connected to concerns about shifting agriculture (Ormeling, 1955). At the time, the Dutch administration was promoting improved systems of food cropping that used various legumes, including *Leucaena* and *Sesbania grandiflora*, for crop rotation and soil stabilisation. *Leucaena* had probably been known on the eastern Lesser Sunda Islands for several centuries. It is said to have been used in Java and Sumatra since the early 1800s to provide shade and firewood, improve soil fertility, and reduce erosion (Metzner, 1982, 1983). According to Dijkman (1950), it was brought to Indonesia from Central America by early Spanish explorers.

Kecamatan Amarasi, Kabupaten Kupang, West Timor

Amarasi occupies a 740 sq km strip of land, 10–25 km wide and 65 km long located on the south coast of West Timor. It is undulating land with an average elevation of 300 m. The area originally supported dense monsoon rainforests, which were seen as late as 1929 by the naturalist Muller (Metzner, 1981). However, destruction of the forest, development of extensive grasslands, and land degradation had become serious problems by the 1930s because of slash-and-burn cropping. Crop yields, in turn, were decreasing because restoration of soil fertility was slower under grassland than under forest, and famine became an almost seasonal occurrence.

Bali cattle, introduced in 1912 under Dutch encouragement, adapted well to Timor but did little to solve the problems of feeding the population. Livestock, including cattle, water buffaloes and horses, were used mainly for social and ritual purposes and were rarely eaten. Rulers and heads of villages commonly accepted distributed livestock and sold the offspring for slaughter in major centres, or for export. Lack of knowledge about livestock and grazing management systems, or watering systems and improved pastures, resulted in high mortality and low productivity. Uncontrolled, open range, and indiscriminant grazing was also a problem to unfenced crops, and for the regeneration of forest areas after cropping (Ormeling, 1955; Fox, 1977; Metzner, 1981).

Land degradation was further exacerbated when lantana, a woody shrub, entered Timor around 1912. It was probably introduced to Kupang as a pot plant, or with cattle, and it spread eastwards, most likely with the aid of birds, between 1915 and 1935. By 1949, about 80% of Amarasi was covered with lantana (Ormeling, 1955; Fox, 1977; Metzner, 1981). Livestock owners and cropping farmers had different opinions about the plant. To the grazier, it was a weed because it dominated grasslands and was not eaten by stock. Metzner (1981) suggested that a decline in numbers of large livestock, including cattle, horses, and water buffalo, from 6000 in 1916 to 4000 in 1948, was largely due to lantana. Ormeling (1955) considered that livestock numbers in the early 1950s were lower in Amarasi (60/sq km and 50 per 1000 inhabitants) than the Timor average (170 and 450 respectively) because of lantana. Livestock owners were keen to get rid of the plant. To the shifting cultivator, however, lantana was useful because it grew rapidly, provided a rapid soil cover, reduced weed growth, reduced land preparation time for cropping, maintained good soil structure, and reduced fallow periods from perhaps 15 to five or six years (Ormeling, 1955).

Increasing land degradation and the need to find a replacement for lantana that was acceptable to livestock owners and croppers alike encouraged the search for more useful and sustainable systems. In the 1930s, experimental plantings of *Leucaena* were made under the guidance of the Dutch administration on abandoned fields around the village of Baun (Ormeling, 1955; Metzner, 1981, 1983). In 1932, the 'raja' (ruler) pronounced an 'adat,' or traditional regulation, which obliged every farmer in Amarasi to plant contour rows of *Leucaena* not more than 3 m apart on cropping areas before they were abandoned. Failure to comply carried the threat of a fine, imprisonment, or both. Planting expanded eastwards as the adat decree was implemented around Oekabiti and Burain in the early 1940s (Metzner, 1981). The adat regulation was reinforced in 1948 when the government introduced the Peraturan Tinkat Lamtoro, or *Leucaena* Increase Regulation. It compelled all shifting cultivators to plant *Leucaena* hedges along contour lines (Ormeling, 1955). Over time, the plant moved out from the rows and quickly formed an even cover, apparently because the hedges were not trimmed and *Leucaena* colonised the inter-row spaces (Metzner, 1981).

Leucaena-based cropping systems were further promoted in 1938 with the introduction of land use

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zoning regulations. These set aside 10 zones exclusively for cropping. Small livestock, including pigs, goats and sheep, had to be penned and large livestock such as cattle, buffalo, and horses had to be tethered. The zones were amalgamated and expanded in 1960 and 1967, to include most of western Amarasi. Any livestock straying onto cropping land could be killed on the spot. Outside the zones, cattle could graze freely but had to be corralled once a week. The successful implementation of land use zoning eliminated the need to build fences, a pursuit which, according to Ormeling (1955), took up 25–30% of the time Timorese farmers spent on cropping. Thereafter, farmers were able to spend more time on other agricultural activities.

The increase in land area planted to *Leucaena* (Table 1) underlines the success of the campaign promoting its adoption. In 1948, Kabupaten Kupang had 465 ha of *Leucaena*. All but 28 ha of it was in Kecamatan Amarasi (Ormeling, 1955). By 1980, Metzner (1981) estimated that *Leucaena* covered two-thirds, or 500 sq km, of Amarasi. Lantana had been largely eliminated as a weed problem. According to Jones (1983a), *Leucaena* was continuing to spread in the south and east of Amarasi. The local ruler, who had earlier decreed that *Leucaena* should be planted by all shifting cultivators, also promoted the cultivation of cassava and fruit trees in the late 1940s. By the 1960s, seasonal famine had been eliminated, and Amarasi was exporting food.

The widespread and successful adoption of *Leucaena* in Amarasi was only possible because of the supportive regulations introduced and enforced by the adat ruler (*raja*), who was later appointed administrative head (*camat*) of Kecamatan Amarasi. He was able to pronounce his regulations because of an adat law stipulating that all land belonged to the ruler. Local farmers were given the right to cultivate the land by the local ruler's representatives in each of the 62 Amarasi communities. A farmer's right to use the land expired as soon as he ceased to cultivate it. This system still operated as recently as 1976 because, up to that time, only 100 farmers in Amarasi had decided to have their land surveyed and registered. The majority opted for continuation of the right of usufruct because registration of individual ownership involved surveying costs and payment of a tax (Metzner, 1981, 1983). After 1960, most farmers in eastern Amarasi opted to tether and hand-feed cattle near their homes rather than let them graze freely. Because fence construction was no longer necessary, they had time to look after their cattle (Metzner, 1981).

Cattle production was further stimulated in 1971 by the provincial Government's introduction of the paron cattle fattening scheme. The government bought cattle from central Timor and distributed them to interested farmers for fattening by feeding them with cut-and-carry legume fodder. This fodder included *Leucaena*, *Sesbania*, *Acacia leucophloea*, and *Tamarindus indica*. After reaching slaughter weight, the cattle were sold through traders for export, with 85% of the profit going to the farmer and 15% to the government. More recently, many farmers have bought and sold cattle on their own account. Of all the farmers in NTT, those in Amarasi benefited most from the paron system because theirs was the only district with abundant cut-and-carry fodder. An adat law obliging each family in Amarasi to fatten between two and seven cattle further increased numbers and evened out the distribution of livestock. In 1949, a total population of 500 cattle was owned by less than 1% of the population. By 1974, 13,000 cattle were owned by 100% of Amarasi families (Metzner, 1981, 1983).

The average Amarasi farmer of the 1980s was described by Metzner (1981) and Jones (1983b), and many features from this time prevail today. The family is composed of six persons and their farm covers 2 ha. *Leucaena* grows over the entire farm at a density of 10,000 trees per ha. As previously described, *Leucaena* hedgerows have not been evident in Amarasi for a long time, and crop and livestock activities require harvesting or cutting the fallow forest of *Leucaena* and associated species. Usually 1–1.3 ha is used to provide fodder for tethered or penned livestock and 0.6–1 ha is used for crop production. The average farmer raises three head of Bali cattle that he has bought from local markets near the end of the dry season. They are bought at 12 months of age for about Rp 75,000. Fattening takes about 18 months and the cattle are sold at the end of the second wet season for about Rp 200,000.

Tethered cattle (Fig. 2) are fed 15–20 kg of fresh fodder (30–40% dry matter) from *Leucaena* and other legumes each morning and night. This means that more than 100 kg of fresh fodder is required per family per day. This can be gathered (Fig. 3) from about 1 ha of dense *Leucaena* in the wet season, but supplementary feed is required in the dry season (Piggin et al. 1987).

In 1989, Widiyatmike and colleagues (Surata, 1993) reported that farmers raised five to seven head per year. They were purchased at 100 kg and sold after four to five months at 300 kg body weight, realising a profit of Rp 200,000 per animal. This excellent weight gain of 1.3 to 1.7 kg/ha.day perhaps reflects a high intake and proportion of *Leucaena* in the diet. Studies in Australia have shown that steers grazing *Leucaena* pastures during favorable wet season periods can gain 1.03 to 1.26 kg/ha.day with a

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legume intake of around 40% (Wildin, 1986; Quirk et al., 1988; Esdale and Middleton, 1997; Galgal, 2002), with seasonal variations in kg/head.day of 1.3 in spring, 0.76 in summer, 0.56 in autumn, and –0.1 in winter (Quirk et al., 1990).

Water supply for livestock in Amarasi is a problem, given the extended dry season and the very porous soils. Many deep wells are evident. However, a convenient system has developed, with increased cultivation of bananas. The tethered cattle are fed banana stems, which contain more than 80% water.

Maize and other crops are grown on one-third to one-half of the farm on a three-year rotation. All *Leucaena* and other vegetation is cut to ground level (Fig. 4) up to four months before the start of the wet season. The cut vegetation is windrowed at right angles to the contour and is burned, usually one or two weeks before the first rains are expected. Dry mulching has been tried (Metzner, 1981), but is not popular because of rodents (Jones, 1983b). At the onset of rain, maize is sown on a 1 m grid using a dibble stick and three or four seeds per hole. Cassava, beans and melons are often sown with the maize. The crop is harvested after four to six months, after the end of the rainy season. Yields in Amarasi are 10,000–20,000 small cobs, or 1000–2000 kg of grain, per ha. It is not necessary to resow *Leucaena* after cropping because of strong regrowth from cut stems and germination of fallen seed. During cropping, green stem regrowth is broken off to reduce competition and to provide some mulch.

Tree crops, including bananas, papaya, mangoes, and coconuts, are generally grown in *Leucaena* areas, especially around houses once moisture regimes have been restored. Families in Amarasi in 1983 owned between 5 and 100 coconut trees and between 10 and 700 banana trees (Jones, 1983b). *Leucaena* systems generated a per capita output of about Rp 100,000 per year from sales of cattle, chickens, maize, bananas, and coconuts, with a similar per capita consumption of *Leucaena* firewood, chickens, maize, bananas, and cassava. Real incomes were estimated to be 20–30% higher than the average for West Timor, and this was attributed to the stable farming system based on *Leucaena* (Jones, 1983b). The prosperity of Amarasi residents is reflected in the houses with concrete walls and floors and iron roofs which have replaced traditional palm-leaf houses.

Kabupaten Sikka, Flores

Sikka covers an area of 1670 sq km. It is 15–30 km long and is situated on the eastern end of the island of Flores. The land is undulating, rising from sea level to several hundred metres. Sikka has a serious erosion problem, and *Leucaena* was introduced to provide vegetative cover and soil stabilisation. Efforts to popularise the plant were first made by the Dutch administration in the 1930s, when it recommended cultivation of *Leucaena* in thickets on non-arable land. Adoption was poor because farmers feared that the thickets would get out of control and spread onto arable land (Metzner, 1976).

The need to control soil erosion remained strong so low bamboo fences were recommended. These were pegged along the contours and often anchored with cassava sticks and covered with grass. Once more, effectiveness and adoption were poor. Traditional terraces were also promoted and, between 1966 and 1973, 750 ha of terraces were built. But enthusiasm was not great because the technique was slow, labor intensive, and ineffective, without accompanying vegetative stabilisation.

Interest in cropping was stimulated and the need for crop fences was eliminated as a result of a 1964 decision. By common consent, farmers agreed that horses and small livestock such as pigs and goats should be penned or tethered (Metzner, 1982). The need for effective soil stabilisation soon became critical. As cropping expanded, the pressure to stabilise about 30,000 ha of erosion-prone land stimulated a search for better erosion control technology.

In 1967, a Catholic priest, Father P. Bollen, was so impressed with the potential of *Leucaena* for land stabilisation and rehabilitation that he established a small demonstration garden with contour rows of *Leucaena* near his church at Watublapi, about 30 km southeast of Maumare. The *Leucaena* rows soon became well established and began to collect washed soil and to build up indirect terraces. The success of this demonstration prompted a local farmer, Moa Kukur, to establish a terraced garden at Wair Muut in 1968, using *Leucaena* rows. Over three years to 1971, yields from the garden were stable, and there was no need to shift cultivation to a new area (Cunha, 1982).

The experience at Watublapi and Wair Muut prompted a farmer group, Ikatan Petani Pancasila (IPP), to trial indirect terracing by establishing a demonstration plot in 1972 at Kloangpopot, 40 km south of Maumere. IPP used contour rows of local *Leucaena* spaced 5 m apart, with clove trees between the rows. The demonstration plot was shown regularly to farmers and participants in the group's training courses, and it stimulated great interest and activity in indirect terracing (Metzner, 1976; Borgias, 1978; Cunha, 1982).

In 1973, the district government of Sikka and the Catholic Biro Social Maumere, with the support of IPP, established a program which aimed to stabilise 30,000 ha of land in five years. It was called

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Figure 2. Tethered Bali cattle on a mound of *Leucaena* branches eating cut-and-carry *Leucaena*, Amarasi, NTT Indonesia.
Photographer: Colin Piggin, January 1984

Figure 3. Leucaena fodder gathered for tethered Bali cattle, Amarasi, NTT Indonesia.
Photographer: Colin Piggin, January 1984

Figure 4. *Leucaena* forest (rear) slashed and burned ready for planting of crops, Binel, South Central Timor, NTT Indonesia. Photographer: Peter Kerridge, November 1982

Figure 5. *Leucaena* contour rows, Watublapi, Sikka, Flores, NTT Indonesia. Photographer: Colin Piggin, January 1984

Program Penanggulangan Erosi Kabupaten Sikka (Sikka Erosion Control Program). Farmer training courses were held, water levels were distributed for making contours, seed was purchased and distributed, planting was supervised and evaluated, and prizes were offered in order to encourage farmer cooperation. Within two years, an estimated 8000 ha of *Leucaena* had been established (Metzner, 1976; Borgias, 1978; Cunha, 1982). *Leucaena* planting was further stimulated by the introduction of giant varieties from Hawaii and the Philippines, and by the local launching in 1974 of the national food crops intensification program (BIMAS), which offered credit for crop inputs if farmers planted *Leucaena* on their farms (Parera, 1982a). Parera (1982b) estimated that, during the mid-1970s, about 20,000 ha of hilly land was terraced with local *Leucaena* (Fig. 5) and a further two million giant *Leucaena* trees were planted. Cunha (1982) concluded that the total area of *Leucaena* at this time was between 27,000 and 43,500 ha.

For indirect terracing, *Leucaena* is sown at about 70 kg seed/ha, in furrows or banks formed along the contours of fields with the aid of an A-frame or water level. Early establishment is slow and the seedlings need protection from weeds and grazing. But with reasonable management, thick hedges form within two years. These collect soil washed from the upper slopes by rain and gradually form terraces. They are called “indirect” terraces because they form naturally rather than being constructed. Once established, the hedges are usually cut every four to six weeks during the rainy season and before seeding, to a height of 75–80 cm. Cut material is thrown on the upper slope to fertilise the soil (Metzner, 1976). Unlike in Amarasi, *Leucaena* is maintained in hedgerows in Sikka and cropping takes place between the rows (Fig. 6).

