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project

Identifying economic and social constraints for water management in vegetable production in East Nusa Tenggara and West Nusa Tenggara

SADI-ACIAR research report

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ACIAR's participation in the Australia–Indonesian Partnership

The Australia–Indonesia Partnership (AIP) supports Indonesia's reconstruction and development efforts, both in and beyond tsunami-affected areas. Assistance will involve long-term sustained cooperation focused on economic and social development.

As part of the AIP, the Smallholder Agribusiness Development Initiative (SADI) aims to improve incomes and productivity for farmers and agribusiness, in response to market opportunities, in four eastern provinces—East Nusa Tenggara, West Nusa Tenggara, South East Sulawesi and South Sulawesi.

ACIAR's commitment to SADI focuses on supporting market-driven adaptive research, improving the transfer of knowledge and developing the capacity of key institutional stakeholders. This commitment will overcome constraints and barriers that prevent smallholders and agribusinesses successfully engaging with the market.

Contents

1 Acknowledgments

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This project was truly a team effort and all members should be proud with its achievements.

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2 Executive summary

Better management of water resources and their effective use to produce high value agricultural crops is seen as a key opportunity for increasing living standards of the rural population in the provinces of Nusa Tengarra Timur (NTT) and Nusa Tengarra Barat (NTB) in Eastern Indonesia. Activities towards improving agricultural water management have been pursued by the governments at various levels in Indonesia, as well as by the international donor agencies. Despite these activities, there are very little significant changes of practice being observed, and it is felt that farmers in these areas could be making much better use of the techniques and the infrastructure available for using the water resources. Understanding of the factors that contribute to this situation is crucial to better directing future activities in this domain. While considerable understanding exists about the technical factors that may constrain farmer's water management and use practices, very little is known about the economic and social factors that may be constraining farmer behaviour.

The aim of this study is to identify a broad set of economic and social constraints that influence farmer behaviour in relation to agricultural water management for high value vegetable crops in the two provinces (NTT and NTB) in Eastern Indonesia. More specifically, the study aims at pinpointing several of these factors that are likely to be most influential in constraining farmer's behaviour, and for which more in-depth understanding is necessary. Consequently, the study offers several strategic research directions on the key socio-economic issues for agricultural water management in Eastern Indonesia. It is felt that addressing these issues will provide essential knowledge and understanding of the underlying problems, which can then inform government policy and international donor activities.

Formulated aims were pursued through a range of research activities. These included: thorough review of previous published work, primary data collection through semi-structured field interviews and through surveying farmers in the research area utilising a formal survey instrument (a questionnaire), analysis of the primary data, and collecting expert input through a stakeholder workshop.

The findings from these research activities enabled us to identify a set of factors that constrain agricultural water management in high value vegetable production in the research area. This broad set consists of the following constraints: capital constraint and access to credit, market price risk, production risks, inadequate incentives for maintenance of water infrastructure capital assets, social attitude and gender factors, marketing problems including transportation and logistics, problems with extension and diffusion of knowledge, inadequate properly rights structure in water management, institutional problems in water management, labour constraints, and land constraints. The analysis of the data indicates that some of these factors are more, and some are less important in constraining farmer behaviour. In addition, the analysis uncovers some interesting relations among these factors, which enabled us to comment on the implications for current activities of governments and donor agencies directed towards improving agricultural water management. For example, it seems that extension efforts should be focused on smaller farms and on female members of the households as those categories seem to have greater interest in using water for high value vegetable production. It seems however those current extension efforts are targeted towards larger farms and male household members.

Further analysis of the broad set of constraints aided by the expert input, enabled us to pinpoint four key areas for which more in-depth understanding is needed. These are:

1. Maintenance and operation of water infrastructure assets: instruments and institutions for empowering local communities.

2. Understanding and managing risk and uncertainty on the farm and in the market related to producing and marketing irrigated high value vegetable crops.
3. Determining market price responses to changing supply conditions for high value vegetable crops.
4. Understanding the role of social attitudes and perceptions in relation to market engagement and technology adoption in NTB and NTT, and identifying possibilities for change.

It is felt that further research efforts in these areas will produce insights that are necessary for managing change in agricultural water use in this part of Indonesia.

3 Introduction

3.1 Context of the project

Managing water resources to achieve better production and economic results from agriculture has been a challenge for farming communities since ancient times. Those successful in consistently and sustainably managing water in agriculture have experienced many benefits over a long period of time. Unfortunately, such examples are not numerous, and agricultural water management has often encountered severe problems due to overutilisation of water resources, salinisation of land and water, and many other water quality and environmental problems. Current state of water resources in Australia is a prime example of such problems.

Water management for improved agricultural outcomes is becoming even more important in the face of rising food demand due to rising world population, rising incomes, and expansion of crops used for energy. This is particularly significant for developing countries that still experience significant demographic change as well as rapid economic growth, while at the same time suffer from poverty or near-poverty conditions in many rural areas.

The eastern islands of Indonesia, in the provinces of Nusa Tenggara Timur (NTT) and Nusa Tengarra Barat (NTB) are characterised by relatively high level of rural poverty, which has historically been related to poor conditions for agriculture due to highly variable rainfall patterns and poor soil quality. In light of this, both the Indonesian government and many international donor agencies have been focusing their efforts on improving the capacity for water management on these islands, and on helping farmers make better use of the water resource through growing high value crops. This has been pursued through various activities and projects, most of which include some form of investment into water infrastructure assets (dams, canals, reservoirs, wells) and/or a technology innovation that enables better management of soil moisture regime (e.g. permanent raised beds, conservation tillage, etc.).

The climatic conditions of the two provinces are characterised by distinct wet and dry seasons, and by the extent of the drought increasing in the easterly direction (while the western parts of the island of Lombok in NTB have less harsh drought conditions, the island of Timor in NTT is characterised with substantially long dry spells). Low level of rainfall and water availability in West Timor forces people to crop their land only for a short period of time during the wet season, and there is typically very little or no cropping during the dry season. In these two islands, which were the focus of this project, the development efforts in the area of agricultural water management have been directed towards altering the natural distribution of water availability so that more water is available for irrigating crops during the dry season. In practice, this means that an additional, and potentially high-value crop, can be grown within a calendar year.

Key approaches to improve water management in Lombok and Timor have been:

- traditional irrigation systems, where large scale publicly owned infrastructure assets (dams and canals often built with international donor funding) are used to irrigate crops during the dry season. The extent of these systems in the two islands is limited, and they cover only relatively small land areas.
- embungs, or community dams, are constructed (again often through international donors) in order to capture very intense runoff during the wet season. The stored water is then used for livestock water consumption, which was the original intention of an AusAID funded project in the early 1980s to build embungs in Eastern Indonesia, but also for domestic purposes in the households, as well as for watering of some crops, typically vegetables and nurseries. The embungs are typically managed by the community at a village or sub-village level.

- deep wells, that are increasingly being constructed in both Lombok and Timor, and are perceived as a more secure water supply. The wells can be privately owned, or communally owned by villages. They are utilising the groundwater for household water needs, livestock consumption and small scale irrigation.
- soil / water management technologies, such as permanent raised beds, that are used to improve the water regime of certain types of soils (vertisols).

While some of these infrastructure assets and technologies have been in place for some time, and others have just been recently introduced, anecdotal evidence from the field suggests that the effectiveness of water use, in particular for producing high value agricultural crops destined for market, has been lower than expected. This suggests that farmers might be forgoing an opportunity to increase their incomes and substantially lift their living standards.

The apparent low rate of farmer uptake in utilisation of infrastructure and technology for better water management to produce high value crops was the key motivation for ACIAR to commission the present study. While some understanding about the technical constraints that might be preventing farmers from improving water management and use has been developed through previous projects, very limited insight existed in relation to the economic and social factors that might be constraining farmers. In this light ACIAR commissioned this research to identify a broad set of economic and social constraints that influence the way farmers in Lombok and West Timor use water infrastructure, and that influence their attitude towards water management technologies.

3.2 Project aims

The specific aims of the project were to identify the economic and social constraints that are affecting the use of communal water storages (embungs) in West Timor on one hand, and to identify the economic and social factors that might affect adoption of permanent raised bed cropping in Lombok, on the other. The project also aimed to derive some general findings pertaining to the potential for better water management in high value vegetable crops in eastern Indonesia. While the scope of this project was limited, so that it could only identify a broad set of issues without detailed analysis of individual constraints, an additional objective was to identify and propose to ACIAR some strategic research directions that could be undertaken to enable better understanding of the importance for improving water management in this part of Indonesia.

3.3 Previous projects and linkages

ACIAR has in the recent past commissioned two projects that were of particular relevance to the current project, and to which linkages were established via interviews with project leaders, having joint members on projects teams, and detailed review of documents and publications of these two projects.

One of the projects, "*Seasonal Climate Forecasting for Better Irrigation System Management in Lombok*"- SMCN/2002/033 aimed to build a seasonal climate forecast tool that could be used to improve the management of irrigation systems and water resources in Lombok in order to achieve greater and more secure crop production by refining the decision support systems already developed for optimising choice of crop, crop area and irrigation water allocation. The project also aimed to use the decision support system and multiple historic climate scenarios to simulate the benefit of SCF (Seasonal Climate Forecasts) in terms of economic output and income distribution.

The other project, "*Improved Soil Management on Rainfed Vertisols in Nusa Tenggara*"- SMCN/1999/005 aimed to test alternatives to the existing tillage systems used in Lombok where there are heavy clay soils (vertisols). In particular, the study evaluated the performance of permanent raised beds (PRB) on these types of heavy soils.

3.4 Brief description of the issues in Lombok and West Timor

On the island of Lombok (NTB), a raised bed cropping system, sometimes referred to as the ACM cropping system, involving a combination of flat land and permanent raised beds with water harvesting and redistribution, has been developed and is currently being trialled with a small number of local farmers. The system is effectively based on the notion that 1/3 of the field is under permanent raised beds that are used to grow high value vegetable crops, while 2/3 of the field is under the traditional rice / soybean system (gogorancah). The system is described in Figure 1.

