IDENTIFICATION OF SOCIAL CAPITAL FOR UNDERSTANDING AND RAISING PLANT BIOSECURITY AWARENESS, KNOWLEDGE, AND ACTIONS

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Abstract

Social capital is increasingly used as a comprehensive approach for overcoming complex problems. In this study, a social capital approach was used to increase understanding and improve interest, knowledge and implementation of biosecurity measures. This study was conducted from May to July 2007. Data was gathered through household surveys and field observations in Noelbaki village, Kupang District, Nusa Tenggara Timur. Results of the analysis indicate that some variables of social capital relate closely to knowledge and implementation of biosecurity measures. However, variables that relate to a single aspect of biosecurity may not necessarily have any relationship with other aspects. The level of 'interest' has a positive correlation with the number of collective activities occurring and the level of participation in these collective activities. Interest also increases with frequency of communication and total information sources accessible by members of the community. 'Knowledge' improves with involvement in an increased number of community groups, increased collaborative activities and greater cooperation. Knowledge levels also improve where information is sought from a greater number of stakeholders and the time needed for transfer of information is decreased. Finally, community members will be more willing to participate in 'implementation' of control measures if they are involved in a greater number of groups, have increased communication with other stakeholders, the time needed to access information is decreased and more information sources are accessible.

Introduction

Crops are subject to pests and diseases that reduce production both in quantity and quality. This yield loss is much higher in developing countries where crop protection has not yet been appropriately implemented than in developing countries where crop protection policy is well established. As an illustration, global crop loss estimates provided by Oerke *et al.* (1994) showed that crop loss in Asian countries was higher than that in North American and European countries. Crop loss for wheat in North America was valued at US $ 6 million (NRC 2002; Wheelis *et al*. 2002). The value of crop loss for food crops in Southeast Asia is lower due to the lower production quantity, but it has tremendous impacts in terms of food security. Brown planhopper explosion in 1985 resulted in

Indonesia becoming an importer of rice after being an exporter during the previous year (Untung 1993).

Efforts to reduce the crop loss caused by pests and diseases have been evolving from trial and error through the use of pesticide as the main weapon to finally using an ecological approach called integrated pest management (IPM) (Kogan 1998, Levins & Wilson 1980). IPM focuses on existing pests and diseases rather than on those invading from outside. Within the last decade, especially after bioterrorism using biological agents has become a serious threat worldwide, a more comprehensive approach in dealing with pests and disease problems has been developing. This approach is called biological security, or biosecurity for short, within which crop protection is an important component of a much broader context (Delane 2001, Meyerson & Reaser 2002 a, b). As with crop protection policy and practices, much initial work was on technological aspects and little attention was given to social aspects of this approach.

Previous experiences have shown that social aspects play important roles in determining the success and sustainability of a particular crop protection program. Research has indicated that farmers do not implement a particular pest management measure as it was prescribed but according to their interpretation based on their traditional way of thinking (Vayda 1996, Vayda & Setyawati 1998). Farmers also make their own simple economic calculation on which they determine pests and diseases to be given priority. As the result, pest and disease management programs developed by the government are not necessary followed by farmers (Londingkene *et al*. 2004, Mudita *et al*. 2004). Social aspects of crop protection are in fact very complex, dynamic, and consist of various interlocking components. To deal with aspects of such complexity in nature, a new approach called social capital has been now becoming widely used. Social capital has been proven by Grootaert (1999) as a useful approach in elucidating factors related to the widespread poverty in Indonesia after the 1998 economic crisis.