The primary aim of the *Leucaena* planting program in Sikka was to control erosion. A measure of its success can be seen in the improvement in water balances. The Batikwair River, which ceased to flow in the dry season in the 1920s, has been flowing continuously since 1979 and Maumare, once a flood-prone town, has not been flooded since 1976 (Parera, 1980; Prussner, 1981; Metzner, 1982).

Figure 6. “Indirect” *Leucaena* terraces and peanuts. Leucaena is cut and laid on terraces to drop leaves for mulch and dry for firewood. Watublapi to Maumere Road, Sikka, Flores, NTT Indonesia. Photographer: Colin Piggin, January 1984

Other benefits have followed. Established areas are now being cropped more intensively and are more productive. Unterraced fields can be cropped for three to four years, but need a recovery period of four to nine years because of the loss of soil and fertility. Terraced slopes, on the other hand, can be cropped continuously if *Leucaena* herbage is used as green manure and cereal-legume rotations are used. *Leucaena* also discourages weeds, such as *Imperata cylindrica*, which often appears after the abandonment of unterraced fields. Many terraced fields have been planted with permanent tree crops, such as coconuts, coffee, cocoa, cloves, and pepper. The contour hedges of *Leucaena* provide shade, soil stabilisation, increased soil fertility, and improved soil infiltration (Parera, 1980, 1982b; Metzner, 1982).

Unlike in Timor, cattle have not traditionally formed a significant role in the Flores livestock industry, partly because of a lack of water and extensive grasslands (Metzner, 1982). *Leucaena* herbage is, instead, fed mainly to small animals such as pigs, goats, and chickens. There were efforts to encourage cattle farming in 1967, with the introduction of 100 head of Bali cattle under a government credit program. However, according to Cunha (1982), only 50 cattle remained in Sikka in 1970, and they were owned mainly by the Department of Animal Husbandry and the Roman Catholic Mission. The cattle industry received a stimulus with the introduction of the giant *Leucaena* varieties K8, K28, K67, and Peru, from the Philippines and Hawaii in 1978 and 1979. These were planted widely in areas not used for cropping, because the less vigorous local variety was considered more suitable for contour planting in cropping areas. Further Bali cattle were brought in, and numbers climbed to more than 2000 in 1982 (Cunha, 1982), and to 3400 in 1987 (Barlow et al., 1991).

Heteropsylla cubana and *Leucaena* productivity

Before the arrival of the *Leucaena* psyllid (*Heteropsylla cubana*) in NTT, studies from 1982 to 1986 showed that the maximum annual production which could be expected from well-established *Leucaena* was around 6000 kg of dry matter per hectare of leaf and a further 6000 kg dm/ha of stem. This came from three- to four-monthly cuttings of *Leucaena* with 1.5 m between rows and 10 cm between plants. This level of production is at the bottom of the range of 6–18 t/ha of edible dry matter quoted by Horne et al. (1986), no doubt because of the severe moisture limitations in the mid to late dry season. Leaf production rates follow rainfall patterns, falling from 25–30 kg/ha.day to just 1–2 kg/ha.day in the mid to late dry season (Piggin et al., 1987). Assuming that cattle need 10 kg/day of edible dry matter, it would be possible to feed at least 1.5 cattle/ha.year from a good *Leucaena* stand. This agrees with the frequently mentioned carrying capacity of 1–2 cattle/ha in the Amarasi district (Piggin and Parera, 1985).

The arrival of the psyllid to eastern Indonesia in 1986 initially devastated *Leucaena* plantations (Piggin and Parera 1987). Trees were bared and, in places, died. One study estimated that *Leucaena* productivity was reduced by 25–50% (Piggin et al., 1987). For a time, farmers in Amarasi raised fewer stock and used alternative fodder. This was reflected in an 11% fall in cattle sold in trade markets, from 88,000 head in 1986 to 77,000 in 1987 (Fig. 7).

At the time, grave fears were held that the systems of Amarasi and Sikka would be destroyed, with associated long-term hardship and land degradation. However, this has not happened. Over the years, psyllid numbers have declined and productivity of *Leucaena* has gradually recovered. This is perhaps

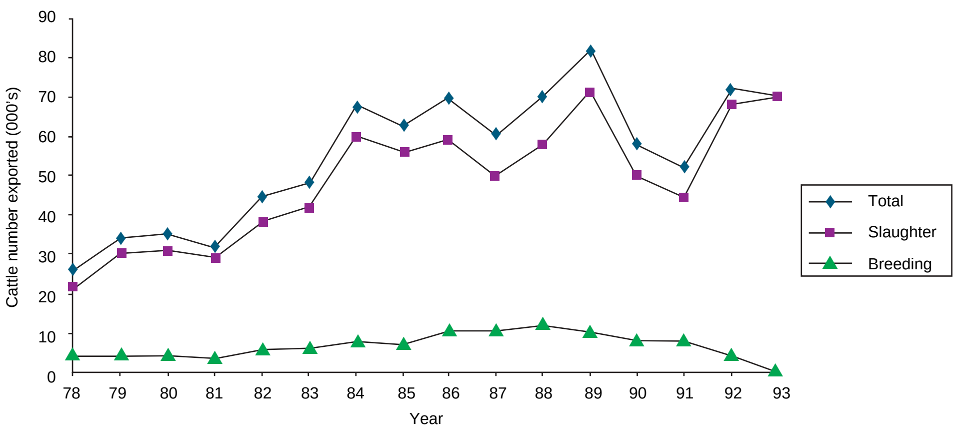

Figure 7. Cattle exported from NTT for slaughter and breeding.

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due to a build-up of psyllid predators. In 1989 in Amarasi, Widiyatmike and colleagues reported weight gains of 1.3–1.7 kg/head.day for cattle fed on *Leucaena* (Surata, 1993). In Australia, Quirk et al. (1990) and Esdale and Middleton (1997) have recorded gains of around 1.3 kg/head.day for *Leucaena*-fed cattle in Australia. Both these reports illustrate the high productivity that can be achieved with *Leucaena* fodder, despite the psyllid.

However, the psyllid experience highlighted the danger of over-dependence on a single species and has led to a concerted effort to find alternative shrub legumes. Research has shown that *L. diversifolia*, *L. collinsii*, *L. pallida* and several *Leucaena* hybrids are well adapted and exhibit good resistance or tolerance to psyllids in West Timor (Piggin and Mella, 1987a, 1987b; Mella et al., 1989) and support good animal production (Galgal, 2002). Other species, like *Sesbania*, *Acacia villosa*, *Gliricidia sepium*, *Calliandra callothyrsus*, and *Desmanthus virgatus*, are also well adapted and useful as multi-purpose trees. Seed production of these has been promoted by local NTT departments and NGO groups, and they are being more widely used by farmers.

Reasons for the success of *Leucaena*

There are many reasons why *Leucaena*-based systems have developed and persisted in Amarasi and Sikka. These can be distilled from the historical and detailed accounts above and include the following:

A recognized need for better systems

Serious land degradation associated with slash-and-burn cropping, increasing livestock numbers, and the spread of the weed lantana, was causing low farm productivity and poverty. Compounding the problem, population densities had reached 25–75 people/sq km, above the limit that could be sustained by traditional slash-and-burn systems (Fox, 1977). By the 1930s it was realised that serious efforts had to be made to develop more sustainable farming systems. Such systems, nevertheless, had to permit a continuation of traditional swidden rotation methods of restoring soil fertility, suppressing weeds, and providing timber. As recently as 1983, about 70% of the 500,000 ha cropped in NTT, and 85% of the 30,000 ha in Sikka, were still under shifting cultivation (Barlow et al., 1991).

Failure of alternatives

Attempts to control erosion and land degradation with physical structures and traditional terraces in the 1960s and 1970s were not successful because of the labor and cost involved and the general ineffectiveness of the technology. This encouraged the continued development of biological systems using *Leucaena* and other plants.

Adaptation of *Leucaena* to the local environment

Leucaena is very well adapted to the semi-arid climate and the alkaline or relatively neutral soils of the area. The plant is deep-rooted and drought-resistant and, being a legume, is adapted to low-N soils. Although its early growth is slow and susceptible to grazing and weed competition, *Leucaena* has proven easy to establish and is very persistent in most situations. It was devastated when the *Heteropsylla cubana* entered NTT in 1986, but has since recovered much of its productivity and remains a persistent and dominant species in many village areas.

Compatibility of *Leucaena* with local farming systems

Fallow species in NTT must be able to withstand severe treatment. Once established, *Leucaena* is a robust plant able to persist and regenerate despite traditional swidden practices that involve regular and quite severe cutting and burning. It is attractive to cropping farmers because it adds nitrogen to the soil, suppresses weeds, and provides wood for the construction of fences.

Research in NTT has shown that *Leucaena* can be relatively easily established under corn crops without reducing corn yields and can re-establish from cut stumps or seed in subsequent years. With proper management, it competes little with the crop and provides valuable livestock forage and soil N improvement (Field and Yasin, 1991; Field, 1991a, 1991b, 1991c). Field (1986) has also shown that maize yields can be doubled by including two to three years of *Leucaena* in crop–fallow rotations.

Capacity of *Leucaena* to supply local needs

Village life is harsh in NTT, and villagers struggle with many constraints. *Leucaena* is a multi-purpose plant contributing a multitude of village needs, from firewood and building timber to forage for livestock, mulch for crops, weed suppression, shade for tree crops, and soil stabilisation. In Amarasi, it has become like a forest and supports more or less permanent slash-and-burn cropping as a fallow species which improves soil fertility and suppresses weeds. Its capacity to supply nutritious forage has led to the development of a large-scale industry involving the fattening of tethered cattle in Amarasi (Table 1). In Sikka, contour hedgerows of *Leucaena* have been maintained with cropping between the rows. This has led to the buildup of indirect terraces as soil washed downslope by rain is trapped by the hedgerows. Soil loss in the terraced fields of Sikka is

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consequently much lower than the natural levels in NTT of 200 metric tons/ha.year reported by Carson (1979). Demand for fodder has been of little influence on the use of *Leucaena* in Sikka because cattle were not introduced until the 1970s and numbers have remained low. However, cattle numbers are now building up, partly in response to the increased availability of *Leucaena* forage.

Local farming systems have compensated for some weaknesses found in *Leucaena.* Measurements in NTT of the mineral content of *Leucaena* suggest that low sodium, phosphorus and copper may limit its nutritive value and, consequently, its role in animal production. However, farmers in Amarasi already compensate for sodium deficiency in *Leucaena* by the common practice of adding salt to drinking water. Feeding a diverse mix of species to the livestock also helps overcome other deficiencies. For example, *Sesbania*, which is commonly mixed with *Leucaena* in cattle feed, is high in sodium.

Commitment of local leaders and groups

Local village heads, NGOs, church groups, and government departments showed great commitment to the need to develop more sustainable systems in Amarasi and Sikka. They were instrumental in recognising and demonstrating the potential of *Leucaena* to local villagers. Church and farmer cooperative groups were prominent in Sikka, while Dutch administration and local government officials provided the impetus in Amarasi.

Creation of a favorable policy environment

Local administrators recognised the importance of a favorable policy environment to promotion of new technology. They instituted new regulations to encourage not only the planting of *Leucaena,* but the development of more permanent and productive agriculture. These measures provided for the following:

- The tethering or confinement of livestock in cropping areas to reduce the need for fences and give farmers more time for crop and livestock husbandry. This was promulgated in 1938, 1960, and 1967 in Amarasi, and in 1964 in Sikka.
- The availability of cropping credit only to those farmers who were prepared to plant *Leucaena* on sloping land in Sikka.
- The development of erosion prevention programs. These were established in Sikka in 1973 and 1978.
- The obligatory planting of *Leucaena* in Amarasi, pronounced by the local ruler in 1932 and the government in 1948.
- The encouragement of cattle husbandry by livestock distribution schemes in Sikka in 1967 and in 1980–82, and in NTT in 1971.

Effectiveness of *Leucaena*

Leucaena's adaptation to the local environment in Amarasi and Sikka has produced a persistent and productive plant, which has grown well in contour rows or forests. Its use has been encouraged because it is able to support traditional slash-and-burn cropping as well as providing many essential community and household needs. Mature *Leucaena* has been effective in reducing soil erosion, both directly as a physical barrier and indirectly through improved infiltration and reduced runoff. Indirect terraces up to 1 m high have built up naturally against *Leucaena* contour rows over large areas of Sikka. The improved water balance in Sikka, where the Batikwair river now flows continuously and rarely floods, is reportedly due to revegetation of bare catchments by *Leucaena*.

Leucaena fallows suppress crop weeds in the same way that natural forests do in traditional rotations. Crops sown where shrub legumes have been cleared benefit not only from improved soil nitrogen, but also from the absence of weeds. *Leucaena* seems capable of depleting seed reserves of annual weeds in the same way as other forest species. Tree canopies reduce the amount of incident light reaching the ground (Nye and Greenland, 1960). This shades out annual weeds and stops them from flowering and seeding. The longer the fallow growth persists, the more efficient it is in depleting the seed reserves of annual weeds. While it may be destructive to weeds, the shade provided by *Leucaena* has also been significant in allowing the establishment of tree crops such as mangoes, cocoa, pepper, and cloves.

Contribution of *Leucaena* to development of more commercial farming systems

Leucaena has helped village farmers to move from subsistence to more commercial farming systems. In Amarasi, this has been through the development of commercial cattle fattening and establishment of orchards of bananas, papaya, mangoes, and coconuts. In Sikka it has fallowed the development of permanent orchards of tree crops such as mangoes, cloves, pepper, and cocoa. The shade provided by *Leucaena* on previously bare slopes has assisted in the establishment of shade-loving tree crops. In Sikka, increased availability of forage is encouraging the adoption of intensive cattle breeding and fattening. This potential for commercial development has been an important factor in farmer acceptance and enthusiasm for the use of *Leucaena*-based systems.

Development of modern legume-based systems

The improved fallow systems described above, which are based on *Leucaena*, have been modified and developed in parts of eastern Indonesia using other species such as *Sesbania*, *Gliricidia sepium*, *Calliandra callothyrsus*, and *Acacia villosa*. Such systems, using *A. villosa* at Camplong in West Timor and *C. callothrysus* in West Flores, have been described by Field (1991b). The use of these other species has been partly a response to concerns of dependence on one species, after the *Leucaena* psyllid experience. However, it also recognises the adaptability and suitability of other species and the need for diversity in farming systems.

Leucaena-based farming systems have also developed in other countries. Very similar systems of slash-and-burn cropping and tethered livestock can be seen in Jala Jala, Rizal, Philippines. About 150,000 ha has been established in Australia to support extensive, mechanised systems to raise cattle (Quirk et al., 1990; Esdale and Middleton, 1997)

Conclusions

It is fascinating that two contrasting systems, both using *Leucaena leucocephala*, should develop and persist in close proximity in eastern Indonesia. Both were prompted by concerns about land degradation, low productivity, and poverty, and both focused on the introduction and promotion of a perennial shrub legume.

The Amarasi system, sustainable since the 1930s, is based on the use of *Leucaena* forests for swidden cropping of corn and feeding of tethered or confined livestock. The Sikka system, sustainable since the 1960s, involves the establishment and maintenance of *Leucaena* hedgerows to support alley cropping of corn, peanuts, and mung beans, and permanent tree crop plantations of mangoes, cloves, cacao, and pepper.