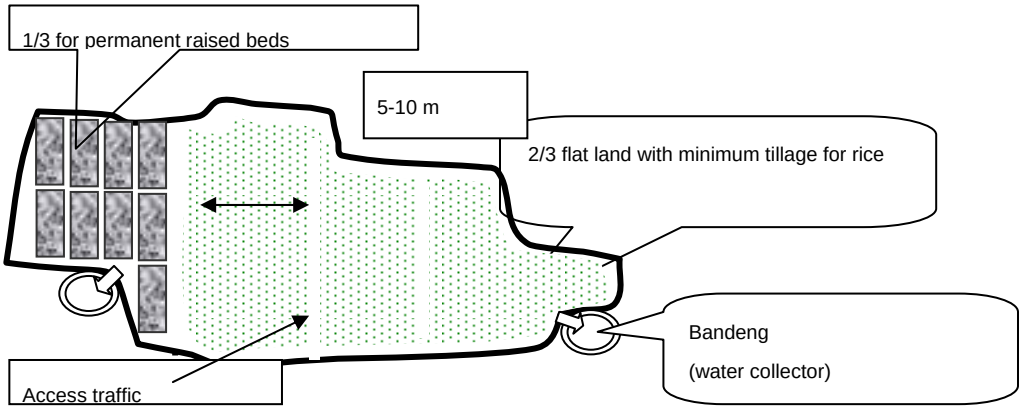

Figure 1: ACIAR Cropping Model (ACM) Source: Kusnarta et al. (2004)

However based on some evidence from the field, there are concerns about whether this new cropping system is likely to be adopted by the wider farming community in Lombok, raising questions as to whether some actions can be taken to encourage greater technology uptake. Some of the pre-identified key issues that might be binding and preventing farmers from uptaking this technology were: potential resource constraints (land, labour, capital); potential constraints for market engagement (uncertain prices and marketing channels, logistical issues (e.g. transportation), market reaction to increased supply; potential constraints in production (need for annual maintenance of PRBs, lack of technical knowledge and extension support, production uncertainty); and social constraints (gender issues, traditionalist behaviour). This potential set of constraining factors was investigated through the project activities.

In West Timor, a number of water storages (embungs) have been constructed to capture the excess water during the wet season. These are used for multiple purposes, including domestic use, livestock drinking, and for irrigation. It is expected that using this water in production of high value crops can encourage greater productivity and value adding to the local agricultural production, subsequently leading to increased incomes and improvement of quality of life. However, even though these water storages have been constructed for some time, it is observed that their usage, in particular in irrigation, is well below expectations. Pre-identified key issues that could potentially explain this behaviour were in the domain of infrastructure asset maintenance (embungs suffer from a problem of severe sedimentation, and as they are not properly managed, their productive life span is quite short (Figure 2); property rights (there is no clear ownership structure of the embungs and on the land on which they are build, and there is no clear ownership of the water resource); and the market engagement and production constraints similar to those found in Lombok. These sets of constraints were investigated in the project.

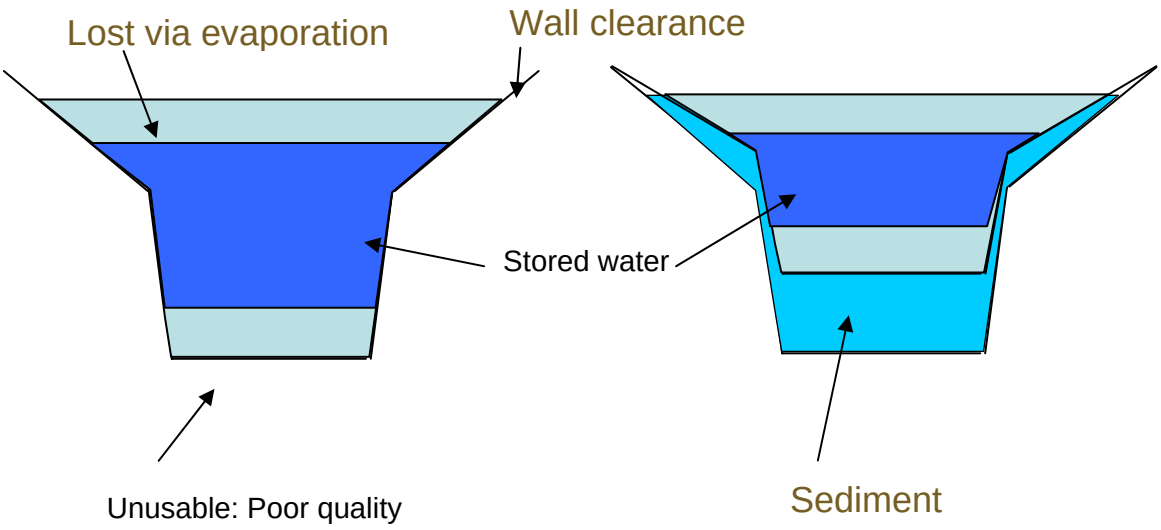

Figure 2. Available water in embung, pre and post sedimentation.

4 Activities and Methods

The identified research aims were pursued through several avenues of inquiry. These included: a detailed review of the previous published work relevant for the current study, primary data collection from farmers in the two islands through semi-structured interviews and through administering a farmer survey questionnaire, analysis of the collected data, and communication of the preliminary findings to, and discussion with, key stakeholders (international donor agencies, relevant provincial government departments, NGOs and universities and research institutions).

4.1 Review of the previous published work

Agricultural land accounts for about 23 per cent of total land in Indonesia and contribution of agricultural sector to Gross National Product is 15.20 per cent (Arsanti et al., 2007). Indonesia's economic development has depended largely on productivity changes in the agricultural sector and particularly in irrigated agriculture (Hussain et al., 2006). This is reflected in the incidence of poverty in Indonesia, which is much lower in irrigated areas than in rainfed areas (Hussain et al., 2006).

Vegetables are a promising agricultural enterprise in Indonesia, as there seems to be substantial unmet domestic demand for many types of vegetables. Vegetable production in Indonesia fulfils only 13 per cent of the local consumption demand (Arsanti et al., 2007). The prices received by producers for vegetables such as tomato, onion, cabbage, potatoes, cucumbers, carrots and others, have increased substantially over the last 10 to 15 years (Arsanti et al., 2007).

This review of the previous published work focuses on studies related to technology adoption constraints, water infrastructure asset management, and the role of property rights and social constraints on technology adoption and water management practices.

4.1.1 Constraints to Technology Adoption

A number of studies on constraints to technology adoption were reviewed focusing on several important constraints on technology adoption: availability of labour, availability of capital/credit, farm size, variation in market price, and lack of information.

Labour Constraint

The labour force in Indonesia has tended to move gradually from the agricultural sector into the manufacturing and services sectors, thus reducing the share of employment in agriculture from 50 per cent in 1993 to 45.1 per cent in 2000, and further to 44.5 per cent in 2006 (Hasoloan, 2007). Access to labour markets and/or farming family labour availability can be a very important constraint to technology adoption (Feder et al., 1985). New technologies often increase the seasonal demand of labour, so that adoption is less attractive for those with limited family labour or those operating in areas with limited access to labour markets (Feder et al., 1985; Perret, 2006, McCulloch et al., 1998). The seasonal increase in labour requirements raises the seasonal wage rates, thus reducing the profitability of new technology, particularly for those with insufficient family labour (McCulloch et al., 1998). In the presence of local labour market, farmers can hire labour as needed, and they can also sell their labour to obtain cash, if necessary (Doss, 2006). In places where labour markets do not function effectively, households must supply their own labour for farm activities. Therefore, they may not choose to adopt technologies that require more labour in specific times of the year, such as at the time of land preparation, or weeding (Doss, 2006). Ransom et al. (2003) reported farmers who have sufficient family labour available were more likely to adopt the improved maize varieties in Nepal, since cultivating improved variety of maize required more labour compared to the

traditional maize varieties. They reported that adoption of improved maize varieties would decrease by 18.76 per cent if farmers needed to hire labour for maize cultivation. Similar argument could be used in analysing constraints to adoption of permanent raised beds technology in Lombok, Indonesia, since this system has a greater labour requirement than the traditional farming system (gogorancah).

Land Constraint

The research on the effects of farm size on technology adoption is inconclusive, as there are studies finding both positive and negative relationship between the size of the farm and the tendency for technology adoption. For example, a study conducted in Indonesia regarding application of chemical fertiliser in rice farming (Pakpahan, 1992), reported a negative relationship between fertiliser use and farm size: the larger the land holding, less chemical fertilisers were used. Similar relationships were observed for other crops like corn, cassava, sweet potato and soybean. A study on fertiliser adoption in Ethiopia has reported similar results: the effect of land size on fertiliser adoption was negative, as it was found that an additional unit of land area decreases demand for fertiliser by 4.9 kg (Croppenstedt et al., 2003).

On the other hand Pannell et al. (2006) report that managers of larger landholdings are more prone to adoption of new technology. This was also found in some other studies. For example, in the case of adoption of improved maize varieties in Nepal, farm size was found to positively affect the adoption behaviour. It was estimated that every 1 ha increase in farm size would increase the adoption by 13.5 per cent (Ransom et al., 2003).

There is ambiguity in the previous published work about the effect of farm size on technology adoption, with various studies reporting different outcomes. It might be concluded that the effect of farm size on technology adoption process can vary depending on the location and the type of technology being introduced. However, the differences in estimated effects of land size can also reflect differences in the extent to which the effects of other adoption-relevant factors that are correlated with farm size have been removed in the various studies.