Social capital can be viewed as a unifying concept embodying multidisciplinary contexts along three dimensions: its scope (or unit of observation), its forms (or manifestations), and the channels through which it affects development (Grootaert & van Bastelaer 2001). Referring to work of Putnam *et al*. (1993), Colleman (1990), and North (1990), the scope of social capital can be divided into micro, messo, and macro levels. At its micro level, social capital is understood as those features of social organization, such as networks of individuals or households, and the associated norms and values that create externalities for the community as a whole. Meanwhile, social capital as a variety of different entities which all consist of some aspect of social structure, and which facilitate certain actions of actors –whether personal or corporate actors– within the structure implicitly considers relations among groups, rather than individuals, and thus provides a messo scope. The third and most encompassing (or macro) view of social capital includes the social and political environment that shapes social structure and enables norms to develop. Whether at the micro, messo, or macro level, social capital exerts its influence on development as a result of the interactions between two distinct types of social capital, *i.e*. structural and cognitive. Structural social capital facilitates information sharing, and collective action and decision-making through established roles, social networks and other social structures supplemented by rules, procedures, and precedents. On the other hand, cognitive social capital refers to shared norms, values, trust, attitudes, and beliefs. The later is therefore a more subjective and intangible concept then the former (Uphoff 2000). Any form of capital, material or non-material, represents an asset or a class of assets that produces a stream of benefits. The stream of benefits from social capital, or the channels through which it affects development, includes several related elements, such as information sharing and mutually beneficial collective action and decision-making (Collier 1998).

The stream of benefits from social capital is capable of generating material/market and non-material/non-market returns to the individual. For example, Kamrul-Islam *et al.* (2006) found a positive association between social capital and better individual health. With respect to plant biosecurity, it can be expected that social capital will also be associated with awareness, knowledge, and actions among members of the community. The challenge is to determine which components of social capital have significant roles in raising awareness and understanding of biosecurity and can lead to taking necessary action. To find out, social capital was used as an approach in the East Nusa Tenggara site of a long term Australia-Indonesia cross-boundary research on raising community-based awareness of biosecurity. It was expected that from the phase I of this multi-years research, baseline information on determining social capital components could be identified. This information will be useful as an entry point to understanding and raising biosecurity awareness among members of the community in the next phase.

Research Methods

Time and Location

This phase I research was carried out in April-July 2007 in a village selected from three proposed villages for the site in East Nusa Tenggara Province. Selection was based on criteria of existence of various land uses, existence of unharvested crops in the field, and heterogeneity of ethnic composition of the population. The selected village, Noelbaki, is located in Kupang District, 16 km to the east from the town of Kupang on the main road linking Kupang with Atambua, the easternmost Indonesian town in the island of Timor. This village is easily accessible from the town of Kupang using rural transportation vehicle (angdes) or using inter-town busses. The village area is 17.7 km^2 and the population in 2006 was 6,389 people in 1,321 households, resulting in a population density of 361 people/km^2 or 75 households/km^2 (BPS Kabupaten Kupang 2006).

Most of the village area consists of flat land. This flat land is part of a larger Oesao-Pariti Lowland, the second most important lowland in the island of Timor after the Besikama lowland located in the southern coast of Belu District. A slightly undulating topography is found only in the southern part of the village along the village border with its neighboring Oelmasi Village. The lowland receives an average of 1,481 mm annual rainfall within 120 days during the period of November-March. Irrigated rice field is the dominant land use, particularly in northern part of the village, compared to permanently cultivated dryland, shifting cultivation, secondary woodland, and settlement concentrated in the southern and southeastern part of the village area (Kantor Desa Noelbaki 2006). Irrigation water for the rice field is provided by the Dendeng Dam, a small dam located within the village area, and more recently also by the Tilong, a large dam located in Oelmasi Village.

Data Collection

The collected data consisted of primary and secondary data. The primary data were collected through interviews and field observation, whereas the secondary data were obtained from village offices and other institutions. In the process, secondary data were collected ahead of primary data so that the resulting information could be used as the baseline for designing the survey and field observation.

The sampling unit for the survey was the household, whereas for policy makers it was government institution. Household samples were determined according to the stratified random sampling procedure, for which the strata and the sample size within each stratum followed the recommendation of the Denpasar workshop held in May 2007 as follows: (1) farmers (24 respondents), (2) non-farmers (8 respondents), and (3) local organization leaders (9 respondents). Samples for policy makers was intended to be from three institutions (Village Office, Sub-District Office, and Kupang District Food Crop Service Office), but only one institution was available. Randomization was done within strata after consulting the village staff concerning the household population within each stratum being used as a sampling frame.