The history of these systems suggests that a range of factors has been important in their development, evolution, and persistence. These include a recognised need for better systems, the failure of alternatives, the adaptation of *Leucaena* to the local environment, the compatibility of *Leucaena* with local farming systems, the capacity of *Leucaena* to supply local needs, the commitment of local leaders and groups, the creation of a favorable policy environment, the effectiveness of *Leucaena*, and the contribution of *Leucaena* to the development of more commercial farming systems. Many of these factors can be recognised in descriptions of the processes involved in the successful diffusion of innovations by Rogers (1983).

In a review of slash and mulch systems, Thurston (1997) suggested that "the jury is still out on the future and potential of alley cropping systems". Sikka and Amarasi provide compelling evidence that, at least in some places, villagers have incorporated shrub legumes into long-established, sustainable farming systems that are supporting a much better quality of life than would otherwise exist.

Leucaena and other shrub legumes are common in East Timor, but don't seem to be utilised in livestock or cropping systems. These examples of successful *Leucaena*-based systems presented here provide a guide for the development of local systems to utilise this resource and improve village livelihoods in East Timor.

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Chromolaena in Southeast Asia and the Pacific

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Abstract

Chromolaena odorata is a major weed of pasture and plantation crops in many countries in Africa, South and Southeast Asia and the Pacific. Attempts at biocontrol started in the late 1960s but have been hampered by the lack of funds in the affected countries. Successful control has been achieved, first in the Marianas and other Pacific islands, and now in Indonesia with the gall fly *Cecidochares connexa*. The gall fly is currently being released in Guam, Thailand, and Papua New Guinea, and releases should be made as soon and as widely as possible in East Timor. New agents currently being studied in South Africa may be needed in drier or high altitude areas.

Introduction

CHROMOLAENA (Eupatorium) odorata (Asteraceae), known as chromolaena or siam weed in Australia, is a major invasive weed of pasture, plantation crops and forests in much of the Old World tropics, from west and south Africa to South and Southeast Asia and into the Pacific region (McFadyen, 1989; McFadyen and Skarratt, 1996; Baskin, 2002). It is spread by human movement via machinery and packing materials and is continuing to increase in East Timor and other countries of Southeast Asia. Biological control was first suggested in the 1960s but successful control has only been achieved recently.

Taxonomy

The tribe Eupatorieae (Asteraceae) is a well-defined, mostly New World tribe, with white, reddish or blue flowers lacking ray florets. There are no crop plants in the tribe but important weed species are *Mikania micrantha*, a major weed in tropical Southeast and South Asia, and the herb *Ageratum conyzoides* which is a common weed of crops and gardens in the tropics worldwide.

The genus *Eupatorium* contained over 1200 species before it was split, most in the Americas with a few in Europe, Asia and Africa. Several species are important weeds: *Ageratina adenophora* and *Ageratina riparia* in Southeast and South Asia; *Austroeupatorium inulaefolium* in Indonesia and Sri Lanka; and *Praxelis clematidea* in north Queensland and southern China. The genus *Chromolaena* has 129 species all from the Neotropics (King and Robinson, 1970) but only *C. odorata* has become invasive outside its native range. *C. odorata* is native to the New World tropics from southern Florida, USA, to northern Argentina, and is found in most suitable habitats below 1000 m altitude and receiving at least 1200 mm annual rainfall (McFadyen and Skarratt, 1996).

Habit and importance as a weed

C. odorata is a herbaceous perennial, forming dense tangled bushes 1.5–2 m in height, very occasionally reaching a maximum of 8 m as a climber on trees. It only grows in the open or partial shade, and does not grow in intact forest. Stems branch freely and a large plant may have 20 or more stems of varying size from a single rootstock, often bent over under the weight of the branches and shading an area of up to 4 sq m. *Chromolaena* is a short daylength plant, flowering in December/January in the northern hemisphere and in June/July in the south. Close to the equator, flowering may lose synchrony and generally occurs at the start of the dry season. The flowers are pale bluish-lilac and form in terminal corymbs on all stems and branches, covering the whole surface of bushes. After flowering, most leaves wither and fall

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and branch tips may also die back, depending on the severity of the dry season. In dry areas, fires may destroy all above-ground growth. With the onset of the rains, regrowth is rapid and extensive, with new stems from the root-crown and from all intact stem buds (McFadyen, 1989).

Chromolaena is an invasive weed of pasture and forest clearings, disturbed land, plantation crops, forestry, and other similar land uses. It forms dense thickets 2–3 m high and chokes out other vegetation. No vegetation survives beneath the plants and tree seedlings cannot penetrate the dense growth. Grasslands are rapidly invaded, the grass shaded out and completely replaced by *Chromolaena*. All parts of the plant contain high levels of pyrrolizidine alkaloids (Biller et al., 1994) and are bitter tasting so that livestock will not usually it. If cattle or goats do eat it, the alkaloids progressively destroy their liver, and animals die (Pancho and Plucknett, 1971).

Spread methods

The primary long-distance vector responsible for its spread is human activity. In Asia and the Pacific region as elsewhere, the direction of spread reflects human movements rather than wind patterns (Fig. 1). The seeds bear minute hooks, and cling to animal hairs, clothing, vehicles and machinery. Movement of military equipment and personnel are a major source of long-distance spread, and troop movements during World War II were responsible for much of the spread through Southeast Asia and the Pacific. Initial infestation sites were usually ports used as bases by both Japanese and Allied forces, such as Rabaul in New Britain and Jayapura in Irian Jaya. Sri Lanka and the Western Ghats in India were probably infested by troops and their equipment returning from Assam and the Burma front. The initial infestation in the Marianas was at Rota island, also a Japanese base in the war.

In the same way, Indonesian army movements undoubtedly carried the weed into both West and East Timor after 1975. The importance of military vehicles and equipment in spreading seed is confirmed by the Australian experience with vehicles used in East Timor by Australian forces serving there. When the vehicles were cleaned prior to return to Australia, they were found to have up to 0.5 kg of seeds in a single vehicle, primarily around the radiators and undercarriage. Without the rigorous cleaning program instituted for Australian forces and their equipment, the Timor operations would have

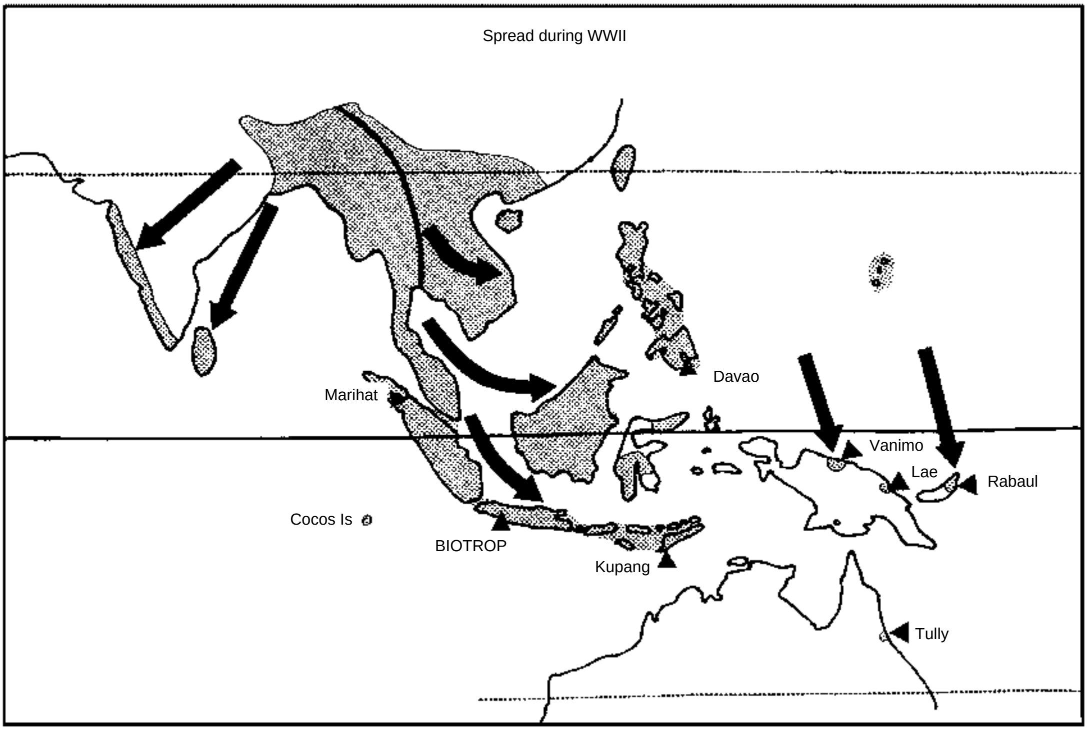

Figure 1. Spread of *Chromolaena* during WWII.

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resulted in massive *Chromolaena* infestations at army bases throughout northern Australia.

The transmigration program in Indonesia, with the movement of people, vehicles and equipment from Java and adjacent islands into eastern Indonesia, was almost certainly responsible for the introduction of the plant into southern Sulawesi, the Moluccas, and the other eastern islands. Ships trading between the southern part of Borneo and the southern Philippine islands were probably responsible for the arrival of the weed in Mindanao.

Once established in a new area, seed continues to be spread by human activity, typically the movement of bulldozers and other heavy machinery associated with road-building, forest clearing, or the development of new agricultural areas. Tree-clearing associated with logging, road-building, and increased agricultural activity creates open land in which *Chromolaena* thrives, at the same time as the machinery spreads the seed into the newly-cleared areas. Re-vegetation of road banks or mine sites has also spread the weed, through the use of planting material or mulch contaminated with *Chromolaena* seed. Villagers moving into new areas or working in forestry and along roads may carry the seed with them in their clothing and equipment. There is thus a progressive movement of the weed into previously clean areas along roads and tracks, which has been well documented in many countries.

Despite the conspicuous pappus on the seed, wind is only the vector for purely local spread, dispersing the seed away from the parent plants for less than 50 m. Seed which falls under dense vegetation will lie dormant for years until the land is disturbed by clearing, fire or other causes. This can result in there being little visible problem in an area until trees are felled and land cleared, when there is a sudden massive germination. In grassland, whether natural or planted, the natural disturbance resulting from grazing in dry conditions and/or seasonal fires, which leaves patches of bare soil, may be sufficient to stimulate germination. Seed germinates rapidly after rain and the seedlings quickly grow above the grass which is progressively shaded out. Grasslands in areas with a dry season are particularly vulnerable to invasion, and there is no easy control method in these situations. Valuable pasture is rapidly replaced by a dense growth of *Chromolaena*, leaving the livestock to starve and the villagers deprived of their source of meat or cash income.

Biological control

In forestry and plantation crops and on grazing lands where *Chromolaena* is a serious invasive weed, chemical control is possible but not economically or environmentally feasible, as the large seed bank means that repeated treatments are required. The only permanent and sustainable control method is biological control using insects or pathogens from the countries where the weed is native. Biocontrol using imported insects and diseases has a long and successful history worldwide (McFadyen, 1998) and is very safe with no undesirable side-effects so long as the biocontrol agents are carefully tested for host-specificity and are imported free from parasites (Labrada, 1996; FAO, 1996).

Biocontrol of *Chromolaena* was first proposed by the Commonwealth Institute of Biological Control (CIBC) in the mid 1960s (Bennett and Rao, 1968). From 1966 to 1972, the Nigerian Institute for Oil Palm Research financed exploration in Trinidad, supporting a CIBC entomologist full time for three years and part time for another three years. Most of the work was done in Trinidad but brief surveys were made in Central and South America. Over 240 phytophagous insects were recorded, several of which were sufficiently host-specific to be potential biocontrol agents (Cruttwell, 1974). Of these, the eriophyiid mite *Acalitus adoratus* was host-tested in 1971 but never deliberately introduced anywhere. However, it was accidentally released in Sabah, Malaysia, from where it spread very rapidly throughout Southeast Asia. It is now present in all Asian infestations (McFadyen, 1995) and is also present in East Timor. It is particularly abundant in hot, exposed sites but its impact on the plant is minor.

The leaf-feeding moth *Pareuchaetes pseudoinsulata* was the first agent to be deliberately introduced, from Trinidad into India and Ghana in the early 1970s (Bennett and Cruttwell, 1973). It was then introduced to Sri Lanka and Sabah, establishing in both countries but not causing much damage to the plant. From Sabah, it spread naturally to Palawan and Mindanao in the Philippines, where it is also not usually present at damaging levels. In 1985, it was taken to Guam, and subsequently to the other islands of the Marianas and adjacent countries, where it gave excellent control of the weed (Muniappan and Marutani, 1988). From Guam it was imported into Indonesia in 1992, and has resulted in good control in north and central Sumatra, but has not established in Java or the other islands. It has also been introduced from Guam into Papua New Guinea and Ghana, where it established rapidly and is spreading.

The next insect released was the gall fly *Cecidochares connexa*. This was first reported from the Americas in 1970 (Cruttwell, 1974) but was not host-tested until 1993, and was first released in Indonesia in 1995 (McFadyen et al., 2003). It established readily and has been widely released within Indonesia. It is

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Figure 2. Siam weed dominates the landscape in many areas of East Timor. Photographer: Colin Piggin

now present in all the major Indonesian islands including Kalimantan and Irian Jaya, and has been released and established in Palau and Guam in the Pacific, in Papua New Guinea, and in Thailand.

The female fly lays eggs in stem tips, both terminal and axillary buds. Two or more larvae feed inside the bud which swells into a stem gall, 10–15 mm across. Pupation occurs in the gall and the lifecycle takes 50–60 days. The fly is an effective biocontrol agent, taking about two years to reach population levels where every stem is galled. The following year, plants suffer increasing dieback and, by the fourth year after release, effective control of the weed is achieved. The fly is very good at locating isolated plants and seems able to maintain itself on a low plant population. The initial rate of spread, about 60 km in five years or 3–4 km per generation, implies that individual females may fly up to 4 km. Parasitism in Indonesia remains very low (0–5%), even in areas where the fly has been present since 1994. Experience in Indonesia has demonstrated that the gall fly is limited only by a requirement for sunlight or high daytime temperatures (>27°C) for optimal adult feeding, mating and oviposition. Consequently, it does not do well in areas with frequent cloud or mist cover, nor at sites over 900 m altitude, unless the area has particularly warm and sunny days. The fly survives the dry season well, diapausing as fully-grown pre-pupal larvae in the galls. When the rains come and plant growth recommences, the larvae respond to the increased sap flow by cutting an emergence window and pupating, emerging as adults 11–14 days later. Unfortunately, dry season fires will destroy the diapausing larvae in the galls.

New agents

South African researchers continue to discover and host-test new agents from South and Central America. A leaf-mining fly *Calycomyza eupatorivora* has been tested and found to be completely safe, and will be released in Papua New Guinea shortly. A stem-boring weevil *Lixus aenulus* has also been tested and should be released in South Africa shortly. A root-feeding chrysomelid *Longitarsus horni* is being studied and host-testing will start soon. All of these agents would be safe for release in East Timor, and might be effective in very dry areas where the gall fly may not be sufficient.

Conclusions

Chromolaena is now abundant and widespread in many regions of East Timor, where it has a negative impact on cattle and goat production. It is threatening biodiversity and the environment in the natural grasslands, both the *Eucalyptus alba* savannas and the grasslands of the Los Palos district, in East Timor. In slash-and-burn agriculture, it may be of value, as its abundant leaf fall breaks down rapidly, thereby maintaining soil fertility. It is easier to remove when preparing soil for cultivation than are *Imperata* or other grasses. On denuded slopes, it may help reduce soil erosion, although probably less so than the grass cover it replaces. In both situations, use of legumes such as *Leucaena* is preferable, as these increase soil nitrogen as well as provide fodder for cattle or goats.