Market price responses to new technology adoption

Another significant phenomenon with implications for technology adoption is the market price response to increased supply of the crops that have been subject to technology innovation. In relatively small, isolated markets, this effect can play a major role in depressing the market price (McCulloch et al., 1998, Hayami et al., 1977, Gabre-Madhin et al., 2003). This phenomenon not only has adverse effect on farmers' income following widespread adoption of the new technology, but it also threatens the process of sustained technological advance (Gabre-Madhin et al., 2003). However, if the new technology is capable of reducing average costs per unit of output by more than the reduction in the market price of the output caused by overall rise in supply, then the new technology may be attractive to the farmers on aggregate (McCulloch et al., 1998).

Capital Constraint

It is difficult to measure the access to cash (through accumulated savings) and to credit in developing countries. It is therefore difficult to understand to what extent the lack of credit represents a constraint for adoption of a new technology (Doss, 2006). It is important to know whether there are formal and informal credit facilities, are they accessible to farmers, and what requirements farmers have to meet to be able to obtain credit (Perret et al., 2006). Access to credit was reported to be an important constraint to fertiliser adoption in Ethiopia requiring increased government investment to help establish credit facilities (Croppenstedt et al., 2003). A study on adoption of soil conservation technology and fertilisers reported that access to formal credit market was one of the major determinants of fertiliser adoption decisions. Households with access to formal credit were 24 per cent more likely to adopt fertiliser than those without access (Yesuf, 2004).

Off-farm income sources can act as a relevant source of finance for undertaking agricultural practices, as the off-farm income can reduce the capital constraint to some extent (Feder et al., 1985; Schuck, 2005, Pannell, 2006). However, off-farm employment may also decrease the tendency to adopt some practices that are potentially profitable but require more intensive management, because of increased time commitment off-farm (Pannell, 2006). In a study related to adoption of improved maize varieties in Nepal and micro-irrigation technologies in India, off-farm income was found to positively affect the technology adoption rate (Ransom et al., 2003, Namara et al., 2007).

Based on this review, previous published work shows the importance of capital for technology adoption decisions. The lack of capital might be a serious constraint for the use of better water management technologies in Eastern Indonesia, since such technologies require high initial investment for infrastructure (e.g. constructing the embung, digging a well, or constructing the permanent raised beds) as well as ongoing maintenance of that infrastructure.

Information/ Knowledge Constraint

Lack of information on the nature of the technology, including labour requirements, capital requirements, input requirements, and management process, can limit adoption (Perret et al., 2006). Overcoming information inadequacy requires a strong and effective extension service as well as learning from other sources, such as from neighbours (Doss, 2006). Existence of farmer groups or associations can have a positive effect on technology adoption as it may be helpful to overcome technical problems that are faced at individual or farm-level, and also can help in disseminating information from farmer to farmer (Perret et al., 2006; Pannell et al., 2006). A study on adoption determinants of micro-irrigation technologies in India finds that the successful adoption of micro-irrigation requires two pre-conditions in addition to the technical and economic efficiency. These are: “(1) the target beneficiaries need to be aware of the technical and economic superiority of the technologies. This may be achieved through extension service in the form of demonstrations, and (2) the technologies need to be accessible to the potential users since awareness or knowledge does not guarantee actual adoption unless the technologies are made accessible to the farmers through developing institutional support system” (Namara et al. 2007, pp.288).

Ransom et al. (2003) found that lack of information on improved varieties, and unavailability of improved seeds were the most important constraints restricting adoption of improved maize varieties in the hills of Nepal. Based on these findings the study recommends on-farm demonstration and testing to provide exposure of farmers to the new technology (Ransom et al., 2003). In addition, trialling has been found to enhance adoption as it provides an opportunity for the landholders to learn the skills to apply the innovation, and also provides information that reduces uncertainty about the relative advantage of the practice (Pannell et al., 2006).

Proper dissemination of information for promoting vegetable production in the study area can have a great impact on the farmer’s decision to undertake technology adoption. Farmers should have clear understanding of the various aspects of the technology i.e. what the technology demands (like labour, capital requirements) and what returns will the farmers get (economic benefit). In addition farmers should have complete knowledge on the vegetable production process from early stages of production, all the way through to post harvest handling and marketing information.

4.1.2 Asset Management

In the context of the present study, both permanent raised beds and embungs can be considered as infrastructure assets since they provide a flow of benefits over time. Depreciation of these asset calls for appropriate actions to be taken to maintain the assets, and ensure maximum benefits are derived from them. Currently, the users of these assets in Eastern Indonesia do not seem to have a clear sense of responsibility for

their maintenance, and this creates significant management problems. In particular, the accumulation of sediment in the embungs in West Timor due to continuous soil erosion in the catchment, as well as regular physical deterioration over time of PRBs in Lombok, are the main issues that require better management. The review of the previous published work on asset management especially focuses on management of soil erosion and sedimentation in the reservoirs which can be related to both embungs and PRBs.

Deposition of sediment in the reservoir over time reduces the flow of reservoir services, and can therefore be viewed as asset depreciation (Hansen et al., 2007). Sedimentation management activities, such as catchment management to reduce the rate of sedimentation, and physical removal of accumulated sediment can preserve, and recover lost capacity of reservoirs (Kapadia et al., 2002). Catchment management and soil conservation activities to reduce the rate of sedimentation include: enhancement of plant cover, improved land management practices, and construction of conservation structures (Pattanapanchai, 2005). While the soil management practices mitigate the sedimentation rate, sediment removal is often necessary to recover the lost storage in order to retain the usefulness of the reservoir for prolonged time. Some of the most important sediment removal techniques in use around the world include flushing, sluicing, dredging, hydrosuction, and trucking.

The suitability of a particular sediment management strategy can vary depending on various factors such as sedimentation rate, the use of the stored water, size of the catchment, size of the reservoir, soil type, rainfall intensity and other factors affecting rates of erosion, topography, and the opportunity cost of capital. It is not necessarily the case that the technically efficient option will be the most economically suitable. Kapadia et al. (2002) carried out an economic analysis of two conservation practices: contour farming, and strip farming, and compared these with the benefits of adopting no conservation technology in a reservoir in Northwest Connecticut. The results of the study indicated that on average, strip farming is most effective to control erosion, but economic analysis favoured the adoption of contour farming.

Sediment removal options can restore the reduced benefits from the reservoir services, so the cost of cleaning sediment can be considered as asset replacement cost. According to Perrin (1972), an important aspect in asset replacement is the determination of the replacement age. The main objective of asset replacement from a manager's view point is to maximise the present value of the entire future stream of benefits obtained from the asset-provided services. Hansen et al. (2007) note that in order to maximize the net benefits from sediment removal it is necessary that the marginal returns to cleaning are equalised with the marginal cost at the time when the reservoir is cleaned. They also note that the optimal time of sediment removal would typically be when sediment has accumulated up to 20-40 per cent of the original water storage capacity. They used 30 per cent sediment accumulation as the optimal cleanup timing in their empirical study (Hansen et al., 2007).

Various factors influence the desirability of particular sediment management options, including discount rate, sedimentation rate, and sediment removal options. At higher discount rates the sediment removal option may be less profitable than catchment and soil erosion management options. Discount rates are likely to strongly influence the optimal choice among sediment removal and catchment management strategies (Kawashima, 2007). Similarly, the sedimentation rate can alter the optimal choice of sediment management strategy. With high sedimentation rate, the time lag between the successive sediment removal events decreases, making the catchment management a more desirable strategy (Kawashima, 2007). Among the sediment removal options, Liu et al. (2001) recommend sluicing techniques for reservoirs with low sedimentation rate, and dredging for reservoirs with high rate of sedimentation.

4.1.3 Property Rights

Clearly specified property rights play an important role in managing and maintaining resources such as land, water, and irrigation systems. Property rights also establish incentives for continuous maintenance of these resources (Meinzen-Dick, 2000). Since property rights create confidence that the rightholders will get the future benefits of investment, and will bear the losses incurred by misuse of the resources, it motivates the users to avoid any inefficient use of these resources (Meinzen-Dick, 2000, Sarwan et al., 2005, Vermillion, 2001). According to McCulloch et al. (1998) if farmers do not have secure rights to natural resources, they generally lack the necessary incentives to adopt the new technology as they are not assured of the future benefits. Farmers' incentives to invest in technologies are mostly inhibited by weak tenure security of land, and by lack of land titles which hinders them from obtaining credit to make investments in new technology (McCulloch et al., 1998).

The importance of establishing proper water use rights system allowing local communities to manage water services and to achieve efficient water allocation has been emphasised by Sarwan et al. (2005) and Vermillion (2001). According to Vermillion (2001), continuing government or NGO assistance as well as international donor assistance, has created a sense of dependency among farmers, and discouraged them from taking collective action to maintain the irrigation systems, and leaving them with a notion that the irrigation structure belonged to the government/NGOs. Vermillion (2001) recommends that the potential for devolution of irrigation asset management can be further enhanced by establishing appropriate water right systems, which include exclusivity, transferability, clearly defined tenure of the right, and security of rights.

According to Bruns (2007), for property rights to be meaningful there have to be ways to enforce them. The right holders should pursue enforcement of their rights through the formal institutions in a society, most typically through the legal system. Educational efforts that promote legal literacy can be very helpful in improving the awareness about the legal rules, and inform the right holders of the appropriate steps for seeking help in case of problems (Bruns, 2007).

4.1.4 Social Aspects

Gender Constraints

Development projects that fail to consider and integrate gender considerations are seldom as successful as they could have been, as men and women often play distinct roles in a community (Seniloli et al., 2002). For example, women frequently plant certain crops and men plant others. Alternatively there may be a gendered divergence between who uses water and who manages the resource (Hunt, 2004). Women and men can also have different roles for both subsistence and cash crops and throughout the different stages of production i.e. preparation, planting, routine management, harvesting, post-harvest handling and marketing. It is important that any development project has a clear understanding as to what the gender roles are and how they interrelate. In many cases both men and women play important roles in decision making linked with technology adoption (Boserup, 1970, Hunt 2004). Given this, it is important that gender be considered during all four stages of a development project to ensure that new technologies are adopted effectively by the community[1].