A questionnaire was designed to collect social capital as well as biosecurity data. The part of the questionnaire for collecting social capital data was designed according to the social capital questionnaire structure developed by Grootaert *et al.* (2004). Questions on social capital were designed to capture the multi-dimensional aspects of social capital, both its structural and cognitive aspects (Krishna & Uphoff 1999). The structural aspect covered group and network type in which members of the community were involved and contribution provided to, and benefit obtained from, such groups and networks. On the other hand, the cognitive aspects covered subjective perception on thrustworthiness of one member to another that in turn would influence the livelihood of the member and norms concerning joint actions taken and reciprocity to attain a particular common goal. In addition to these aspects, questions were also asked to cover a third aspect called linking social capital, concerning the relationship of someone to those having certain political and private authorities (World Bank 2000). Following Grootaert *et al.* (2004), questions on social capital were grouped into the following sections:

1) Groups and Networks. The questions here considered the nature and extent of a household member's participation in various types of social organizations and informal networks, and the range of contributions that one gave and received from them. It also considered the diversity of a given group's membership, how its leadership was selected, and how one's involvement had changed over time.
2) Trust and Solidarity. This category sought to procure data on trust towards neighbors, key service providers, and strangers, and how these perceptions have changed over time.
3) Collective Action and Cooperation. This category explored whether, and how, household members had worked with others in their community on joint projects

and/or in response to a crisis. It also considered the consequences of violating community expectations regarding participation.

4) Information and Communication. This category of questions explored the ways and means by which households received information regarding market conditions and public services, and the extent of their access to communication infrastructure.
5) Social Cohesion and Inclusion. Questions in this category sought to identify the nature and extent of these differences, the mechanisms by which they were managed, and which groups were excluded from key public services. Questions pertaining to everyday forms of social interaction were also considered.
6) Empowerment and Political Action. The questions in this section explored household members' sense of happiness, personal efficacy, and capacity to influence both local events and broader political outcomes.

The above sections thus reflects the group membership ("structural") and subjective perceptions of trust and norms ("cognitive") dimensions of social capital (sections 1 and 2), the main ways in which social capital operates (sections 3 and 4), and major areas of application or outcomes (sections 5 and 6).

In addition to the part concerning social capital, the questionnaire also consisted of parts covering awareness of, knowledge of, and actions taken to, manage pests and diseases damaging crops in the village. Questions concerning these aspects of biosecurity were coupled with direct field observations to enable any pests and diseases mentioned during the interview be verified. The field observation was carried out using IRRI (1983), Kalshoven (1981), and Semangun (1988, 1989, 1990) as references and field guides. Pests and disease control actions taken by farmers were verified using government recommendations as available in Komisi Pestisida Departemen Pertanian (1999).

Data Analyses

Answers to social capital questions are tabulated to yield data of nominal, ordinal, or rational variables. The list of social capital variables covered in this survey is presented in Table 1.

Table 1. List of Social Capital Variables Derived from the Social Capital Questionnaire

Section	Variable	Code
Groups and Networks	Involvement in groups	GRPS
	Involvement in networks	NETS
Trust and solidarity	Trust to community	CTRUST
	Trust to government	GTRUST
	Solidarity	SOLID
Joint action and cooperation	Number of joint action participated	ACTS
	Community leader participation	LEAD
Communication and information	Number of communication carried out	COMS
	Time required to access information	TINFO
	Frequency accessing information	FINFO
	Number of information sources	SINFO
Social cohesion and inclusion	Perception of safety	SAFE
	Number of excluded households	EXHSE

	Perception of being excluded	BEXCL
	Perception of being included	INCLS
Empowerment and political action	Control over household decision making	HCTR
	Control over decision making in the community	CCTR
	Control over governmental policy	GCTR