Biological control using the gall fly is therefore recommended. There will be a lag of at least four years in each village or district between the introduction of the gall fly and the first reduction in *Chromolaena*. During this time, the villagers can adopt a program of planting *Leucaena* to replace *Chromolaena* as the fallow plant. Initial releases should be made in areas of natural grasslands and *Eucalyptus* savanna, where there will be no negative impact and where the villagers are in favour of control of the weed.

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Recommended proceedures

- In accordance with the FAO Guidelines, the Minister of Agriculture, Forestry and Fisheries of the Republica Democratica de Timor-Leste would officially approve the importation into East Timor and subsequent releases of the gall fly *Cecidochares connexa*. A copy of the approval letter would be sent to the plant quarantine personnel at Dili Airport.
- Two or three suitable release sites would be chosen. These should be accessible by road, below 500 m altitude, and in areas where the dry season is not too long. Sites should have large infestations of *Chromolaena*, and be in areas where the villagers and MAFF staff wish to control it and are supportive of the program.
- Collections of galls would be made in West Timor, where the gall fly is common in all areas below 800 m altitude from Kupang east to at least Soe and possibly much further east, by MAFF staff, with the assistance of UNDANA staff who are now experienced in re-distribution of the gall fly
- The galls would be taken to the selected release sites and distributed among the *Chromolaena*.
- This process can be repeated in subsequent years.
- Once galls are abundant on the *Chromolaena* at the release sites (usually two years after the first release), MAFF staff can collect galls for redistribution into new areas. Some training in procedures will be required to ensure galls are not wasted.
- When the gall fly begins to spread significantly, probably four to five years after the first releases, a program should be developed to plant *Leucaena* to replace the *Chromolaena* as a fallow plant and for erosion control.

Acknowledgments

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Forestry — for economic, social and environmental benefits

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Abstract

Much of the landscape of East Timor is covered by early successional forests, where swidden cropping is widely practised. These forests, although often in a degraded state, provide a range of economic benefits, supplemented by relatively small areas of exotic plantations, primarily teak. Products include sandalwood, timber for construction purposes, fuel and honey. Forested lands also provide environmental benefits including catchment protection and mitigation of soil erosion, while shade trees are part of the vitally important coffee production system. Several important tree species, which are indigenous to East Timor, for example, sandalwood and *Eucalyptus urophylla,* represent sources of germplasm of major international significance. The remnant native forests, regrowth and planted forests each provide opportunities for increased wealth creation and social and environmental benefits. In this contribution, starting points for new directions in forestry are indicated and suggestions for the enhancement of existing management and utilisation practices are made.

Introduction

EAST TIMOR is a mountainous island situated between latitude 8°S and 10°S with a highly seasonal rainfall pattern. The island's vegetation, which was originally dominated by forests, has been much reduced and modified during the more than four centuries of European colonial influence and the recent occupation by Indonesia. A brief summary of the geophysical and biophysical environment of East Timor was recently provided by Carter et al., 2001. It has been estimated (Monk et al., 1997) that only 15% of the natural forests remain. Early successional forests occur over much of the landscape, where swidden cropping is the main agricultural system, mixed with introduced exotic woody species, weeds and grasses. The remnant forests and areas set aside for regeneration and planted trees have the potential to provide products for local consumption, fuel and energy, to generate income for village communities and in the longer term to diversify export earnings (Atkinson, 2002). In this brief article, a summary of current and potential benefits from forests in East Timor is presented and some options are explored for new directions and changed emphases in forest management and product generation. Finally, several "next step" suggestions are made in the context of the theme of this conference.

Forests as an economic resource

Historically, the prime aim of forest operations in East Timor has been the extraction of *Santalum album*, the most valuable sandalwood species, which occurs naturally throughout the island. A comprehensive review of the current knowledge of all aspects of management of this and other commercial sandalwood species is given by Doran et al. (2003). The future of sandalwood as a forest resource in East Timor is difficult to predict as few efforts have been made to manage trees to optimise oil production in natural stands and plantation cultivation has not so far been practised on the island. Sandalwood oil is formed only in the heartwood of these slow-growing trees. Haffner (1993) reported that heartwood initiation in *S. album* in East Timor varied from 14–46 years, so careful management is essential for long-term viability of such a valuable resource which has a current world price in excess of US$23,000 per tonne (Atkinson, 2002). It is generally agreed that the

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sandalwood resource of East Timor has been grossly exploited during the last few decades, with small diameter trees being taken and roots excavated. Even if the most conservative practices are followed, sustainable management of native sandalwood is unlikely to be achieved. Atkinson notes that although significant resources of sandalwood exist in the Bobonara District, it was sold during the Indonesian occupation to Chinese smugglers for US$2.0/kg and that this trade is probably continuing after independence.

The preferred species being grown for sawn timber and round wood is teak (*Tectona grandis*). Although not indigenous, this species is well adapted to climatic and edaphic conditions in East Timor and was introduced during the colonial era to many parts of the Indonesian archipelago. A recent estimate of the teak resource (Atkinson, 2002) puts the plantation area at around 2000 ha. These stands could yield valuable round wood from thinning operations in about 25 years, with good quality sawn products after a further 25 years. *Eucalyptus alba*, an indigenous species which is common on lower slopes on the drier northern coast of the island, is a primary coloniser after clearance or fire. This species, which coppices very strongly after felling or lopping, has an important role in providing poles for house construction and fuel.

Non-wood forest products are increasingly recognised for their economic and social value, especially for village and isolated communities. In East Timor 'sacred forests' have been features of national culture and have played an important part in the conservation of the few remaining pockets of native forest. It is likely that forests were, and are, used for a range of food and medicinal products but very little is known regarding the extent of their collection and use. The knowledge base exists in local communities and needs to be catalogued before effective management options can be designed and implemented.

East Timor is the custodian of a unique forest resource, by virtue of its status as the largest provenance source of germplasm of *Eucalyptus urophylla*. This species is one of the few eucalypts not indigenous to Australia and is one of the most important forest plantation species in the tropics worldwide. The highly productive *E. grandis* × *urophylla* hybrids, which are widely grown in Brazil, attain annual increment rates of more than 60 cu m and are the basis for a very successful pulp and paper industry.

Although several seed collecting expeditions to East Timor have been mounted in the past, there is inadequate knowledge of native stands, their location, conservation status and long-term security.

Honey is one of the better-known non-wood products emanating from forests. Protection of large trees with a timber volume of more than 12 cu m has recently been enacted in East Timor as a means of ensuring sites for hives.

Environmental benefits from forests and plantations

Trees provide a wide range of environmental benefits including catchment protection, slope stability and reduction of soil erosion. The widespread deforestation of East Timor, highly seasonal rainfall patterns, swidden agriculture and overgrazing have contributed to landscape degradation which must be arrested, if not reversed, by improved land management. Tree planting and management of regrowth of deep-rooted species have the capacity to contribute to improved landscape management. In addition, tree plantations can be incorporated into rural economies to provide shade for those garden and plantation species that thrive best in reduced light and as small plantations on farms. The widespread use of *Paraserianthes falcataria* as the preferred shade tree for coffee has made this a vital component of the landscape in the major coffee-growing areas of East Timor. Plantations of selected, site-adapted tree crops can provide commercial products and land protection on more difficult (dry and low nutrition) sites where other forms of crop production may increase land and water degradation. The integration of trees into agricultural systems in other countries has produced significant socio-economic and environmental benefits that should be reproducible in East Timor.

The familiar sight of street traders selling small bundles of firewood in Dili and other small towns provides a clear example of environmental benefits from tree products. The popularity of wood fuel partially reflects the impact of increased oil prices on an impoverished society, but has the benefit of switching from a fossil fuel to a greenhouse-neutral energy source. Management of such resources is crucial to avoid overexploitation of forests close to population centres. In the longer term the fuel-wood option could be further explored, as new technologies make it possible to fuel highly efficient turbo generators, using gasified wood, and generate electricity for use by remote communities (Fung et al., 2000)

New directions for forest-based benefits

Management of natural forests

East Timor is fortunate, with internationally recognised forest species including *S. album, E. urophylla, Pterocarpus indicus, Casuarina junghuhniana* and *Tamarindus indica* occurring naturally. Also, the common occurrence of *E. alba* close to the main population centre offers management opportunities. The very high value of *S. album* merits long-term management strategies, including plantation establishment, with conservation as a primary aim and cessation of exploitation. Similarly, for indigenous forest species the principle aim should be conservation of native resources. These will be invaluable as sources of locally adapted germplasm for plantation initiatives of the future. Accordingly, there is an urgent need to survey and map the occurrence of these native provenances. Measures are also required to assure their future survival, by protection from overexploitation and by reduction of the risk of contamination from extraneous pollen sources. This particularly applies to *E. urophylla* and *C. junghuhniana* which hybridise readily with related species which may be planted nearby as part of revegetation programs, as fast-growing trees in commercial plantations or as shade trees.

Natural species of cultural or medicinal significance should also be managed for sustainability, although management plans will rely on detailed information on location, biology, use and other elements. In order to get this information, it may be necessary to negotiate agreements covering ownership and use of the genetic materials to protect the interests of local people with knowledge of traditional use. There are internationally agreed protocols and standards upon which these agreements can be based.

Stands of up to several hectares of *E. alba,* such as those bordering the Dili–Ailue road and south of Liquica, offer opportunities for improved management to supply firewood and poles for local use and sale in Dili. It is clear that coppicing is already a common practice and that *E. alba* withstands such severe treatment without losing vigour or succumbing to disease. It should be possible to take this practice and improve the reliability of coppice production e.g. by varying stump height and time of coppicing. Product value could also be enhanced, for example, by the singling of multiple stems and by selection and subsequent propagation of fast-growing individuals. It seems likely that a few simple silvicultural recommendations could considerably increase the value of these stands and their products.

New plantations

Currently, the range of forest plantation species in East Timor is limited to *Tectona*, *Swietenia* and *Cassia* spp. This reflects historical trends and preferences and the presence of infrastructure aimed at processing these species. In addition, *P. falcataria, C. junghuhniana and Leucaena spp*. are grown as shade trees and nurse crops with high-value plantation crops such as coffee, cloves and vanilla.

Over the past two decades, the nature of plantation forestry has changed considerably, not least in Indonesia, e.g. with the advent of very fast-growing tropical acacias grown almost exclusively for fibre. Also, the technologies for converting wood fibre to industrial wood and other products, such as medium-density fibre board, flake board and wood fibre cement board have made great strides. Production of traditional types of wood product such as plywood is being curtailed as native forests are exhausted. Indonesia, for example, will become a net importer of forest products in less than a decade and East Timor, now highly dependent on imported timber, will find it difficult to meet building and reconstruction targets.

A new direction to redress this problem would be the diversification of plantation forestry to a broader range of species with the potential to meet the above demands.

Such an undertaking would need careful planning and matching of species to product range, plus considerable investment in industrial infrastructure. If the aim is fibre board, for example, then the selected species must yield fibre with good compatibility with adhesives. *Acacia mangium*, although fast growing, is proving unsuitable for making cement/wood fibre board, due probably to its high tannin content, whereas *Eucalyptus* fibre is very suitable. Economics will drive such an initiative, however, the costs of plant need not be great. For example, a ‘wood wool’ cement board plant with an output capacity of between 150 and 500 cu m/day, suitable for producing building materials for low-cost housing construction, would require between US$1.8–4.5 million to build and commission. Such a plant would make a significant contribution to urban reconstruction and provide employment.

If the assumption is made that fast-grown wood will be a future need then it is necessary to establish provenance trials of a sufficiently broad range of tree species to match both environmental conditions and product requirements. Such an undertaking would need an expansion and investment in nursery and propagation facilities by MAFF. Suitable fast-grown species could include *Eucalyptus urophylla*, *E. tereticornis, E. pellita, Acacia mangium, and A. auriculiformis.*

In addition to fast-grown forest plantation species a case can be mounted to invest in R&D for the cultivation of alternative high-value species, such as *Pterocarpus, Swietenia* and *Santalum.* This would complement the initiative on farm forestry species instituted by the Portuguese through the nursery operation at Ermera. There is also an urgent need to select replacement species for *P. falcataria* which is

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being severely attacked by the rust fungus *Uromycladium tepperianum*, (see paper by Old and Dos Santos Cristovao, this proceedings). This full range of species, including fast-growing species, high-value trees and shade species, could be grown at a well-equipped and managed nursery on the existing site close to Dili. CSIRO could be available to assist in collection and supply of seed of suitable species and provenance origins and advise on propagation, silviculture, seed stand development and plantation protection from pests, diseases and fire.

The next steps

The following is a list of starting points for new directions as discussed above:

- Inventory of remnant native forests, both within and outside the current reserved areas throughout East Timor
- Identification and protection of high-value resources, e.g. seed stands *of E. urophylla*
- Cultural and heritage assessments, especially of "sacred forests"
- Reconciliation of competing land uses by consultation with local communities
- Location of priority sites for rehabilitation (demonstration sites) of degraded landscapes
- Development of resource protection strategies for grazing animals, pests, diseases and fire
- Selection of native and exotic tree species suited to purposes and products based on experience gained in developing countries in Southeast Asia
- Sourcing of seed of preferred species (indigenous and exotic) for propagation and establishment of seed orchards to assure future supplies
- Establishment of nurseries at strategic places in East Timor
- Identification of priority products for East Timor and appropriate utilisation methods
- Products and market analysis for future investment in forest-based products
- Policy and regulation to protect forest resources, encourage investment and assure wellbeing of forestry and mill staff.

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A rust epidemic of the coffee shade tree (*Paraserianthes falcataria*) in East Timor

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Abstract

During the past two years a very damaging disease has affected *Paraserianthes falcataria* (formerly *Albizia falcataria*), the tree most commonly grown in East Timor to provide shade for coffee plantations. A taskforce established by the Department of Agriculture and Forestry of East Timor in 2001 found that 67% of the total coffee plantations, across all eight districts where the crop is grown, were affected. The district of Ermera, which accounts for more than half of the total coffee-producing area of the country, was one of the most severely affected regions.

The disease is caused by *Uromycladium tepperianum*, a rust disease known to affect only acacias and *Paraserianthes/Albizia* spp., resulting in the formation of galls on foliage and branches. So far it appears that the strain of the fungus causing damage is restricted to *Paraserianthes*. The pathogen attacks all above-ground parts of susceptible hosts, however damage is most severe when shoots and branches are affected, as these are girdled by the rust and secondary invading insects and saprophytes which invade galls. As shoots are partially girdled and come under severe stress, massive defoliation of the tree crowns occurs and, eventually, large trees can be killed.

The loss of shade is expected to result in significant reduction in coffee yield and is promoting weed invasion on an unacceptable scale. Shade-tree crown components and, eventually, whole trees are dying and falling branches and wind-thrown trees will damage the coffee. Falling branches will create very dangerous conditions within the plantations and along sections of highways, which are overhung by heavy limbs.

No practicable remedial measures can be recommended to restore the health of standing trees. The likely solution will be to remove severely affected shade trees from plantations, replant with alternative shade species or rust resistant selections of *P. falcataria* and probably replant the coffee. Expert opinion quoted in a recent survey of the coffee sector in East Timor has indicated that virtually all the coffee plantations in East Timor would benefit from replanting. In the longer term, therefore, some positive benefits will flow to the farmers and the industry by the provision of an opportunity to replace coffee plantations with improved cultivars.