Many data collection (rapid appraisal) techniques employed during the needs assessment and monitoring stages of development projects do not adequately provide opportunities

[1] *The four stages of the project cycle where gender needs to be considered include: (1) needs assessment and problem identification, (2) project design and appraisal, (3) project implementation and monitoring, and (4) evaluation (Quisumbing et al., 2006; UNDP, 2003).*

for women to talk freely especially when in the presence of men or community members of higher status (Hunt, 2004; Quisumbing et al., 2006). In many cases, the results derived from these data are less likely to be sensitive to gender or social dynamics. In Indonesia, even if women appear to be present in focus group discussions, it is often the case that they are the wives of the leaders; with women from different socio-economic strata rarely consulted (Gillian, 2000). Therefore project designers and implementers have a responsibility to be sensitive to gender and power dynamics within a community throughout the entire development process – this is particularly important when project interventions target the broader community rather than specific segments.

Social and economic analysis can bring about an understanding of the dynamics that dominate decision-making processes, attitudes, roles, responsibilities and actions of the target communities, which can in turn inform design of relevant projects, which can potentially stimulate higher uptake of new technologies. In some cases women do not wish to be included in project programming as they do not have the time or do not wish to be burdened with extra responsibilities (Gillian, 2000). However in many cases, it is women that hold the key to a project's success.

Crop preferences – constraints to technology adoption

Southern Lombok and West Timor are critical land areas in relation to water availability, experiencing frequent drought conditions and regular crop failures in both staple crops – rice and maize (Meindertsma, 1997). Smallholder farmers are the most vulnerable group under these ecological conditions as they have access to small parcels of land, little savings to draw upon in times of need, and low education levels. As a result, food security is often their highest priority (Perret et al., 2006). Vegetable production specifically for the market is often perceived as too 'risky' for smallholder producers, and as such, programs promoting vegetable production as part of their technological package may experience low adoption (Perret et al., 2006).

In Lombok and to a certain extent West Timor, the traditional staple crops (rice and maize) are often culturally and socially significant, providing the family with increased social status, hence farmers may be unwilling to reduce land areas dedicated to these crops (Meindertsma, 1997). In addition to being staple food and retaining social value, there is a long history of rice and maize growers getting support and subsidy from the Indonesian government (stable prices, subsidies and allocative priorities for inputs) (Mahar, 2003). This provides farmers with a sense of security under prevalent climatic and economic environments. This may affect how willing farmers are to move away from these 'safe' crops to endeavours that are perceived as more 'risky'.

Disconnect between technology providers and recipients

There is often disconnect between recipients of technology and technology providers, as the two parties may have 'diverging interests and agendas, and time scale perspectives' (Perret et al., 2006). This is becoming more apparent as the emphasis on 'sustainability' becomes prevalent among development workers. To keep up with this trend, 'researchers may be prone to develop resource conserving technologies for the sake of conservation, whereas the farmers' immediate agenda is short term production for survival' (Perret et al., 2006). As a result, programs are developed with little consultation or cooperation with the community and the ensuing technologies are often cumbersome and incompatible with local livelihood systems (social, economic and institutional) (Chambers, 2007; Perret et al., 2006).

Projects which are introducing new technologies and concepts must endeavour to work with target communities to ensure that the social beliefs, norms and values are incorporated into any new technology strategy. In addition they need to acknowledge local practices, knowledge and innovations to ensure that the resulting technologies are appropriate for local conditions and encourage increased adoption.

Summary

The review of previous published work indicates that availability of labour, farm size, cash/ credit constraints, lack of information, variation in market price are the most important constraints to technology adoption. These factors require serious attention in the process of introducing any new technology. From a range of literature on property rights it can be concluded that existence of clearly defined property rights also plays a crucial role in the farmers' decision on technology adoption. Properly defined and secure ownership of resources play an important role in assuring the sustained benefits from the adoption of technology and provides incentives for proper management of assets. Management of assets, such as regular maintenance of permanent raised beds, as well as management of the sedimentation problems in embungs are important areas of focus in this study. The literature review on asset management establishes that there is a need to undertake continuous management measures in order to maximise the benefits from use of assets since the established assets undergo a process of depreciation over time, resulting with declining benefits unless proper management actions are implemented. The importance of choosing the proper time and type of management to suit the prevailing economic, environmental and social conditions in order to maximize the benefits is highlighted in the literature. In addition to technical and economic aspects, some social constraints, like gender constraints and preference of traditional crops, are also crucial in the process of technology adoption and management of assets. Development of clear understanding about gender roles in farm activities requires attention so that the further steps in technology dissemination can be planned accordingly. Similarly, the prevalence of crop preference that can act as a constraint to technology adoption and the reasons for such preference should be better understood.

4.2 Data Collection

To further pursue the formulated research questions, primary data from farmers in the islands of Lombok and West Timor were collected during team members' visits to these islands. Two visits to the study locations of Southern Lombok and West Timor were made by the project team members in November 2007 and in February 2008. Each visit was relatively brief thus necessitating effective and efficient data collecting techniques, both qualitative and quantitative in nature. The initial visit in November 2007 was dedicated to collecting large amounts of qualitative information that was used by the team to gain a solid understanding of the various issues present in the target locations, and to help develop some initial research directions for the project. These data were collected with the aid of semi-structured interviewing and focus group discussions. The second visit in February 2008 was focused on the collection of quantitative data through the use of formal farmer surveys.

4.2.1 Semi-structured interviews and Focus Group Discussions

Team members used the rapid rural appraisal (RRA) technique of semi-structured interviewing (SSI) to collect qualitative data. The team consisted of individuals with various skills and backgrounds, including agricultural economics, social geography, and agricultural extension. The team made use of these various skills to gather a wide range of information from the target population in a relatively short period of time. At each target location key individuals or small focus groups were contacted and the team interviewed them as a group, or the team broke off into small groups of one to five to interview respondents. In this way, the team was able to focus their individual skills to direct the discussions/interviews in a targeted manner gathering valuable information on a range of different relevant topics.

This method aided in the collection of the bulk of social data as well as providing much of the background information to assist the understanding of the economic issues. It targeted many different individuals within a community, thus ensuring a balanced view of the

issues (women, men, youths and the elderly). The interviews were carried out with key informants, i.e. individuals who possessed specific knowledge that would be useful to this project to gain particular and in-depth information. To aid the carrying out of SSI, tools such as crop calendars and sketch mapping were utilised as aids to information acquisition, with the interviews conducted in houses, fields, gardens and around the water sources.

4.2.2 Farmer surveys

Formal surveys were conducted during the second visit to Lombok and Timor (February 2008). The survey questionnaire was designed around the previously identified factors (constraints) affecting farmer behaviour in agricultural water management and vegetable production in Lombok and West Timor. The aim of the survey was to collect further evidence about the relative importance of these factors from the viewpoint of the farmers themselves. Two questionnaires were designed, so that four of the five sections were common, and one section was specific to Lombok and West Timor, respectively.

The survey was developed with consultation and input from all team members and was carried out by students from the University of Mataram (Lombok) and Undana University (West Timor). The students were taken through the entire survey questionnaire to ensure that they understood each question and were trained by the team members in interview techniques before they were sent out to the field to implement the survey. The survey was tested by the students in both Lombok and Timor and the feedback from the field testing was used to modify and improve the survey questionnaire. Once the survey design was completed to the team's satisfaction, simple random sampling software was developed to randomly select respondents from the list of villagers. The students worked in pairs to collect all survey data from the selected respondents.

In Lombok, 90 respondents were surveyed in villages of two districts: Central Lombok and South Lombok districts. The villages that were covered during the survey were Mujur, Kawo, Segala Anyar and Rembitan. In West Timor, 76 respondents were surveyed in villages of two districts: South-Central District (TTS) and Kupang District. Within these two districts the villages that were covered include Nusa, Tupan, Manutapen, Oemasi, Bismarak and Oeltua.

4.2.3 Data analysis

Data collected from the farmer survey were analysed using statistical software packages EXCEL and SPSS. The analysis consisted of the following: frequency distribution and analysis, two-way contingency tables, and graphing.

4.3 Stakeholder workshop

To validate and cross check preliminary findings, as well as to elicit input from local experts, one day stakeholder workshop was organised in July 2008. The workshop was organised with the aim of presenting and discussing ideas and findings from the project. One of the main aims of the workshop was to elicit input and feedback from workshop participants in order to determine priorities for future research activities.

5 Key Findings and Discussion

The results from the analysis of collected data provide further evidence that some of the earlier identified factors indeed play an important role in determining farmer attitude towards water management, vegetable production and market engagement in the study areas. Some of the key findings are discussed below.

5.1 Constraints to technology adoption

5.1.1 Labour constraint

In both Lombok and West Timor, 3 out of 5 family members in an average household are available to work on the farm. Tendency of hiring outside labour for farm activities was found more pronounced in Lombok, as 67 per cent of the respondents reported to have been hiring labour, compared to only 51 per cent of the respondents in West Timor. Vegetable production is quite labour intensive and time consuming both during the production process and during post harvest handling. However, the respondents who were not producing vegetables in the dry season did not rank insufficient labour as an important factor governing their decision to not grow vegetables. This indicates that labour availability might not be a binding constraint to growing high value irrigated vegetable crops. However, as there were reports that preparation of permanent raised beds in Lombok, as well as sediment management for embungs in West Timor requires extra labour and extra cost, a further, more detailed analysis on the seriousness of the labour constraint may be required.