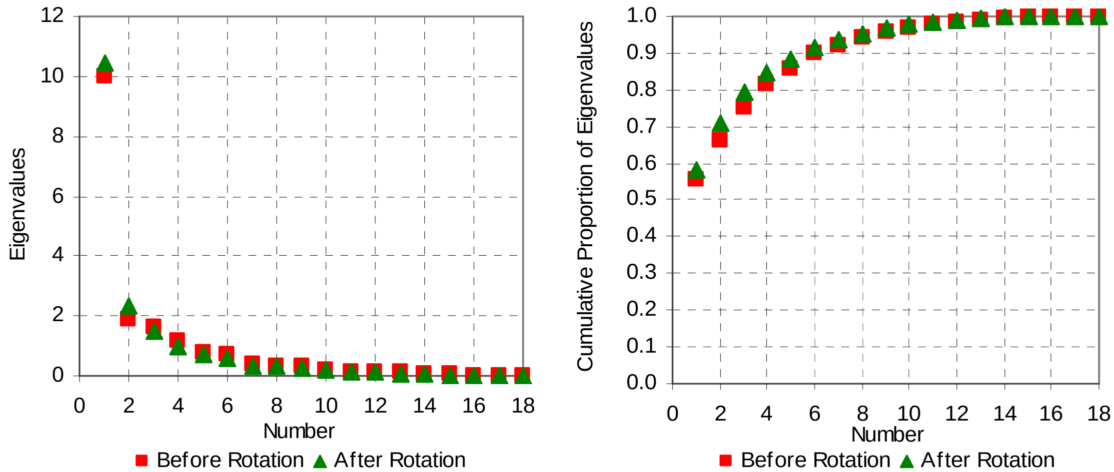
At the same time, tabulation was also carried out on biosecurity variables. The resulting values of biosecurity variables were then used to calculate the indices as follows:

1) Awareness index (AWARE): the proportion to the maximum ratio of the number of pests and diseases mentioned in the interview (s) to the total number of pests and diseases found from field observation (q). If the ratio of s/q was denoted as r_a then AWARE was calculated by dividing the r_a of each respondent with the maximum r_a of all respondents.
2) Knowledge index (KNOW): the proportion to the maximum ratio of the number of pest and diseases correctly mentioned during the interview (p) to the total number of pests and diseases found from field observation (q). If the ratio p/q was denoted as r_k then KNOW was calculated by dividing the r_k of each respondent with the maximum r_k of all respondents.
3) Control action index (ACTIONS): the proportion to the maximum ratio of the number of appropriate control measures taken according to the government recommendation (m) to the total control measures taken by farmers obtained from the interview (n). If the ratio m/n was denoted as r_c then ACTIONS was calculated by dividing the r_c of each respondent with the maximum r_c of all respondents.

Separate regression analysis was carried out for AWARE, KNOW, and ACTIONS using social capital as independent variables. Before regression analysis was carried out, a diagnostic test was carried out to determine which social capital variables were auto-correlated. This diagnostic test was performed simultaneously with a preliminary test aimed at reducing the number of independent variables to be involved in the regression using principal component and factor analyses (SAS Institute Inc. 1990a, b). Regression analysis was then carried out by retaining only social capital variables that were appropriately represented by the first factor after the data were rotated using factor procedure. Multiple regression analysis was performed using the score of social variables resulting from the factor procedure by employing the stepwise variable selection procedure (SAS Institute Inc. 1990a).