Background

COFFEE is East Timor's major export and the approximately 45,000 ha of plantations provide partial support for an estimated 45,000 families. It is by far the main source of cash income for these families and the decentralised nature of the industry makes it a mainstay of the rural economy of five of the western districts of East Timor. A coffee survey was conducted in May 2001 with World Bank support (Braz and Cristovao, 2001). Results indicate that an average family, participating in coffee growing, earns about US$200 per year from coffee sales (about 90% of its cash income). The current world commodity price of coffee is depressed, the farmgate price for dried Arabica beans has fallen from 8600 Indonesian Rupiah/kg in 1988 to Rps 4300 in 2000. Even allowing for currency fluctuations this fall has had a negative impact on coffee growers although there is a trend for premiums to be attached to quality and organically grown coffee is set to have a valuable market niche.

Coffee is grown using a shade tree system often on very steep sloping terrain. The main shade trees

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being used are *Paraserianthes falcataria* (formerly *Albizia falcataria*), commonly called madre de cacau, and *Casuarina junghuhniana.* In the principal coffee growing districts of Ermera and Liquica visited during this consultancy, *P. falcataria* was the only shade tree being used on any significant scale (Fig.1).

Figure 1. Coffee growing under *Paraserianthes falcataria*.

During 1998–2001, *P. falcataria* has become widely infected by a rust disease that has attacked shade tree plantations, especially in the Liquica and Ermera districts (Figs 2 and 3). The time of the initial outbreak has not been recorded but the condition of the worst-affected plantations suggests that the fungus has been present for at least five years. A task-force report prepared by the Forestry and Plantations Division, Ministry of Agriculture and Fisheries (Anon., 2001) provides a very good summary of the status of the disease, an indication of the levels of impact in coffee-growing districts and a list of recommendations. The report estimated that 67% of coffee plantations in East Timor were affected by the disease. Both the distribution of the disease and its severity can be confidently expected to have increased since that time.

Figure 2. Lightly infected crown showing spreading canopy.

Figure 3. Tree with total defoliation and many galls.
Photographer: Ken Old

The pathogen

A preliminary identification of the causal agent of the disease as *Uromycladium tepperianum* in the taskforce report (Anon., 2001) has been confirmed by microscopic examination of fruiting bodies collected in the three localities visited during the consultancy. Only two *Uromycladium* species are known to result in massive gall formation on woody shoots and other affected plant parts of acacias and *Albizia/Paraserianthes* spp., namely *U. notabile* and *U. tepperianum* (Figs 4 and 5), (Old et al., 2000). These fungi can be distinguished by the morphology of their sexually produced teliospores, the teliospores of *U. tepperianum* having radially oriented ridges (Fig. 6). In addition, no asexual urediniospores have been reported for *U. tepperianum,* whereas these are produced early in the fruiting season by *U. notabile*. So far all reports of *Uromycladium* sp. on *Paraserianthes* appear to have been attributed to *U. tepperianum.*

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Figure 4. Globose galls formed on infected branches.

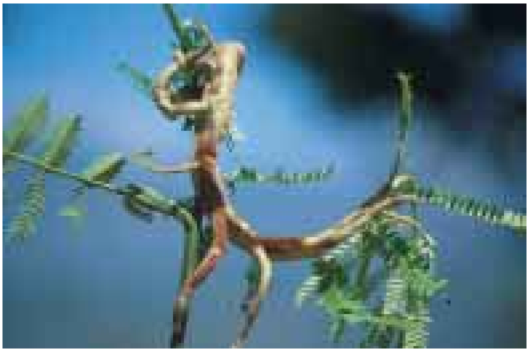

Figure 5. Elongated galls formed on foliage.

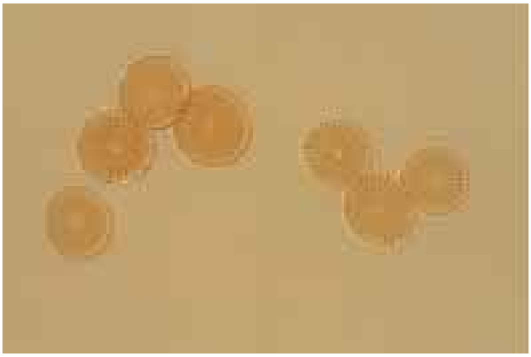

Figure 6. Spores with radiating ridges characteristic of *Uromycladium tepperianum*. Photographer: Ken Old

Potential remedial measures for standing trees

Despite the value of standing trees to coffee growers, no remedial measures can be recommended. The current level of inoculum is very high and all trees will be exposed to infection. Each of the possible remedial measures is considered in turn.

Eradicate the disease from infected plantations and other locations by lopping branches from lightly infected trees

This will not be practical. *P. falcataria* shade trees are often very tall and spreading in habit and such operations would be very dangerous and expensive. The species is also common in the landscape arising from seed cast by plantation trees or planted around dwellings. Also, the disease has a latent period from infection to symptom development so it would not be possible to remove all affected branches. Eradication of the disease, therefore, will not be possible, as further trees will succumb to infection. As felling and tree removal are very expensive, this could only be envisaged in coffee plantations leaving roadside trees and volunteer trees in other sites as a source of infection.

Remove dead and dying trees

This may have to be done in the long term due to safety concerns and to replant new shade trees and coffee plantations. Costs will be great and erosion damage will be severe on steep slopes, which are characteristic of many coffee plantations.

Systemic fungicides to kill the pathogen

Even if a suitable chemical could be identified, a major R&D program would be needed to develop such a control measure. As this is a systemic disease persisting in woody stem tissue, complete control would not be possible. Chemical control would be very expensive, would carry risks of polluting the environment, affect non-target fungi and resistant strains of the target pathogen could arise. East Timor coffee would lose its market niche as an organic product.

Biocontrol using antagonistic fungi such as Penicillium or Acremonium spp.

This was suggested by the taskforce team as a possible means of control. Although such an approach may be possible for some crops and pathogens it would be neither practical nor reliable for the *Paraserianthes* rust epidemic in East Timor. Such an approach would require a major program to find possible agents and develop delivery systems to treat the crowns of 20–30 m high trees. The chances of failure would be high. The colonisation of older galls by insects and fungi is already going on and is probably already reducing the inoculum load on trees to some extent. Such naturally occurring biocontrol may increase over the next few years and exert some beneficial effect without any attempt at manipulation.

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Let the disease take its course

The rust outbreak may subside to some extent over the next decade due to insects and fungi naturally colonising the galls, however the level of damage to existing trees will be very high. The incidence levels in the plantations, e.g. 90% plus of trees affected in older outbreaks in Liquica, suggests that the *Paraserianthes* currently being grown in East Timor has a very limited level of resistance to rust with very limited opportunities for natural selection to operate.

Impacts on plantations

Uromycladium tepperianum has the potential to severely damage plantations of susceptible hosts. An outbreak in Sabah (Anon.,1993) has been partially responsible for reduced interest in planting of *P. falcataria*, similarly, incursion into New Zealand by the closely related *U. notabile* resulted in plans to establish *Acacia* plantations as the basis for a tannin extraction industry being abandoned (Dick, 1985). In South Africa, *U. tepperianum* has been successfully introduced as a biocontrol agent for *A. saligna*, an introduced Australian species that has become a major weed problem (De Selincourt, 1992).

In East Timor, the level of damage to *P. falcataria* at both stand and individual tree levels is very high. In the taskforce report, the three districts of Ermera, Liquica and Manufahi were the most badly affected and percentage crown infection on a tree basis was between 57 and 90%.

Almost all the fine branches in many tree crowns bore galls and have died, shedding leaves from the canopy (Figs 2 and 3). In badly affected stands the disease appears to have already gone through one or more cycles of crown recovery with epicormic shoots in some trees constituting the total leaf biomass. The epicormic shoots, in turn, are likely to become infected, resulting in carbon deprivation, extreme stress and death of trees.

Other trees may survive but with reduced crown area and may not provide enough shade to maintain coffee yields. More information is needed on the rate of disease development in individual trees and stands and the onset of secondary invasion by fungal pathogens and boring insects that will hasten the death of large trees. A secondary effect of crown thinning and tree death is to allow the invasion of coffee plantations by weeds, especially vines and other woody species, which compete with the coffee and must be hand-removed.

Despite the very high level of defoliation, limited sampling of trees with severe crown symptoms in April 2002 indicated that they were alive with functional phloem and sapwood and some capacity for recovery. Indeed, it is possible that some trees will recover and the outbreak may remain worse in some areas than others but the outlook for the future of existing trees appears poor. There are several examples of newly introduced diseases virtually wiping out tree populations, even including native stands (for example chestnut blight and white pine blister rust in North America). *P. falcataria* currently growing in East Timor seems to be very susceptible to rust and the prognosis must be for widespread tree death.

Sources of inoculum

The severity of damage, the absence of reports of this conspicuous disease prior to a few years ago and the high disease impacts in a wide range of age classes, including trees more than 50 years old and 30–35 m high, are very strong indicators that *U. tepperianum* has only recently been introduced into East Timor. Reports of the fungus in the literature are most commonly on *Acacia* spp., however there are reports of the pathogen on *Albizia/Paraserianthes* from Sabah (Anon., 1993), Papua New Guinea (Shaw, 1984) and the Philippines (Braza, 1997).

At the outset of this consultancy it was considered possible that the pathogen could be the same as that on acacias, in which case Australia would be the most likely source of inoculum. However, inspection of roadside acacias at several locations, e.g. Liquica, Armera and Ailue, failed to find any rust infections on *A. auriculiformis* and *A. mangium*. At the latter location very heavily infected *P. falcataria* was nearby. The taskforce team also reported that the rust was found only on *P. falcataria*.

The likelihood is therefore that race specialisation exists in the pathogen with some strains infecting only *P. falcataria* and others specialised on acacias. Detailed DNA studies of populations of the fungus from a wide range of localities and hosts could throw some light on the possible origins of the incursion. Cross-species susceptibility between *Paraserianthes* and some acacia species is still a possibility, but this genus appears to be poorly represented in the landscape, compared to Australia. Cross-species infection to other genera is highly unlikely.

For the foreseeable future, the widespread use of *P. falcataria* as the ‘madre cacau’ will ensure the continued availability of inoculum to sustain the epidemic. Also, the common presence of the species elsewhere in the landscape will assure the disease as a major problem for the cultivation of *P falcataria*.

Alternative shade tree species and selection of resistant *P. falcataria*

There are many and varied cropping systems that incorporate coffee worldwide. These systems vary according to the presence of shade, management and planting densities and many other factors. It may be grown in monocultures or mixed cropping systems in which coffee is but one component of a shrub layer. Among the conclusions of the Task Force report (Anon., 2001) are recommendations to seek alternative shade species and to select and propagate resistant *P. falcataria*.

The choice of shade also varies, temporary shade being provided by a variety of species and permanent shade, where this is used, by a range of tree species of which *P. falcataria* is but one. The taskforce suggested several alternative species including *Erythrina suburbrans, Casuarina equisetifolia, Leuceana leucocephala, Gliricidia sepium* and *Samanea saman.*

Selection of rust-resistant *P. falcataria* is another option, although this does not seem to have been attempted before. Two factors may be taken to indicate potential for this being a viable alternative.

Firstly, the impact of rust on *P. falcataria* in East Timor has been very severe and widespread in many stands. Within these stands, little between-tree variation in impacts could be discerned. In contrast, where this pathogen occurs in native acacia stands in Australia, there is typically considerable between-tree variability in the numbers of galls present. Some trees are very heavily infected and may be killed. Others bear many galls but carry reasonably heavy crowns, and yet others show little evidence of infection despite being close to heavily infected individuals. This suggests that genes for resistance to the rust exist in the host trees and their presence is a major factor in determining disease impact. Such genes occur in other rust–tree combinations, for example western gall rust of radiata pine caused by *Endocronartium harknessii* (Old et al., 1986), and phyllode rust of acacias caused by *Atelocauda digitata* (Old et al., 1999) In studies of these host–pathogen systems we have found variation in resistance at the provenance, family and clonal level and this may well exist in *Paraserianthes* with respect to *U. tepperianum.*

The second factor, consistent with the uniformly susceptible reaction to rust infection, is that the genetic base of the *P. falcataria* grown in East Timor may be very narrow.

Paraserianthes falcataria is not indigenous to East Timor, the several sub species being native to the Moluccas, Papua New Guinea, the Bismark Archipeligo and the Solomon Islands. Furthermore, the species has been cultivated extensively for many years, without catastrophic disease outbreaks, for example as a timber production species around Yogyakarta, Indonesia. It seems likely that the original introduction of the species by the Portuguese colonists may have consisted of a small quantity of seed, possibly from very few mother trees. From such an introduction, the rest of the trees grown in East Timor have probably been derived. Although the above is speculation, molecular technologies can test such a hypothesis.

It would be possible to import a structured sample of *P. falcataria* germplasm from the species' native range in the Solomon Islands, Papua New Guinea and eastern Indonesia for field testing in one or more high disease impact sites in coffee areas, to determine whether there are disease-resistant genotypes.

Management strategies to reduce rust impacts

As indicated above, and in broad agreement with the findings of the taskforce, management strategies fall into three categories:

1. Assessment of the impacts and progress of the rust epidemic, especially in regard to crown damage and tree mortality so that, where necessary, salvage logging can be carried out. Decisions can then be made on those coffee plantations that can be rehabilitated and those that will need to be replanted.
2. Selection of alternative tree species that can be planted during rehabilitation or replanting of affected plantations.
3. Selection of resistant *Paraserianthes falcataria*.

Impact assessment

Where the disease has already resulted in significant numbers of dead trees, felling shade trees and replanting with alternative shade tree species is clearly a priority. It is, however, essential to systematically assess the current condition of selected plantations in each of the main affected coffee-growing areas and to derive baseline data on which the progress of the epidemic can be assessed. Plots need to be established and assessed at three-monthly intervals for at least two years with records being kept of crown condition, evidence of crown recovery, crown dieback and tree mortality.

Records would be kept on a stand and individual tree basis by trained observers using agreed criteria. Such data could then give a means for estimating the likely impacts of the disease across the whole East Timor coffee estate and for planning rehabilitation or replanting of individual plantations with both coffee and shade trees.

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Where salvage logging is to be carried out, advice will be needed on minimising disturbance and erosion on difficult steep sites. Only simple equipment, such as axes and perhaps chainsaws, will be available, unless a large investment in specialised equipment in the hands of contractors is made. As the removal of trees will be expensive, any possible value-adding through wood utilisation must be sought. Trees close to roads could be felled and logs extracted for local sawmilling. The species has very light, soft wood that is not suitable for outdoor or structural applications. In Indonesia, the timber is used for making rough furniture, and internal cores of plywood doors. Defect-free sawn timber can only be obtained if trees can be harvested alive. Standing dead trees are rapidly invaded by saprophytic fungi and stem-boring insects. Even if large stems are removed from the site of salvage operations, large volumes of branch wood will remain to interfere with subsequent planting operations and it may be necessary to burn this coarse woody debris on the site.

An adaptive management approach is needed whereby information, on the severity of the epidemic, rate of mortality and improved knowledge of site clearing and rehabilitation methods, can be rapidly incorporated into practice.

Alternative species

Currently the only species, apart from *P. falcataria*, used to provide shade for coffee plantations in East Timor is the native *Casuarina junghuhniana*. Of the several species recommended by the taskforce, *C. junghuhniana*, *Leucaena leucocephala* and *Sesbania sesban* seem to be prime candidates. Although *C. equisetifolia* was recommended by the taskforce, experience suggests that it is unlikely to perform well above 700 m. It would be important to obtain cultivars of *L. leucocephala* resistant to the leucaena psyllid, *Heteropsylla cubana*. An example is the advanced-generation hybrid KX2 between *L. leucocephala* and *L. pallida* (Hughes, 1998).