5.1.2 Land constraint

The farm land was mostly owned by interviewed and surveyed farmers in both Lombok and West Timor, with only few respondents stating that they were farming on rented land. Average farm size based on the survey responses was found to be 1.26 ha and 0.96 ha in West Timor and Lombok respectively. Since the proposed farming system using permanent raised bed technology involves converting 1/3rd of the farmland to raised beds, it was expected that the farmers in Lombok would be wary of devoting this significant proportion of their small land area. In addition, and considering the traditional attitude towards growing rice, most smallholder farmers were expected to be unwilling to sacrifice the small amount of land they have for rice cultivation in favour of the structures (beds and water storages) necessary for vegetable production. However despite these expectations, the survey respondents did not report land size to be a constraint to vegetable production in the dry season in Lombok. In West Timor only one respondent reported land size to be the main reason for not producing vegetables in dry season. The two way contingency table tests showed negative relationship between farm size and the tendency to grow vegetables in both West Timor and Lombok (Tables 1 and 2). The tables show the association between a farmer proneness to grow vegetables, and the farm size grouped in two categories; farms larger than 1 ha, and farms smaller than 1 ha. In these tables odds represent a ratio of the number of respondents who stated they are growing vegetables to the number of respondents who did not. The odds ratio is the ratio of the odds, and can be used to test whether the probability of a certain event varies across groups. In both West Timor and Lombok, the estimated odd ratios of less than one indicate a negative association between farm size and the tendency to grow vegetables.

The odds ratios in tables 1 and 2 indicate that it is only half as likely (0.43 and 0.56 times for West Timor and Lombok respectively) that a respondent who has a farm greater than 1 ha will also report growing vegetables, compared to a respondent who has a farm smaller than 1 ha. This implies that the smaller the area of the farm, the greater the proneness to grow vegetables. While the statistical significance of these results is limited

(see the reported statistics), they indicate the popularity of vegetables among small holder farmers, especially in West Timor.

Table 1: Contingency table for the relationship between total land and vegetable production, West Timor

Count of Respondents	Respondents growing vegetables				
Total Cultivated Land	Growing	Not Growing	Grand Total	Odds	Odds ratio
More than 1ha	28	5	33	5.6	0.43
Less than 1ha	39	3	42	13	
Grand Total	67	8	75		
Statistics for significance of the odds ratio:					
Pearson uncorrected chi-square test for significance: 1.244 (p-value:0.265)					
Fisher exact left-tailed test (to test if the Odds Ratio is significantly less than 1): p-value 0.229					

Table 2: Contingency table for the relationship between total land and vegetable production, Lombok

Count of Respondents	Respondents growing vegetables				
Total Cultivated Land	Growing	Not Growing	Grand Total	Odds	Odds ratio
More than 1ha	7	32	39	0.22	0.56
Less than 1ha	14	37	51	0.39	
Grand Total	21	69	90		
Statistics for significance of the odds ratio:					
Pearson uncorrected chi-square test for significance: 1.115 (p-value:0.291)					
Fisher exact left-tailed test (to test if the Odds Ratio is significantly less than 1): p-value 0.211					

The survey results showed that farmers with smaller land area planted greater variety of crops, and also that the smaller the land area the more farmers choose to grow vegetables (Figure 3, Tables 1 and 2).

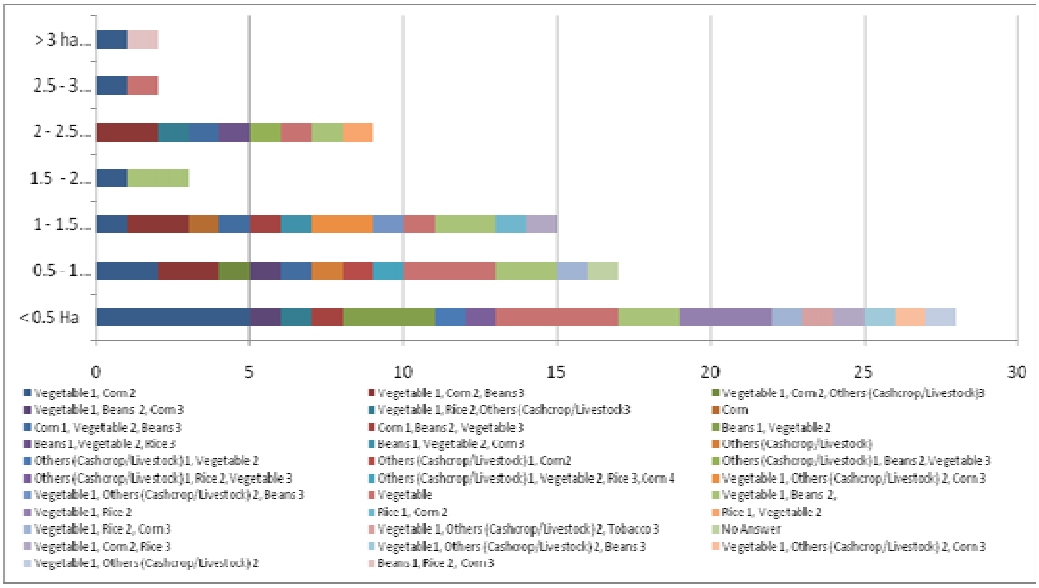

Figure 3: Crops grown by farmers with various land sizes

This implies that the extension and training programs related to vegetable production should target farmers who are interested in growing vegetables, rather than targeting the operators of larger farms who mostly grow staple crops.

5.1.3 Capital constraint

The initial establishment costs and maintenance costs for permanent raised beds was pre-identified as a possible constraint to adoption of this technology. Semi-structured

interviews revealed that it requires roughly 11 million rupiah to build raised beds. This is a very significant amount, and farmers face enormous difficulties to secure it. This indicates that lack of credit, or indeed lack of capacity to accumulate own capital, is a serious problem in Eastern Indonesia.

In principle, there are two ways for the farmers to access capital: (1) credit and (2) continuous own capital accumulation. However, there are various problems associated with both of these in the study area. In both West Timor and in Lombok more than 70 per cent of the respondents reported that they have no access to any type of credit facility. Since collateral is needed to access credit, farmers find it difficult to meet this requirement because of the low value of their farm land. Moreover, lenders charge very high interest rates due to the high transaction costs involved in monitoring small and risky loans for agriculture. Other alternatives for loan placements are often seen as more advantageous and less risky by lenders. Own capital accumulation is a potential alternative, but it is difficult for the farmers because of their limited resource base. Also the lack of future planning skills among the farmers may play an important role in their inability to accumulate capital as they tend to consume all of the current productivity gains only for the purposes of increasing current consumption.

5.1.4 Information/ Knowledge constraint

Survey results show that one of the major constraints for taking-up high value vegetable production is that many farmers are not confident about their capacity to cultivate vegetables (this was also verified through earlier semi-structured interviews and focus group discussions). Respondents stated that there is a lack of sufficient knowledge of production, pest and disease management, post-harvest handling as well as lack of understanding and knowledge about markets and marketing of vegetable crops.

Access to extension services was found to be more critical in Lombok compared to West Timor, as 71 per cent of the respondents in Lombok reported to have never met with an extension agent, while only 5 per cent in West Timor reported the same. Table 3 shows the distribution of respondents with respect to frequency of their meeting with extension agents. The reported low attendance of the extension service in Lombok could be a vital constraint to adoption of ACM, due to lack of awareness regarding the technology and its impact. An indication for this is that 66 per cent of the respondents in Lombok reported that they have never heard about PRB.

Table 3: Frequency of Meeting with Extension Workers (including but not only PPL)

Frequency	% Respondents (Lombok)	% Respondents (West Timor)
Once a month	0	21.05
Once every 2 months	1.11	1.316
2-3 times a year	14.44	10.53
Once a year	5.55	25
Never	71.11	5.26
Other	7.77	32.89
No response	0	3.95

The current status of providing training in water management and in growing vegetables in both study areas seems to be reasonable. 51 per cent and 79 per cent of the respondents in Lombok and West Timor respectively reported to have attended training on water management / or vegetable production. However, the survey results indicate that men have been typically targeted for training activities rather than women, even though women seem to be the ones that are responsible for vegetable production in the household. The gender bias in targeting the beneficiaries for training activities in Lombok was found to be more critical than in West Timor, as not even a single response was received for a female member getting training (Figures 4 and 5).

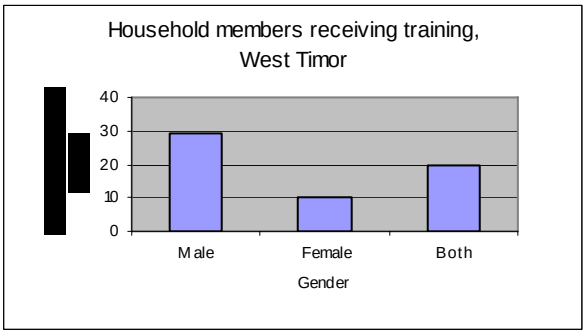

Figure 4: Distribution of extension beneficiaries by gender, West Timor

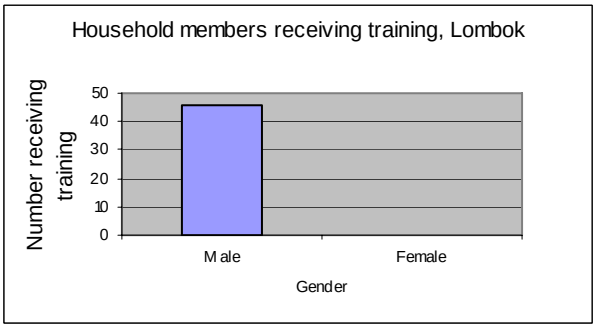

Figure 5: Distribution of extension beneficiaries by gender, Lombok

5.2 Constraints for market engagement

5.2.1 Logistics and transportation

Logistics and transportation were perceived as constraints to market engagement by 19 per cent and 3 per cent of the respondents in West Timor and Lombok, respectively. High transportation costs were emphasized as a matter of concern. Results on perception of main problems in dealing with market are given in Table 4. The fixed overhead costs, and the cost of transporting vegetables to the market for individual farms are relatively high because each household has only small amounts of marketable vegetable produced at any one time. To achieve a reduction in transportation cost, the household must either (1) grow larger amounts, (2) grow crops that allow storage of daily harvests without significant deterioration, so that larger quantities can be transported; (3) cooperate with other farmers so that one person can convey and sell produce on behalf of multiple households; or (4) sell directly to traders at the farm gate.

Cooperation of farmers in transporting and marketing may not be acceptable because of lack of trust in each other as to market dealings and proper return of sales income. Selling to traders / middleman can result with increased efficiency in transportation, but removes farmers from direct contact with the market, thereby reducing their information on market prices and conditions. At the present stage, the involvement of traders in the marketing chain appears to be relatively weakly developed. Therefore, promoting the role of traders in the marketing of vegetables to reduce the cost of transportation and storage, along with the establishment of proper information dissemination system about market prices to the farmers might be significant in reducing the marketing constraints.

5.2.2 Risk and uncertainty

Many respondents in both Lombok and West Timor expressed lack of confidence when dealing with the market, and limited knowledge of market opportunities. Respondents in Lombok highlighted two key problems when dealing with the vegetable market i) low prices (49.4 per cent of respondents) and ii) uncertainty related to vegetable prices (over 40 per cent of respondents). In West Timor, the two key problems were i) price uncertainty (61 per cent) and ii) difficulty of transportation and logistics (19 per cent) (Table 4). Traditional crops such as rice, maize and soybean remain more attractive, as farmers feel comfortable with the market for these products. However, even the marketing of these traditional crops i.e. rice and maize is quite limited as most of the produce is used for home consumption. In contrast, soybean in Lombok seems to be mainly grown for market (Table 5). Apart from the market related problems, risk and uncertainty in production seems to have an important effect on farmer's decision whether to grow vegetables.

Table 4: First Ranked Problems Faced in Marketing of Produce (% Respondents)

Problems	% Respondents (Lombok) n=90	% Respondents (West Timor) n=76
Uncertain price	44	61
Assured sale	1	5
Prices too low	49	6
Transportation and logistics	3	19
Others	3	9

Table 5: Distribution of respondents by share of crop sold in the market

Crops	Rice		Maize		Soybean	
Share sold	West Timor	Lombok	West Timor	Lombok	West Timor	Lombok
=> 50%	2.63	33.33	17.10	23.33		85.55
< 50%	97.36	66.66	82.89	76.66		14.44

Uncertainty about access to water was found to be another important factor in preventing farmers from producing high-valued crops destined for market. Among those respondents who are not producing vegetables in the dry season, the most important reason for not growing vegetables was lack of access to water for irrigation in West Timor, and in Lombok (Table 6). The two way contingency table tests indicate that there is strong relationship (statistically significant at 13.7 per cent level) between having access to sufficient water and growing vegetables in the dry season in both Lombok and West Timor (Tables 7 and 8).

Table 6: First Ranked Reasons for not Producing Vegetables in Dry Season (% Non Vegetable Growing Respondents)

Reasons	% Non Vegetable Producing Respondents	
	(Lombok) n=69	(West Timor) n=8
Inadequate Labor	3	0
Land size	0	12.5
Uncertain access to water	76.8	37.5
Don't know how to grow vegetables	3	12.5
Previous failure	4	12.5
Prefer other crops	4	0
Not interested	2	25
Other reasons	7	0

Table 7: Contingency table for relationship between access to water and vegetable growing in dry season, West Timor

Count of Respondents	Grow vegetables for market in dry season				
Can access enough water	Yes	No	Grand Total	Odds	Odds ratio
Yes	42	3	45	14	3.04
No	23	5	28	4.6	
Grand Total	65	8	73		
Statistics for significance of the odds ratio:					
Pearson uncorrected chi-square test for significance: 2.215 (p-value:0.137)					

Table 8: Contingency table for relationship between access to water and vegetable growing in dry season, Lombok

Count of Respondents	Grow vegetables for market in dry season				
Can access enough water	Yes	No	Grand Total	Odds	Odds ratio
Yes	4	3	7	1.33	3.21
No	17	41	58	0.41	
Grand Total	21	44	65		
Statistics for significance of the odds ratio:					
Pearson uncorrected chi-square test for significance: 2.212 (p-value:0.138)					

Apart from the limited access to water, other important problems found were: lack of knowledge, previous failure, and preference for crops rather than growing vegetables. All of these indicate that production risk and uncertainly is perceived to be particularly important for vegetable production.

Many respondents in West Timor stated that they would prefer to grow vegetables if they had sufficient water for producing high value crops (Figure 6). However, the farmers in Lombok indicated that they would prefer growing rice, provided that the water availability for irrigation is adequate. In West Timor more farmers would be growing vegetables in the dry season for market supply provided that they have reliable source of water supply for irrigation. In Lombok, it seems that more effort will be required in order to change the traditional attitude of the farmers, who seem to invariably favour rice.

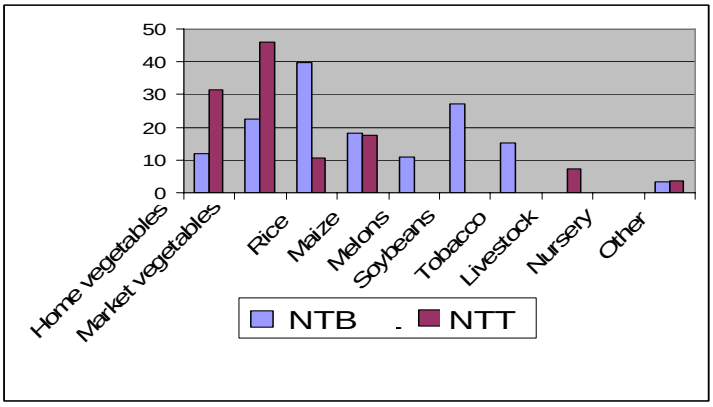

Figure 6: How farmers would use water if readily available in dry season

5.2.3 Market price response

The major market related problems that farmers are currently facing, i.e. uncertainty of price and generally perceived low price, may be expected to become even more pronounced if a significant number of farmers turned to high value vegetable production. Therefore, the issue of market response to widespread adoption needs to be addressed very seriously and calls for a more in-depth study on market demand and supply including the demand of the local market for fresh consumption, as well as for processing industries and export, in order to provide farmers with possible recommendations on adoption of water management technology and associated crop choice.

5.3 Issues around management of water infrastructure assets

5.3.1 Sources and access to water

Most of the respondents in West Timor reported that they access water from an embung (74 per cent). Deep wells (33 per cent) were also commonly used. The situation seems to be different in Lombok, where deep wells were the most accessed source of water supply (63 per cent), followed by supply from a spring (16 per cent), and embungs (14 per cent).

During the dry season access to water in Lombok is very unreliable (90.2 per cent of survey respondents indicated that they could not access enough water) with even deep wells drying-out. As a result of this intermittent supply, there is no sense of water security and 76.8 per cent of respondents indicated that this lack of water was the main constraint to taking up vegetable production (Table 6).

This implies that other water sources will have to be found, or more community water sources developed. In Lombok, traditional water use organisations (similar to those in Bali) are in place and need to be reviewed for their suitability in the target areas if communal water sources are to be introduced. To date, community water sources around the world have faced many of the same management issues as are faced in Lombok and West Timor, and these problems will only intensify if the water user groups are not strengthened.

Surveyed respondents in West Timor are also facing major water shortages, which present a significant constraint to the uptake of vegetable production at greater scale. This is despite the fact that many locations within West Timor are using community water storages (embungs), as farmers in some of these locations still reported significant shortage of water. Social issues impeding the use of water for improved vegetable production in these areas appear to relate to social conflict and poorly supported (eg. very limited training in infrastructure and water resource management) water user groups.

5.3.2 Issues around asset management

The benefits derived from assets decline over time due to continuous deterioration of the assets and require regular maintenance in order to sustain the flow of benefits. Water related assets in West Timor (embungs) and Lombok (PRBs) need proper management to restore the benefits lost due to soil erosion and sedimentation. The required extra cost and time for the maintenance activity can be an important constraint to adoption of PRBs. This was supported by the information collected from the semi-structured interviews.

The survey results regarding the management of embungs showed that the respondents are well aware of the sedimentation problem in embungs, and also of the possible causes of soil erosion (Figure 7). The need for embung management was widely recognised, as 73 per cent of the respondents perceived that management is necessary, and indicated their preferred type of management (Figure 8), while only 27 per cent preferred doing nothing at all with respect to the management of embungs. Despite acknowledgements of the problem, these problems are still not being addressed due to various social and economic reasons associated with embung management.

Social issues to embung management

The major factor contributing to the respondents' lack of interest in embung management seems to be the lack of a clear property rights structure. It appears that many embungs have been developed with little consultation with the affected community. As a result, there have been issues with apathy, land ownership, and jealousy between and within villages. There is a "lack of ownership" necessary to take on the responsibility for the embungs as most villagers were not involved from the beginning of the project.

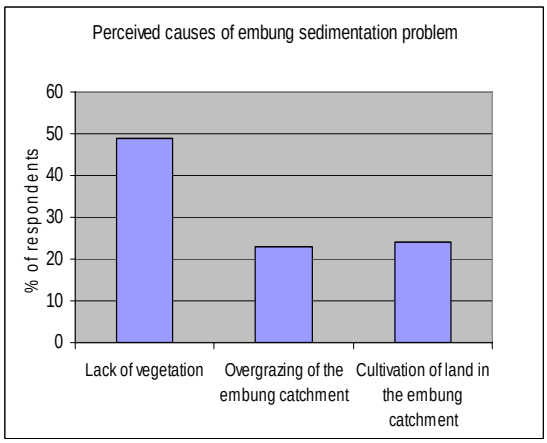

Figure 7: Causes of Embung Sedimentation

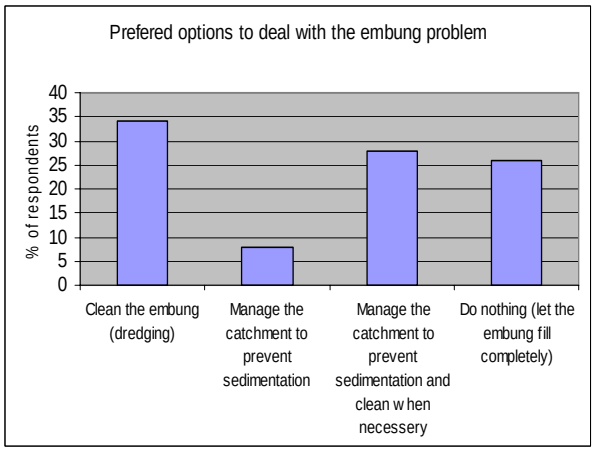

Figure 8: Activity to manage sediment in embung

The embungs are seen as the property of either the government or the original owner of the land (Figure 9). Survey respondents (66 per cent) expressed the view that embungs should be established as communal property (Figure10). In addition, some embungs are built too far from the village, thus making their maintenance very difficult. Also, the organisation of the users groups seems to be poor in West Timor. Initiating possible steps towards strengthening of the water user groups could be an important step towards establishing adequate water use rights.