Other potentially useful shade species include *Casuarina oligodon* and *Grevillea robusta* (both suitable for high elevation sites at altitudes greater than 1000 m above sea level). Ideally, several alternative tree species will prove to be useful and can be matched to site and environmental parameters, thereby avoiding future reliance on one or two species to provide shade for coffee plantations.

Seed of the different species for evaluation in East Timor, and guidelines for raising the different species and establishing field trials could be provided by CSIRO's Australian Tree Seed Centre via the 'Domestication of Australian Trees' project (http://www.ffp.csiro.au/tigr/atscmain/whatwedo/projects/dat/index.htm).

Selection of rust resistant *P. falcataria*

The suggested approach would be to assemble a range-wide collection of seed from the natural populations of *P. falcataria*. From each natural population a number of unrelated mother trees would be collected. This would provide a comprehensive sample of the gene pool of the species, likely to encompass any genetic variation in disease resistance. If resources do not permit a comprehensive collection from natural stands, then attempts should be made to obtain, through networking with other institutions in Indonesia, Malaysia, Papua New Guinea and the Solomon Islands, representative samples of seed with as much information as possible attached as to their origin.

Selection for rust resistance would be done concurrently with selection for other required traits (vigorous growth and good survival under East Timorese conditions) by planting seed in two or more replicated provenance trials. Each trial would occupy about 2 ha of land. With the cooperation of farmers, it may be possible to establish trials over existing coffee plantations where the cover of *P. falcataria* has been lost to disease. It would be essential to have a reliable source of inoculum to 'challenge' the newly introduced material. Mature *P. falcataria* trees with large numbers of viable galls in their crowns would be retained in the immediate vicinity of the trials to provide inoculum. Differences in disease resistance would become apparent very soon after planting the trials, possibly within one year and reliably within two years from establishment of the trials.

Depending on the characteristics of the germplasm included in the design, the trials would provide information on provenance variation in rust susceptibility, as follows: whether significant differences in rust resistance occur in the species and what form this takes, e.g. fewer, smaller galls or no disease; and whether some provenances contain more rust-resistant individuals than others.

By culling out highly susceptible individuals and retaining resistant individuals, such a field trial could be converted to a seed production area and provide seed with good rust resistance and other silvicultural qualities for decades to come.

Acknowledgments

We would like to acknowledge the assistance provided by colleagues at the Department of Agriculture, Fisheries and Forestry, East Timor during a consultancy visit by K.M.Old on behalf of AusAid. Dr Chris Harwood CSIRO provided essential advice on alternative shade tree species. Thanks are also given to Ms Ruth Gibbs for her expert assistance in preparation of illustrations.

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The role of livestock in the development of East Timor — constraints and potential

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Abstract

This paper outlines the constraints to livestock production in East Timor, specifically with regard to production systems for village chickens and poultry, small ruminants, large ruminants and pigs. As well as being a source of income and animal protein, livestock fulfil a vital social and cultural role in the community. They can be used as a 'living bank' to be sold when income is needed and also traded as a type of currency. The paper describes the three major systems of livestock production and outlines the constraints and appropriate technologies for each of them. Most of the technology needed to improve the livestock sector of East Timor is already available, but unless farmers are involved in the evaluation and selection process they may not want to adopt the technology.

Introduction

THE background to the livestock sector has been outlined by Cesar da Cruz in these proceedings. This paper focuses on the production systems, the constraints to improving those production systems, and some ways that these constraints may be overcome through the adoption of appropriate research and technology. The scope of the paper will be limited to production systems based on village chickens and poultry, small ruminants, large ruminants, and pigs.

Livestock are very important in the lives of the East Timorese people. However, many animals were killed or lost in the independence crisis of 1999. It is now very important that the numbers and quality of livestock are increased to improve the welfare of village people and rehabilitate the rural sector. Livestock are not only used as a source of income and animal protein, but they also fulfil a vital social and cultural role in the community. Livestock have the potential to lift the income of the poorest of the rural community. One reason for this is that livestock (especially goats and cattle) can be used as a 'living bank', to be sold when needed. They are also traded as a type of currency. Livestock may also complement other agricultural activities, as a sideline. Landless people may benefit through the raising of small livestock such as goats and poultry.

Livestock are raised under three major systems:

Scavenging around villages. This applies particularly to pigs, goats and poultry. These animals harvest waste material, scraps, dead leaves, insects, and convert them into very valuable animal protein for human consumption as well as supplementing farmer income.

Utilisation of agricultural by-products. This applies more to ruminants (cattle, buffalo, sheep, goats). These animals consume rice straw and other agricultural by-products. They also graze on rice fields after harvest to pick up any leftover material and weeds. They perform the useful task of converting these waste materials into valuable animal protein for human consumption or supplementing farmer income. Livestock are often integrated into the agricultural system where they may also be used for draught animal power (and manure used for fertiliser).

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Utilisation of non-arable land. Horticultural production or cropping produces more food or income per area than animal production. Therefore, arable land should be used for cropping (perhaps integrated with animal production as in the first two systems). However, large areas of East Timor are not suitable for cropping, and these areas could be used for grazing.

The productivity of livestock in East Timor is generally considered to be low. However, this animal production is achieved with very little input, so the overall system may, in fact, be quite efficient.

Livestock production systems

Village poultry (see Fig. 1)

Constraints to the village poultry system

- Poultry have to be free ranging if they are to effectively scavenge for food. This activity exposes them to predators such as dogs, and makes vaccination more difficult. There may be a high death rate in young and adult birds due to Newcastle disease, lack of food, and predation
- Poultry raising may not get much attention because farmers have other activities in an integrated farming system
- Poultry may be difficult to handle for procedures such as vaccination because they are free ranging
- The free ranging nature of village poultry production enables the spread of diseases from group to group
- Up to 60% of young chickens die. This loss is exacerbated through fewer eggs being available for sale or consumption by the family since nearly all eggs are needed for replacement.

Appropriate technology for the village poultry system

- Improved vaccines and delivery systems
- Improved feeding system utilising locally available materials
- Housing and husbandry system to minimise deaths of adults and chickens — this might involve housing poultry at night.

Village pigs (see Fig. 2)

Constraints to the village pig production system

- Small litter size
- Do not cycle during lactation
- High piglet mortality
- Slow growth rate for piglets
- High adult mortality due to many factors, including disease, theft, and accidents
- Poor quality meat — may be too fat, thin, or old
- Diseases such as swine fever
- Traditional approach to raising pigs. Farmers may not sell animals at the optimum time for profit, but wait until there is a cultural need or festival.

Appropriate technology and research

- Alternate feed sources for breeding and lactating sows
- Farrowing pens to reduce piglet mortality
- Housing and husbandry system
- Control and prevention of disease
- Control feeding to produce lean meat

Large ruminants (cattle and buffalo) (see Fig. 3)

Constraints to cattle production

- Low reproduction rate expressed as low calving percentage, long intercalving interval, or low weaning percentage
- Low milk production
- High mortality in calves
- Slow growth rate of young cattle
- Poor quality meat products
- Damaged and degraded grazing land
- Poor quality grasses (such as *Imperata cylindrica*)
- Degradation of grazing land through overgrazing and invasion of weeds
- Diseases such as brucellosis and haemorrhagic septicaemia.

Appropriate technology for the village cattle system

Most of the constraints listed above are due to environmental effects and poor nutrition during the long dry season. However, in an extensive grazing system, the opportunities to improve the management system are limited to techniques such as:

- Manipulating the mating season so that calves are born at the best time for feed supply and cow milk production. This requires the control of animals (especially bulls) through effective fencing
- Early weaning (and supplementation) of calves may alleviate nutritional anoestrus in the cows, however, research is needed to determine the optimum time to wean calves
- Removing (selling) appropriate animals from the herd at the optimum time can be used to manage the herd structure, as well as maximising income to the farmer. More research is needed to establish the optimum herd structure and numbers.
- Increasing the supply of feed, especially during the dry season and for vulnerable animals such as lactating cows. This may include fodder trees and feed conservation.
- Control and prevention of diseases, especially brucellosis.
- Development of a marketing system.

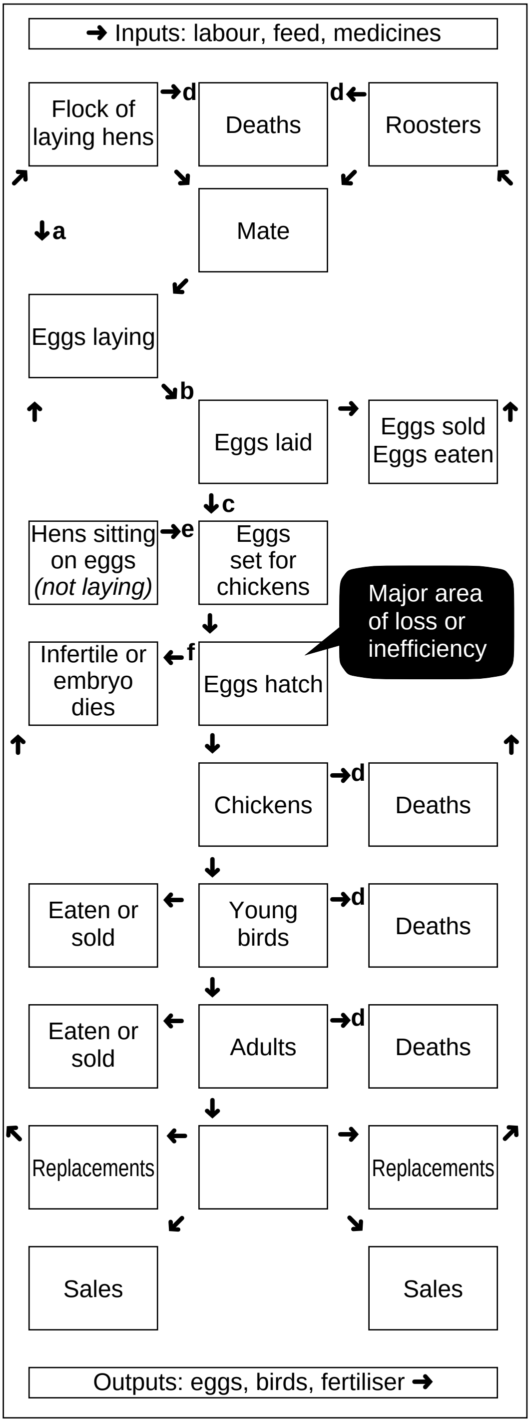

Figure 1. Village poultry production system.

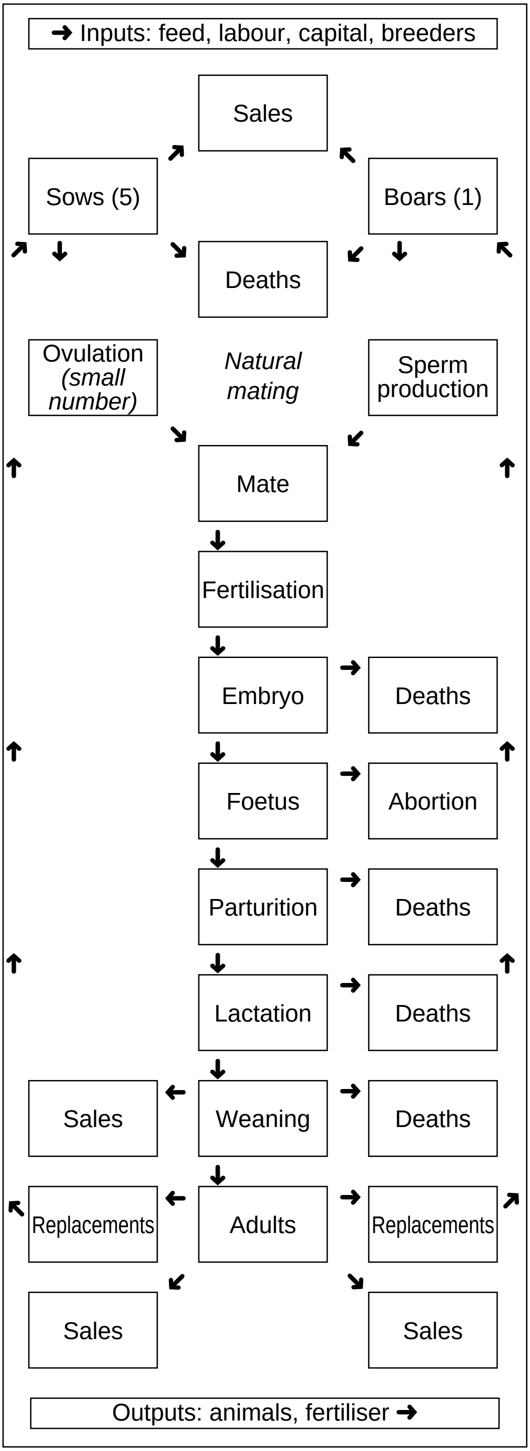

Figure 2. Village pig production system.

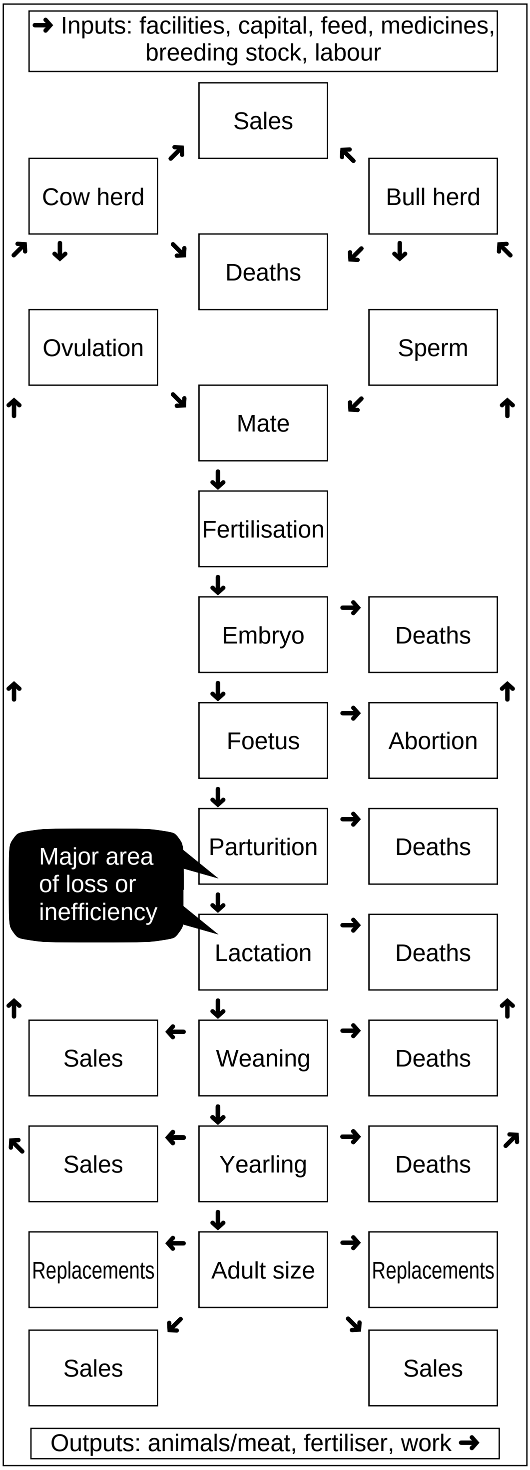

Figure 3. Cattle production system.

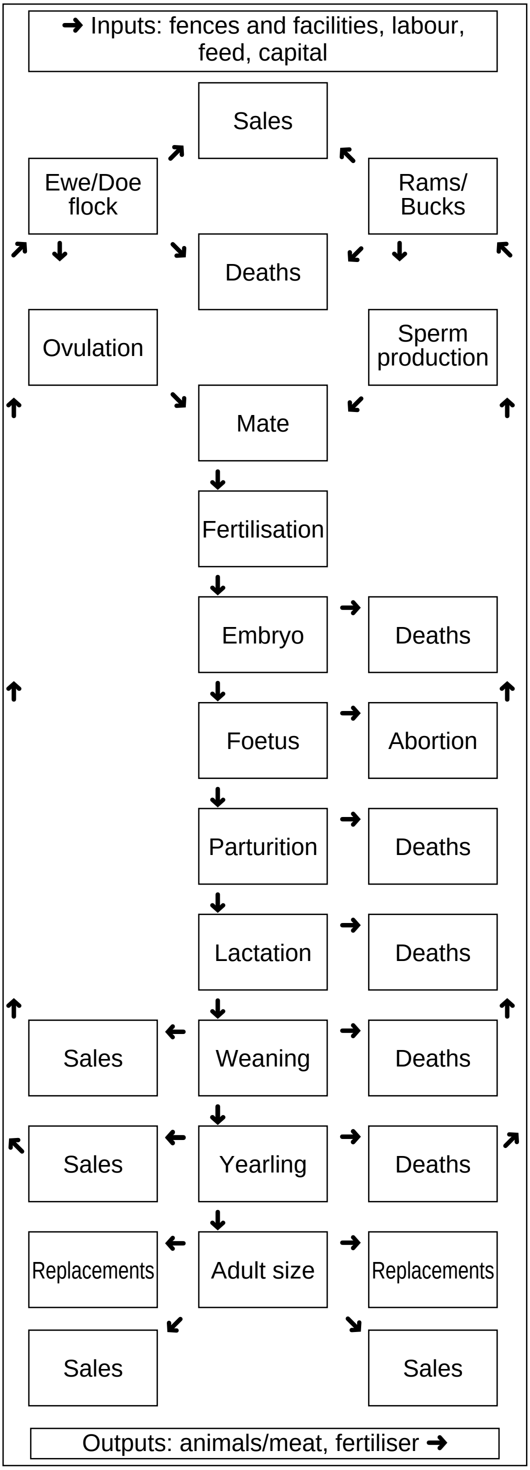

Figure 4. Small ruminant production system.

Small ruminants (sheep and goats) (see Fig. 4)

Constraints to small ruminant production

- Small body size
- High death rate of lambs and kids
- Destruction of grazing land
- Diseases such as scabies

Appropriate technology for the village sheep and goat production system

- Improved meat quality through genetics and nutrition
- Disease control
- Marketing system.

General conclusions

Adoption of technology. Most of the technology needed to improve the livestock sector of East Timor is already available. The technology needs to be evaluated, selected, and, where appropriate, recommended for adoption. However, unless farmers are part of this evaluation and selection process, they may not want to adopt the technology. Much research has been done, but very little has benefited the rural community. Smallholders and their advisers should consider these questions:

- Is there a problem and how important is it?
- Do farmers consider this problem to be important enough to want to do something about it?
- How have other farmers overcome this problem in other areas? Is there technology available to overcome the problem?
- Is the recommended technology compatible with normal farmer lifestyle and culture?

Marketing system. One reason for lack of adoption of technology is lack of capital. Some of this capital could be generated by providing farmers with a good, reliable, fair marketing system.

University education for the agricultural development of East Timor

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Abstract

The agricultural sector remains the dominant component of East Timor's economy and its importance demands a range of educational services in agriculture at primary, secondary, tertiary and adult levels to build capacity in the sector. University undergraduate teaching in agriculture is based on the previous Indonesian curriculum which is fragmented and content orientated and uses an educational approach in which little attempt is made to relate theory to the problems encountered in local farming systems. This abstract approach to the presentation of information leads to rote learning rather than encouraging a deep learning experience that develops in students' capacities to identify and solve problems.

The Faculty of Agriculture of the National University of Timor LoroSae aspires to teach a modern agriculture curriculum based on the sciences and technologies, and which is designed to service a developed industry. However, graduates from the faculty will be dealing with traditional agriculture where farmers depend on their own experience and that of their forbears as a basis for their decision making. The degree courses should produce graduates who have the capacity to understand the traditional animal and crop production systems and who will also be able to conduct scientific research and apply research to improve the performance of local agricultural systems. Comparative studies of relevant traditional and local farming systems which include case studies of successful and unsuccessful interventions intended to improve the productivity of traditional systems is one means of developing graduates who understand how to apply science and technology in their work with farmers to improve production and system sustainability. This approach would foster deep learning experiences that would bring to the students more holistic views of the discipline which, in turn, would change the way in which the learner visualises the farming systems.

Internal and external factors that impact on the quality of teaching and learning are considered. The importance of research activity and its nexus with quality learning is discussed. To sustain research at the university there is a need for a cooperative research model to be developed between the university and other agencies so that significant agricultural problems are identified, and to achieve efficient use of scarce resources.

University of Timor LoroSae staff have made considerable headway in identifying the strengths and limitations of their present curricula, and in setting graduate attributes for their students. Further development of these issues is anticipated in 2004.

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Introduction

PRIOR to the 1999 referendum, agriculture and related activities such as agroprocessing and agricultural input industries employed 85% of the population, contributed 40% of GDP, and accounted for 90% of foreign exchange (World Bank, 2000).

The importance of the agricultural sector in the economy suggests that agricultural education should form a component of primary, secondary and tertiary education. Adult education and agricultural extension are important in assisting the development of human resources in the agricultural sector.

This paper focuses on the development of university education for agricultural development. This will be considered from the viewpoint of 1) Teaching and Learning and 2) Research and Development.

Undergraduate course structure

Undergraduate agricultural courses at universities in developing countries have frequently been modelled on degree course structures found in Europe or America. Typically, the undergraduate agriculture syllabi in the early years are based on basic science or basic economics units. Content orientated units are often taught in isolation with little or no reference to other units or to agriculture. The learning process is teacher-dependent, focused on small bodies of knowledge, and the assessment emphasises recall of the material that has been taught. Many undergraduate courses in agriculture neglect to encourage students to actively learn about the environment, resources and farming systems of the locality. This denies the student the opportunity to actively use their newly acquired knowledge because it is not being related to agricultural problems.

Until recently, the development of curricula in western universities revolved around arguments about what additional content needed to be added and what could be taken out. The curriculum is often developed by the addition of new subjects based on developments in science, technology, economics or sociology. We have heard the calls to make space in the modern curriculum for biotechnology, molecular biology, and information technology in an already crowded timetable. Professor Lindsay of the Animal Science Department, University of Western Australia acknowledges the dilemma faced by academics "if knowledge is increasing exponentially while, on the other hand, students' capacity to absorb it appears to be relatively constant." He says that, therefore, "lecturers must make judgements about what information they can afford to ignore in order that they can consider new information" (Lindsay, 1986). Questions are rarely asked about the impact of crowding the curriculum on the quality of educational outcomes. We need to be aware that it is not possible for students to learn all the knowledge available in the public domain and that much of it will be learnt after graduation.

The Indonesian curriculum

The Faculty of Agriculture, University of Timor Loro Sae, has been using the former Indonesian Department of Higher Education curriculum. The curriculum is a unit system strongly influenced by United States and European systems. The curriculum is fragmented with an average seven units being taught per semester. The units are frequently presented as bodies of knowledge with little reference to the local farming or animal production systems. The presentation of information in this way encourages shallow learning rather than deep learning experiences.

Viewpoints on curriculum development in agriculture

There are various approaches to curriculum development and delivery of undergraduate education. The approaches outlined below serve as an illustration rather than a recommendation for adoption.

Harmon (1992) expresses a traditional approach to the development of curriculum. He states that basic science is essential for animal science professionals and that animal science depends more than previously on the classical basic sciences to explain and to apply technologies.

McColl et al. (1991) considered that as far as curriculum is concerned, courses in agriculture need to cover soils, plants, animals, economics and business but also need to develop a perspective of a total food and fibre system and that graduands should graduate with well-developed communication skills.

According to Pearson and Ison (1992), members of the Department of Crop Science at the University of Sydney are of the opinion that knowledge in the sciences is only one of the learning outcomes required in producing professionals for the agriculture and animal industries. They contend that "Educators have been too preoccupied with technical content and what has been an exponentially expanding base of information rather than the purpose of education." They suggested a list of qualities that educators should assist agronomy graduands to develop:

a) empathy or identification with their client industry, namely agriculture, including horticulture and environmental management

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b) capacity to be self-starters and steerers, not dependent on others for ideas and information, however, they should develop a network of information sources
c) a problem-solving approach: keenness and methodology to identify situations which may be improved, and to seek solutions to problems
d) a rigorous knowledge base in scientific, technological, social and economic disciplines
e) humility: appreciation of what they don't know and where to get help, which is more important than graduates appreciating what they do know.

Staff at Curtin University's Muresk Institute of Agriculture have developed agribusiness and science courses that provide students with a balance between content and opportunities to develop the skills required by the industry and the profession. Some years ago, an education model was developed which reflected the content and skill needs of a farm manager or farm management consultant. The course aimed at producing graduates with the capacity to identify problems, find solutions, evaluate outcomes and revise plans, and who had good communication and interpersonal skills.

In the last few years, the course perspective has changed from a focus on the farm, where the farmer and farm family integrate inputs to achieve efficient production outcomes, to a wider view where the farm is seen in the context of the agribusiness system. The current courses are based on a generalised model of agribusiness systems. This model is used as a basis of curriculum design and assists in the definition of the learning outcomes of the course. During the course, students are encouraged to develop their critical and creative thinking (analysis, synthesis, evaluation) skills as well as professional skills, capacity for effective communication, information technology, teamwork and a cross-cultural business capacity.

Information transfer through the agribusiness system in both directions and logistics are seen as important elements that affect curriculum development in agribusiness courses.

As further elaborated below, course content and learning outcomes may be determined by considering the required knowledge and skills of a graduate entering the profession or industry. There is a lack of local information on community requirements to guide curriculum development at the National University of Timor LoroSae.

The implementation of curricula ultimately requires funding for new books and laboratory facilities, and sometimes new staff with particular expertise. This may impact on curriculum development because agencies that fund university development, such as the World Bank, give preference to proposals that seek to develop courses that will prepare graduates who understand the local agro-ecological environment, socio-economic conditions and agricultural systems.

Comparison of the impacts of modern and traditional agriculture on university education

Modern farming systems are supported by scientific, economic, management and marketing research and a support infrastructure of extension personnel and literature. There is a wealth of information in books, journals, bulletins and online available to practitioners, academic staff and students studying developed agricultural systems. Over the last 20 years, researchers and academics in agriculture have shown increased awareness of the importance of understanding farming systems in the locality where they are working. University research is funded by major industry bodies that are represented on undergraduate course and research advisory committees.

Traditional farmers, by contrast, are guided by the accumulated wealth of experience over generations that develops their convictions about what species to select as crops, where the crop should be placed and how it should be managed. Until recently, traditional agricultural and animal production systems have not received much attention from the scientific community (Fernandes and Nair, 1986) as they have been considered inefficient producers of harvestable yield. Much of this experiential information is poorly documented. Traditional farmers make little contribution to research funding but wealthier farmers (who may use less traditional systems or at least be more open to modern methods) may fully or partially fund their children's university fees and living allowances. There has been relatively little research into traditional farming systems.

In order to increase harvestable production per unit area some traditional farming systems have been replaced with more intensive and less biologically complex systems. Some traditional systems appear to be unsustainable. For instance, it is generally recognised that the traditional dryland farming systems in East Timor have contributed to environmental degradation. There are examples of good practice in the region, which have reversed the process of degradation in Amerasi in West Timor and Sikka in Flores (Metzner 1987a, 1987b). The inclusion of units such as comparative agriculture or comparative animal production systems would encourage students to evaluate local production systems against those in similar agro-ecological zones elsewhere.

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Agronomy

In the project inception report the following curriculum design issues were identified:

a) Basic plant science — basic morphology, anatomy and physiological processes (photosynthesis, respiration, metabolism, dormancy, senescence, role of growth regulators, transpiration) of growth, development and reproduction.

b) Farming systems — there is need for graduates who understand the farming system and are able to identify constraints which limit performance of the whole system. The capacity of the graduate to assess the strengths and weaknesses of various farming systems within the agro-ecological zones of East Timor will be important.

c) System variables — graduates will need to understand which systems variables are manageable and which are not. Agronomy graduates should understand the action of variables on plant physiological processes, particularly those that determine the rate of crop growth and development, final yield and quality.

d) Cropping systems — graduates should understand the impact of changes in the cropping system on other components of overall farming systems and on the environment.

e) Crop protection — weeds, pests, diseases, and the various methods of control including integrated management methods.

f) Sustainable systems — a comparative study of farming systems used in similar agro-ecological zones to those of East Timor.

g) Water balance — soil water balance and water use efficiency are key issues within agronomy.

h) Research skills — graduates will need to be able to define agronomic and related problems within the cropping and horticultural components of farming systems and design and implement research to investigate these problems.

i) High value crops — a range of potential agricultural and horticultural plant crops should be explored as a possible means of improving human nutrition during the dry season and also improving cash income through marketing surpluses.

j) Biotechnology — the impact of biotechnology on improving yield, quality and disease and pest resistance needs to be understood by graduates but the cost of developing a laboratory is beyond the capacity of the university .

k) Information literacy — information literacy will be an important attribute of graduates in future but online facilities are unlikely to be available to staff for some time. However, students require training in accessing and interpreting information.

l) Communication skills — the graduate needs to be an effective communicator in Tetum and in languages such as Bahasa Melayu, English and Portuguese. To be an effective communicator the graduate will also need to be sensitive to cultural issues.

Animal science

a) Basic animal studies — need to understand the basic workings of animals, and of animal disease and production, through knowledge of anatomy, physiology and biochemistry.

b) Farming systems — understanding of animal production requirements (nutrition, water, shade, etc.) throughout production cycles, and how these can be met within the constraints imposed by crop (maize, rice, vegetable) systems.

c) Disease control and basic veterinary procedures — recognition of common diseases, parasitology (internal and external parasites, effects on animals, parasite lifecycles, control treatments), introductory epidemiology (how disease may spread between animals and between farms).

d) Genetics and breeding — evaluation of the productive and stress-resistance characteristics of existing genotypes, assessment of the potential (if any) of exotic genotypes within the context of the existing feed supply, disease regimes and environmental stresses.

e) Husbandry practices — including methods of confinement (stalls, effect of tethering on animal behaviour), product harvesting (milking, butchering), animal restraint methods, training and use of animals for draft/riding purposes, design and use of husbandry equipment (stalls, pens, shade, water, crushes, fencing, etc.).

f) Nutritional management — seasonal changes in forage nutritive value, nutritional enhancement methods, and nutrient supplementation methods.

g) Animal farming skills — graduates need to be able to demonstrate Timorese best practice to farmers (note that this may be different from best practice in the western or temperate world).

h) Humans and animals — need to appreciate the nexus between animal production and human health (animals as sources of essential nutrients, and the risk of passage of animal diseases to humans), the role of companion animals, and the role of animals for recreation (e.g. safari hunting).

i) Animal quarantine issues — recognition of exotic diseases (foot and mouth disease, Newcastle disease, Petit P Ruminants, etc.), control measures, legal issues.

j) Fisheries protection issues — recognition of fish species, knowledge of law and enforcement procedures.
k) Aquaculture and marine sciences — fish farming techniques (construction and maintenance of ponds, choice of species, feeding techniques, diseases, harvesting and processing methods).