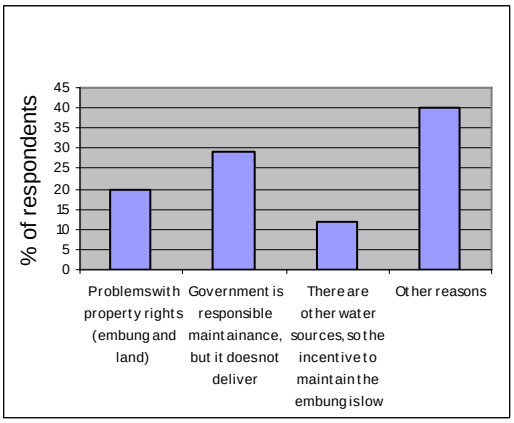

Figure 9: Perceived causes for improper embung management

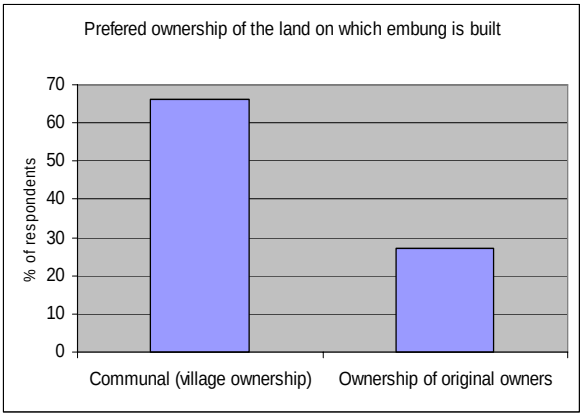

Figure 10: Distribution of respondents by preferred ownership type of embung land

Lack of community consultation has had a negative impact on the sustainability of the embungs. When the embung is being built the community can appear enthusiastic (as they are receiving something for nothing) and for the first few years there are very few problems. Eventually, upstream-downstream problems begin to emerge, as the people living and farming upstream have to travel further to get the water, compared to those who live and farm closer to the embung. In addition, the productive alternatives that the people close to the embung can pursue, and hence obtain higher incomes become very obvious with time, and thus jealousy results. Such jealousy has led to destruction of water assets and to waste of the water resource as individuals from other villages (or sub-villages) come and destroy the pipes or simply open the taps and let water run away so that no-one can use the water.

In many cases the embungs are not being maintained and are filling up with sediment, or they are being polluted, as well as being actively sabotaged. As a result, the embungs provide little water security and little real opportunity for farmers to take on the already high risk of producing high value vegetables. These issues will need to be resolved within

the communities before any extension efforts promoting new technologies are introduced, if sustainable long term results are desired.

Economic issues around embung management

The construction of embungs has in essence provided villages with a free expansion of their resource base. However, for these assets to become a permanent addition to the resource base, their continuing maintenance and management is needed. Management actions to recover the lost water storage space due to sedimentation require continual funding. The information from the semi-structured interviews indicates that it costs around 600 million rupiah to build an embung that services about 70 households, while the cost of cleaning the sediment from an embung is around 160 million rupiah. In addition, any catchment management activity directed towards reducing the sedimentation rate would also be costly, both financially and in terms of resources (labor, land) that would have to be devoted to catchment management.

Currently, there is no provision among the embung water users for collecting any payment that could be used to fund sediment management activities. In a sense, the water users consume the services from the embung, allowing it to deteriorate, without putting aside any 'depreciation' payment to ensure that this valuable asset can be properly maintained, and replaced when needed. The water users seem to expect governments at various levels to maintain the embungs (Figure 9). As noted previously, due to unclear ownership and jurisdiction over the embungs the responsibility is tossed around from one level of government to another all the while the process of sedimentation continues to deteriorate the embungs. Therefore, adequate property rights structure of the embung ownership and use can play a significant role in addressing the issue regarding the responsibility of bearing such costs.

One possible way out of this impasse could be through collection of monthly or annual payments from water users, so that funds could be accumulated for proper maintenance of the embungs and sustainable water supply for these villages. The survey results showed that a significant number of respondents (88 per cent) in West Timor are willing to make some payment for embung management, but the amount of money that the respondents pledge is relatively small (mostly 5,000 rupiah per month, which at the current exchange rate is about 0.9 AUD) (Figure 11).The maximum stated willingness to pay was 10 thousand rupiah per month. No respondents chose the highest option given (15000 rupiah per month).

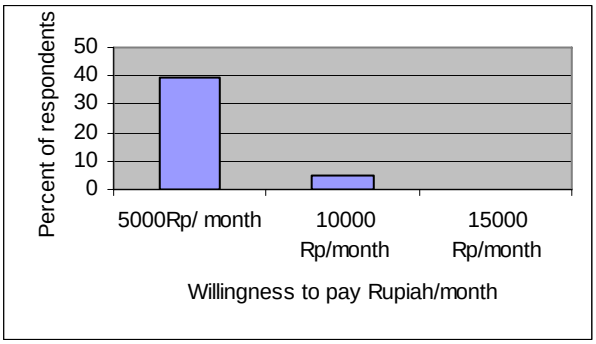

Figure 11: Payment for embung management

5.4 Social issues in water management

5.4.1 Gender Constraints to technology adoption

For both West Timor and Lombok there appears to be significant gender division in production roles. This is more marked in Lombok, where production responsibility appears to be highly differentiated, with vegetable production generally in the female domain while

the production of staple crops along with water resource management for irrigation and commercial crop production being predominantly the responsibility of men. In West Timor too, women appear to hold the primary responsibility for the production of vegetables. However, here the production of other crops such as the staple maize is carried out by both males and females.

In Lombok, the production of vegetables is primarily for household consumption with any excess sold in local markets. Since women are taking care of the whole process, including marketing, they seem to have some discretionary rights over the proceeds from vegetable production. The vegetables are generally not cultivated on main plots and are usually produced on other available land such as around the house, on sawah dikes or along side of roads which are not suitable for main crops. The production of rice and other commercial crops such as soy beans, tobacco, long beans & water melon takes place on the main, most valuable production plots.

In West Timor, as there is more land available, women often have a specific area dedicated to vegetable production and there appears to be more value attached to the production of the vegetables than in Lombok. There is some contribution from both genders, with males assisting in the initial creation of the vegetable beds ('hard'/physical labour). The women carry out the bulk of cultivation and production activities thereafter, including the marketing of the crop.

With this recognition of the gender breakdown of activities in vegetable production, it is quite clear that women in both Lombok and West Timor need to be targeted by extension programs seeking to introduce technologies to enhance high value vegetable production. However, to date, extension efforts have been directed differently, with men having been the primary recipients of these extension efforts (Figures 3 and 4).

In Lombok, commercial crop production and water resource management are in the domain of the men. Male household members will most likely be responsible for the production of high value vegetables, but women will still contribute to most aspects of production as well as taking primary responsibility for marketing. This means that extension programs can usefully target both males and females. In West Timor, it is inappropriate not to target a greater number of women than men in extension training as in all likelihood it is women who will take on the responsibility for commercial production of vegetables, as many men show little interest.

The result of the present bias in extension efforts is that key people are not effectively targeted to participate in training. Village level support for the development of skills and dissemination of information is likely decreased and the overall result will most likely be less effective uptake and implementation of new technologies.

This gender differentiation of roles and responsibilities in West Timor could also be the cause of a significant constraint to maintenance and renovation to most embungs. It is possible that, as water from the embungs is predominantly used for household consumption and the production of vegetables—neither being primarily a male responsibility, this could be a reason for the lack of serious forward movement on maintaining or repairing the embungs. With the interests of men lying in the production of maize that is rain fed in most areas, the loss of embung water may not be perceived by the males in the village as a significant detriment.

5.4.2 Traditional smallholder attitudes to Rice/Maize and vegetables – A constraint to uptake of high value vegetable production methods

In Lombok, the social and economic importance given to rice by farmers means that many farmers are highly reluctant to convert even small parts of their existing productive rice plots to permanent raised beds, or to water catchments such as embungs for vegetable production. Vegetables are at the best of times seen as a secondary crop with rice the preferred smallholder crop. 71 per cent of respondents ranked rice as their preferred crop when all crops were assumed to deliver equal profit (Figure 12).

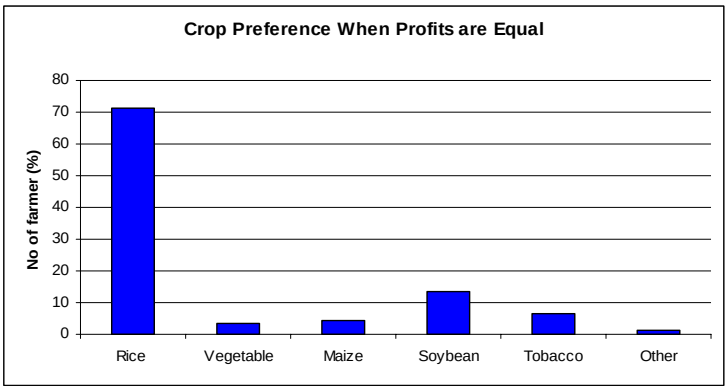

Figure 12: Crop preference when profits are equal, Lombok

Vegetables are also seen as a community good, not commercial, being shared with other households on request. In many cases, only excess vegetables are sold to local traders and markets. Rice on the other hand is traditionally seen by the households as the key to their food security and it is taken to be a family responsibility and commitment to provide rice. This has possibly evolved from the durable nature of rice and the ease of its production (Figure 13). It is also fundamental in ensuring status within the community, as cultural and social status is ascribed with rice production by local communities.