Teaching is about facilitating quality learning

In surface approaches, the teacher transfers to the learner large quantities of "precise knowledge, inert and unutilised" which is later reproduced by the student to pass exams for "pleasing the teacher" (Whitehead, 1967). On the other hand, deep learning approaches "change the way in which the learner conceptualises the world," in other words "how an individual makes sense of something"(Ramsden, 1992). An academic institution using the deep approach strives to bring to the learner more holistic views of the discipline studied. The structure of the discipline is kept intact as the learner focuses overall in relation to the parts, rather than on the parts themselves (Ramsden, 1992).

The teaching/learning process calls for the abandonment of shallow learning and its replacement with approaches which foster deep learning experiences. Research distinguishes between the two types of learning (Radloff and Murphy, 1992; Ramsden, 1992) as described in Table 1.

Factors which influence learning to consider in curriculum development

It is important to recognise the factors that may influence the development of a high-quality learning experience for students.

A. Internal factors

The qualifications, training and experience of existing staff are important factors. The capacity to teach their discipline, and to facilitate active learning by students, is influenced by their own university experience.

The capacity of staff to write learning outcomes relevant to the needs of agriculture is influenced by their understanding of the industry and employment.

Availability of literature and access to information are influenced by lending information systems in place at the university.

Educational support services that demonstrate good practice and assist staff capacity are ones that improve the quality of lectures, practical classes and field tours.

Laboratory and field equipment that support educational activities relevant to the needs of the agricultural and related industries of East Timor are important. This ACIAR[1] project is making a significant contribution to the rehabilitation of the field station and laboratories at Hera. Access to farms, animal production enterprises, and rural communities for study and research purposes help reinforce information and concepts in a practical environment. The ACIAR-funded project provided a pickup and motorcycles to assist staff in the supervision of field research being undertaken by final-year students.

Availability of teaching resources, including model methods of practising in-depth learning, are also important. Dryden (1996) has designed several exercises which develop a deep-learning approach in the agricultural sciences.

B. External factors

External factors that need to be considered include the following: the needs of farming and animal production systems in East Timor; government agricultural policies on issues such as food security and generation of disposable income; and the nature of the physical, biological and socio-economic environment.

Funding of tertiary agricultural education by the government and donors and employment opportunities for graduates in relation to other areas of the national economy are also important.

The quality of students entering the courses, inappropriate recommendations from visiting experts who do not fully understand the local environment and agricultural systems and the availability of scholarships for postgraduate studies must also be taken into account.

Enhancing the research capability of staff and students

Research is an important activity in universities. There is a nexus between teaching and research which, if developed, enhances the quality of learning outcomes. At present, the National University of Timor Lorosae has a limited number of staff with

[1] The ACIAR Project No CTE 2000/164 'Rehabilitation of the Agricultural Faculty of the National University of Timor Lorosae' commenced in June 2001. The commissioning organisation is Curtin University of Technology, Muresk Institute of Agriculture, and collaborating organisations are the Northern Territory University Darwin, the University of Queensland Gatton, James Cook University Townsville and Sydney University, working together with the National University of Timor Lorosae.

Table 1. The differences between 'surface' and 'deep' approaches to learning.

Surface approaches	Deep approaches
Assessment methods which emphasise recall or memorising trivial information	Teaching and assessment methods which foster an understanding of concepts and principles and active and long-term engagement with learning tasks and real world problems
Teacher dependent	Stimulating and considerate teaching which stresses the linking of topics (old and new) and the meaning and relevance of the information and allows students independence
An excessive amount of material in the curriculum	Clearly stated academic expectations, which focus on the development of life-long learning, problem-solving skills and creativity
Poor or absent feedback	Feedback which assists the students attain the institutional and course goals
Rarely question	Frequently question the lecturer to gain insights into the subject matter and its application
Assessment rules their study	Enjoy learning and interested in the subject matter

postgraduate qualifications. In the short term, local staff require support from Australian university staff to develop a suite of applied research projects which address significant problems in agricultural systems, cropping systems, post-harvest handling, estate crops, animal production, soil fertility, rural development, agricultural economics and so on. Faculty of Agriculture staff should seek to collaborate with government and non-government agencies working in agricultural and rural development in East Timor. In this way, staff and students will research significant problems limiting production or affecting the welfare of the rural population.

Development of a new agricultural curriculum suitable for East Timor

In 2002, the ACIAR project supported a curriculum development workshop aimed at revising the curricula of the programs offered by the Faculty of Agriculture at the University of Timor Lorosae. The workshop was conducted at Maubara on 12–15 July 2002 and was very well attended by staff from each of the three departments of the Faculty of Agriculture. The workshop was opened by the Rector of the University, Dr Benjamin de Araunjo e Corte-Real. The Deputy Rector (Academic) Dr Francisco Martins, S.Hum also addressed the workshop.[2]

The Rector said that curriculum development was important to the development of quality higher education at the university. He said that two aspects of curriculum development were important: the capacity of staff to understand and teach up-to-date technology originating from advances overseas; and the capacity to develop graduates who are able to apply this technology to the solution of local problems.

The aim of the workshop was to develop a shared understanding of the meaning of curriculum, to consider the strengths and weakness of the Indonesian curriculum model and to revise the curriculum for 2003.

Strengths and weaknesses of the current curriculum

The staff identified the strength of the Indonesian curriculum as being its scope. Each course presents 50+ units over a four-year period. However, the staff considered that the large number of small units resulted in a high workload for both staff and students, led to a shallow learning experience for students, and resulted in a fragmented curriculum that provides a poor understanding of local agricultural and animal production systems.

Departmental staff identified the strengths and weakness of the current animal science, agronomy and socio-economics curriculum (Table 2).

Goals and broad learning outcomes for the undergraduate programs conducted by the Faculty of Agriculture were developed and agreed upon by staff from the departments of agronomy, animal ccience and

[2] The workshop was conducted by The Dean of the Faculty of Agriculture, Ir Flaviono S. Soares and organised by the Project Officer, Ir Yohanes Usboko M. Agric.

socio-economics. The staff described a high quality curriculum as having the following characteristics:

- Relevant to current and future needs
- Capacity to develop human resources that possess excellent knowledge and skills upon graduation which drive development and national development
- Student centred, stimulating students to learn, value the experience of others and respond to the needs of the community
- Promotes critical and creative thinking and encourages logical, analytical, holistic and lateral thinking
- develops capability to adjust to changing employment and work environments.

Learning outcomes identified

The staff from each department developed a number of desired learning outcomes for each of the fields of study as a basis for curriculum development (Table 3).

A second curriculum conference

A second major revision of the curriculum is scheduled in 2004. We recommend that staff, students, representatives of relevant government ministries, professionals and representatives of farmer groups in East Timor participate in this second workshop to develop curricula appropriate to the professional human resources needs of the agricultural and related sectors of East Timor.

Conclusion

The current curriculum does not have a good framework. It is fragmented and deals with many small bodies of knowledge that are poorly linked to other components of the course and to the needs of agricultural industry. The linkage between the taught knowledge and its application to agricultural or animal production systems tends to be neglected. The curriculum framework and teaching/learning process are not aimed at producing outcomes that result in the development of higher-order cognitive skills such as analysis, synthesis and evaluation but rather the educational system produces graduates with lower-order cognitive skills of awareness and comprehension. A way of introducing students to the study of agronomy is to schedule an introductory unit that has a focus on the plant and soil resources of East Timor, followed by a unit that looks at the plant and soil systems of the nation. Introductory units of this kind would enable the science components to be related to the 'real world' context. The importance of linking theory to the real world is essential to students achieving deep-learning experiences (Ramsden, 1995; Biggs, 1989). Required skills for private-sector employment can be achieved by the further development of current units such as agribusiness, entrepreneurship, community service, farm

Table 2. Strengths and weaknesses of current curriculum.

Agronomy and socio-economics	Animal science
Strengths Graduates rich in knowledge and theory	Strengths None identified
Weaknesses Out-of-date curriculum	Weaknesses Too many irrelevant units
Appropriate to the wet tropics of Java and Bali and inappropriate to Timor	Syllabus of some units is inadequate
Overcrowded with content promoting surface learning	The syllabus of English language is not related to the needs of the field of study
Theory does not leave enough room for practical work	Overlapping of content throughout the curriculum
Surface approaches do not develop sufficient depth of understanding and skills and do not satisfy community needs	Syllabus not presented in a systematic way and some are incomplete
Syllabus of units does not keep pace with scientific and technical development	
Needs a unit which covers interaction between animals, plants and economics	
Not adequate specialisation in the fields of study; courses too general	

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Table 3. Desired learning outcomes.

Agronomy	Animal science	Socio-economics
Able to identify conditions which are limiting plant production	Able to advise farmers on how to obtain a living from livestock systems	Graduate professional agriculturalists who are reliable
Able to market farm products and develop value adding	Able to apply technology to improve animal nutrition, artificial reproduction, breeding, husbandry and marketing	Able to use conventional technology
Able to effectively transfer knowledge and associated technology	Able to produce meat products from animals that are of good quality and do not pose a health danger	Able to give guidance to farmers and the rural community
Able to use resources and develop sustainable production systems	Able to search, organise, file, access and elaborate on information and provide it to farmers, government agencies and professionals	Able to work together with farmers to identify problems and develop solutions
Capable of starting own enterprise	Be a self-directed learner who will search for up-to-date information	Display excellent communication skills appropriate to the area and place of work
Work together with farmers to identify agronomic problems and develop alternative solutions	Work together with farmers to identify animal production problems and develop solutions	
Display capacity to work together with farmers	Display high-level communication skills	

practice, and project management. The academic staff of the Faculty of Agriculture have identified the strengths and weaknesses of the former Indonesian curriculum and have made an excellent start to the revision of the curriculum. This revision aims to make the teaching–learning process and resulting learning outcomes at the university relevant to the development of the rural community and industries in East Timor.

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Working group SWOT analysis on agricultural development in East Timor

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During the workshop, a working group session was held to discuss and consider appropriate research and development (R&D) directions to support future agricultural development in East Timor. Four working groups of 15–20 people addressed the cropping, forestry, fisheries and livestock sectors. The groups first undertook a SWOT (strengths, weaknesses, opportunities, threats) analysis and then discussed some ideas and priorities for R&D, based on the SWOT considerations. Several of the papers at the conference also suggested directions for future R&D. The outcomes of these considerations are captured below in SWOT tables and lists of priority areas for R&D. It is hoped these ideas might be useful for those considering supporting and undertaking agricultural R&D in East Timor.

SWOT analysis

Strengths	*Weaknesses*	*Opportunities*	*Threats*
Cropping			
Field crops (cereals, legumes, tubers)			
available land large number of farmers crop diversity domestic markets support of NGOs and donors regional/international network free trade	low quality varieties lack of agricultural supplies low-skilled farmers lack of markets little data, maps, or meteorological information lack of extension facilities lack of transportation lack of irrigation lack of well structured government systems lack of crop management information	domestic markets export potential support from donors, NGOs and government quality improvement dual purpose crops for humans and livestock increase export research facilities	pests and disease free trade natural resources degradation decrease in foreign assistance
Cotton			
large land potential seed available and easy to get	low quality lack of processing technology low skill of farmers	local market available oil source for cosmetics useful for cloth industry	import competition from abroad diseases and pests

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Strengths	*Weaknesses*	*Opportunities*	*Threats*
'Abaca' banana			
crop of some potential	requires special processing technology	raw material for producing bank notes	cheap imported material pests/diseases imports from other countries
Cacao			
large potential demand	low skill of farmers poor infrastructure	available market	pests/diseases imports from other countries
Coffee			
available land organic certification big market share firewood by-products	low quality low skill and organisation of farmers ageing coffee trees lack of processing facilities lack of supporting infrastructure government policies	strong international and local markets available market channels attractive ET branding of organic coffee residues for compost wood for fuel	diseases international competition
Coconut			
fertile land available multifunctional to meet needs of community	no market potential is not well managed poor infrastructure	local oil industry	imported oil pests
Vanilla			
large development potential competitive market price	low skill of farmers lack of extension capacity long drought	large market competitive production cost	
Forestry			
staff with a variety of experiences and willing to learn extensive natural grasslands valuable native species such as *Eucalyptus alba*, *E. urophylla*, *Casuarina junghuniana* non-timber forest products traditional management practices large available areas	inadequate data on land and water resources no titled tenure for grasslands inadequate data on forestry resource decline in traditional management non-permanent (slash-and-burn) farming	donor and government support provision of forage and shelter for livestock quick regeneration of trees rebuilding of traditional laws reforestation	degradation (landslides, low quality water, wildfires) weed infestations pests and diseases like *Phaeophleospora destructans* on *E. urophylla* and *Uromycladium tepperianum* on coffee shade trees use of valuable timber as firewood uncontrolled and unsustainable exploitation

Strengths	*Weaknesses*	*Opportunities*	*Threats*
Fisheries			
extension of law (No.7/2002) RDTL political stability enthusiasm of staff and fishermen potential of natural fisheries resources	lack of capital lack of expertise low institutional capacity lack of coordination fishing fleet is limited and simple no sense of ownership of equipment	temporary legislation create infrastructure friends to support development	illegal immigration depleted resources illegal fishing by others
Livestock			
society used to raising animals source of income large natural pastures high appreciation and cultural value of farm animals by community live savings for times of need diversity of farm animals export potential	human resources in animal husbandry R & D are limited traditional animal husbandry practices no animal husbandry and veterinary laws quarantine available but not used to maximum potential much animal production and consumption for traditional “adat” ceremonies legal land ownership not available animal housing poor market information not available lack of facilities and infrastructure need to identify local feedstuffs (grasses, weed and natural pasture) lack of water for animal and plants particularly in dry season	strong export opportunities	various diseases feedstuffs very limited in quality and quantity, particularly in dry season animal slaughter not well controlled competition for feeds for animal and human consumption cockfighting emphasis in poultry production new weeds such as siam weed (*Chromolaena odorata*) damage to natural pasture (overgrazing) uncontrolled pasture and forest burning global or free market

Directions for future research and development

Overall

- development of R & D capacity of staff and farmers
- development of technology transfer and village support systems
- understanding and development of domestic and export markets
- assessment of climatic, land and water resources capability
- understanding and management systems to combat land degradation
- understanding, recognition and development of land ownership systems
- improvement of economic and public facilities at village level to attract young graduates to villages.

Cropping

- better adapted germplasm for cereals, legumes and tubers
- matching produce/product quality with market demands
- improved crop management for cereals, legumes, tubers and coffee

- potential of and appropriate management for cotton, cacao and vanilla
- better understanding and management of pests and diseases.

Forestry

- development of inventories and sustainable management policies and plans for valuable and unique forest resources such as *Eucalyptus alba*, *E. urophylla*, and *Casuarina junghuniana*
- development of management and utilisation technologies for natural forests
- consideration and development of appropriate reforestation strategies
- multi-purpose trees for alternative uses (livestock fodder, fuel)
- investigation of *Phaeophleospora destructans,* a very common pathogen of *E. urophylla* in East Timor
- investigation and management of *Uromycladium tepperianum*, a destructive rust in the coffee shade tree (*Paraserianthes falcataria*).

Fisheries

- establishment of agreed national off-shore fishing boundaries
- development of inventories for fish resources
- development of management plans and policies for sustainable utilisation of fish stocks
- development of appropriate fishing facilities and technologies
- development of appropriate on-shore aquaculture technologies.

Livestock

- development of feed/forage resources
- development of understanding and systems for mating management
- development of better livestock management technologies and systems
- development of inventories and management technologies for livestock diseases
- development of appropriate systems for veterinary regulation.

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