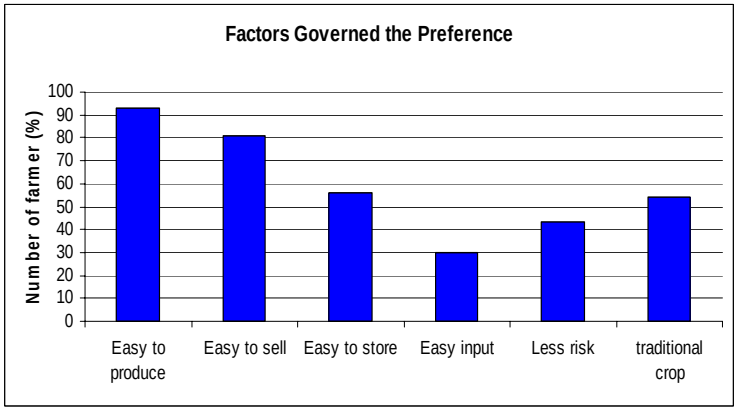

Figure 13: Factors governing crop preference, Lombok

The attitudes to the maize as a staple crop in West Timor are similar to those towards rice in Lombok. Staple crops are highly prized and will be prioritised by many smallholder households to a certain degree, as 86 per cent reported to grow maize in wet season and 59 and 68 per cent grow maize in dry season 1 and 2 respectively. However from the survey results, and from the field interviews it would appear that West Timor small holders ascribe more value to profit since 53 per cent indicated this as the main reason for choosing a crop, with only 38 per cent indicating that staple crops influenced their choice (Table 9). Therefore, households in West Timor may be more willing than those in Lombok to dedicate more time and land to vegetable production in future.

Table 9: First Ranked Factors for the Choice of Crops Grown (% Respondents)

Problems	% Respondents (Lombok) n=90	% Respondents (West Timor) n=68
Food security/ staple crops	28	38
Profit	17	53
Ease of cropping	6	4
Access to inputs	0	1
Copy others	4	3
Water Availability	45	0

It can be concluded that the traditional perceptions of the value of rice/maize over vegetables will be a significant constraint to the introduction of technologies that are designed to promote the production of vegetables at the expense of staple crop production. This will be more evident in Lombok than in West Timor as in the latter it appears that profit is more important to smallholders than in Southern Lombok, where growing rice based on cultural and social motives remains strong. It is especially difficult to promote permanent vegetable production while food security remains a key issue (Table 9) for the majority of target farmers. To ensure that any of the new technologies are appropriate to the community, programs need to be sensitive to this issue and need to utilise farmer-centred methodologies when approaching new communities with vegetable orientated activities.

6 Strategic research directions

The findings reported above encompass a set of constraining factors that appear to be important for better water management in high value vegetable crops in Eastern Indonesia. Based on these findings several key areas for further investigation have been identified. These include: water infrastructure capital asset management; the role of risk and uncertainty and potential risk management solutions in relation to production and market engagement of high value crops; the relationship between quantity supplied and demanded of these high value vegetable crops and their market prices; and the role of social attitudes and perceptions in relation to water management in high value vegetable crops in Eastern Indonesia. It appears that without profoundly understanding these key factors, no definitive policy advice can be given to governments and international donor agencies about the most effective way of directing funds and efforts in improving livelihoods of farmers in this region of Indonesia through improved water management practices. Each of these recommended strategic research directions are briefly discussed below.

6.1 Water infrastructure capital asset management

As the management of water infrastructure capital assets (including embungs, deep wells, irrigation canals, and even permanent raised beds) seems to be a key for sustainable management of available water resources, better understanding of the major constraints that prevent adequate management is required. This includes evaluating the role of alternative property rights regimes, water allocation mechanisms, cost of maintenance, and jurisdictional responsibilities for maintenance of this infrastructure.

While the issue of water infrastructure management is relevant for both NTB and NTT provinces, it seems to be particularly significant in relation to the use of communal water storages (embungs) in West Timor. Several specific research directions have been identified for this problem:

1. Evaluating the cost-effectiveness of alternative sediment management strategies. This should involve testing alternative catchment management options, combined with sediment cleaning activities, so that the least costly option for sustainable management of the embungs are determined.
2. Evaluating alternative approaches to empower user communities to look after water infrastructure assets. This should involve testing alternative arrangements for making local water user groups responsible for maintenance of embungs. Alternative arrangements might include forming community funds (similar to the sinking funds in Australian residential strata plans) that could be earmarked for repair and maintenance of embungs, or introducing a water user fee which could also be earmarked for the same purpose.
3. Examining the effects of current property right regimes on the use of water from the embungs, the resource conflict, and jurisdictional conflict of authority. This should involve detailed analysis of current set of property rights related to embungs (land, storage structures, water use rights) and how it is impacting the incentives of users. This can then be used to explain the resource conflicts that are occurring, as well as shed some light on the jurisdictional conflict of authority.

6.2 The role of risk and uncertainty in relation to market engagement and technology adoption in NTB and NTT

The perception of risk and uncertainty in relation to production of high value vegetable crops, as well as in relation to marketing of these crops seems to be quite significant

among farmers in Eastern Indonesia. Several important research questions have been identified, which if addressed properly can uncover important reasons for the currently observed behaviour. Some of these questions are:

1. Can the production risk be managed by technological interventions, and if so what technological interventions are most appropriate for Eastern Indonesia? This might include determining optimal cropping patterns to minimise production risk originating from uncertain climate; designing decision support systems in conjunction with seasonal climate forecasts that will support optimal decisions by farmers in the face of uncertain production conditions; and evaluating alternative cropping systems in relation to their susceptibility to production risk and uncertainty.
2. Can the production and market risk be managed by some market based instruments, or other institutional interventions? This should include evaluating the suitability of alternative risk-management tools such as insurance products, or community self-insurance funds.
3. Is there justification for the perception of high risk that farmers seem to have, or is it just a product of misinformation and lack of education of how markets operate? This should include testing hypothesis about perceptions of market risk, and potentially conducting field experiments in trying to elicit the correct perceptions of market engagement among farmers.

6.3 Estimation of market price elasticities for high-valued vegetable crops in eastern Indonesia

There are valid concerns being raised about the potential supply shocks that could occur if high value vegetable crops were to be produced on a large scale. This might negatively impact prices, and hence the profitability of the enterprise. A thorough investigation of own-price and cross-price elasticity (where key competing crops are going to be included e.g. rice, soybeans, maize) is necessary to determine the likely impacts of changes in quantities supplied of these vegetable crops. In addition, this will shed some light as to how will the profitability of these enterprises be affected by the volatility of the prices in other commodities, such as current situation with rice prices.

6.4 The role of social attitudes and perceptions in relation to market engagement and technology adoption in NTB and NTT

Social attitudes, traditionalist behaviour and the role of gender are clearly some of the important factors that determine behaviour in relation to water management in high-value vegetable crops in eastern Indonesia. Several research questions have been identified in this area:

1. Is the preference for staple crops (typically consumed in the farm-household) to high-value vegetable crops (typically sold on the market) a result of social attitude and traditionalist behaviour? This should include conducting in-depth socio-economic surveys in the study areas with an aim to elicit response that will determine the causes of observed behaviour.
2. Does the division of roles in farm production according to gender (men are responsible for staple crops, whereas females are responsible for vegetable crops) influence the overall decisions about the crop choice and market engagement? This should again involve in-depth socio-economic surveying to determine the role of gender in farmer decision making.

7 Conclusions and recommendations

Better management of water resources that allows alteration of the natural distribution of available water is seen as one of the ways to improve livelihoods of many farmers in the two provinces of eastern Indonesia, Nusa Tengarra Timur and Nusa Tengarra Barat. The prevailing paradigm has been that if more water is made available in the dry season, which is quite pronounced in these two provinces, the farmers would be able to grow additional and presumably high-value crops, thereby generating extra income and improving their living standards. Even though this paradigm has been present for some time, and some concrete steps by Indonesian governments and international donor agencies have been taken in this direction, it seems that farmers have not been too keen to abandon traditional farming practices of growing staple crops and to engage in production of high value vegetable crops at any significant scale.

The aim of this scoping study was to identify the set of factors in the domain of economics and social science that contribute to this behaviour, and to pinpoint some key research areas that are crucial for understanding such behaviour. Pursuing those key research areas will then produce results that can inform policy and donor efforts targeting agricultural development in this region of Indonesia.

Several research approaches were used to identify the set of factors that affect water management for high-value vegetable crops. These included: review of the previous published work, semi-structured field interviews, formal survey of farmers in the region, and a stakeholder workshop. The information gathered in this way was further analysed, which resulted in identifying the set of key constraints for water management in vegetable production in these provinces of Indonesia. The set of important factors included the following: capital constraint and access to credit, market price risk, production risks, inadequate incentives for maintenance of water infrastructure capital assets, social attitude and gender factors, marketing problems including transportation and logistics, problems with extension and diffusion of knowledge, inadequate properly rights structures in water management, institutional problems in water management, labour constraints, and land constraints.

Of these, several factors were identified as being of crucial importance for understanding the behaviour in relation to water management for high-value crops in eastern Indonesia. These are: economics of alternative approaches to water infrastructure asset maintenance and management; managing risk and uncertainty in high-value irrigated vegetable crops; determining market price responses to changes in quantities supplied; and investigating social attitudes and perceptions in relation to market engagement and technology adoption. More in-depth research into these areas will produce answers that will inform government policy and international donor agencies efforts directed to improved agricultural water management in Indonesia.

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