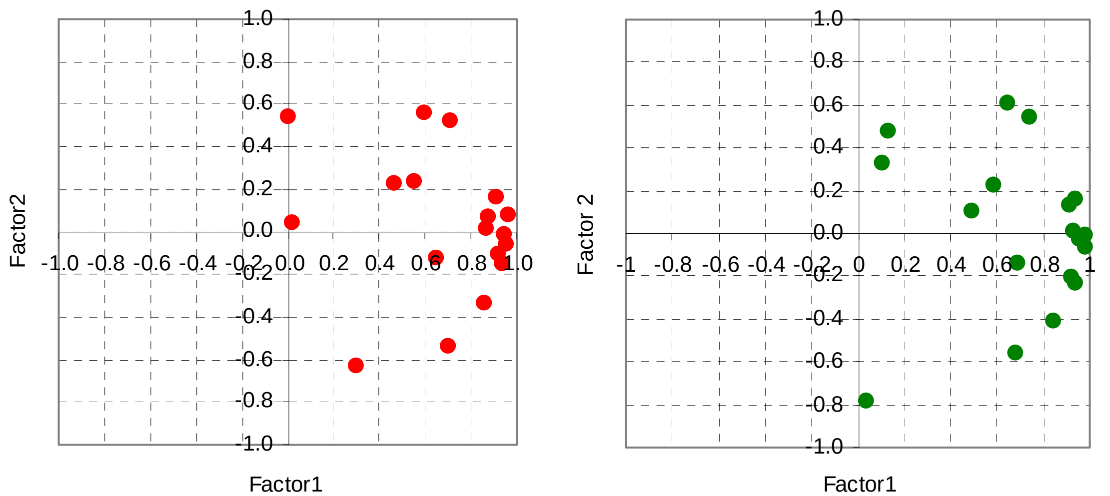
Results

Principal component analysis on social capital variables revealed that there were four large eigenvalues (9.9878, 1.8822, 1.6526, and 1.1420), which together accounted for 81.47% of the standardized variance. Thus, the first two principal components did not provide an adequate summary of the data. Rotating the data monotonically using factor analysis yielded three large eigenvalues 10.4549, 2.3222, and 1.5190), which together accounted for 79.42% of the standardized variance. The first two common factors then provided a better summary for the data compared to the first two principal components before rotation. Rotation provided a slight improvement in data summary (Figure 1) and also better position of variables with respect to Factor 1 and Factor 2 (Figure 2).



(a) (b)

Figure 1. Graphs of Eigenvalues Before and After Monotonic Rotation of Social Capital Data: (a) Total Eigenvalues and (b) Cumulative Proportion of Eigenvalues. Data from Noelbaki Village, Central Kupang Sub-district, Kupang District



(a) (b)

Figure 2. Position of Social Capital Variables to Factor 1 and Factor 2: (a) Before and (b) After Monotonic Rotation of Social Capital Data. Data from Noelbaki Village, Central Kupang Sub-district, Kupang District

After rotation, Factor 1 accounted for 58.08% of the standardized variance and therefore was adequate for selection of variables to be retained in regression analysis. Among social capital variables, SAFE (perception of being secure), CTRUST (trust to village community), GCTR (control over government policy), and CCTR (control over community decision making) were accounted for less than 50% by Factor 1 and therefore were not involved in the regression analysis. Other variables that were accounted for more than 50% by Factor 1 were further subject to regression analysis with biosecurity variables AWARE, KNOW, and ACTIONS separately as dependent variables.

Regression analysis with biosecurity variable AWARE revealed a significant relationship (Pr>F <0.0001) with the following equation:

$$AWARE = 0.37520 + 0.04506*ACTS + 0.06027*COMS + 0.03946*SINFO, \quad R\text{-}Square = 0.97 \text{ and } C(p) = 6.67, \tag{1}$$

where AWARE=awareness index to the presence of crop pests and diseases, ACTS=number of joint actions and cooperation participated, COMS=number of communication performed, and SINFO=number of information sources accessed. The coefficient of determination of 0.97 and the C(p) of 6.67 indicated that data variations were adequately accounted for by the resulting equation. This equation suggests that community awareness to the presence of crop pests and diseases increases in line with the increasing number of joint actions and cooperation participated, the increasing frequencies of communication performed, and the increasing number of information sources accessed by members of the community.

A significant relationship (Pr>F <0.0001) was also produced from regression analysis with biosecurity variable KNOW. The resulting equation is:

$$KNOW = 0.25517 + 0.02843*GRPS + 0.05790*NETS + 0.04377*ACTS - 0.01118*TINFO, \quad R\text{-}Square = 0.97 \text{ and } C(p) = 1.86 \tag{2}$$

where KNOW=knowledge index of the presence of crop pests and diseases, GRPS=number of group joined as active member, NETS=number of parties ever contacted to obtain information, ACTS=number of joint actions and cooperation participated, and TINFO=time required to arrive at information sources. The coefficient of determination of 0.97 and the C(p) of 1.86 indicated that variations were adequately accounted for by the resulting equation. The equation indicates that farmer knowledge of the presence of crop pests and diseases increases and the time to arrive at information sources decreases, if farmers joined more groups, made more contacts to obtain information, and participated in more joint actions and more cooperation.

The biosecurity variables ACTIONS was also significantly related with some social capital variables (Pr>F <0.0001). The resulting equation is:

$$ACTIONS = 0.38007 + 0.05547*GRPS + 0.05210*COMS - 0.0412*TINFO + 0.12043*FINFO, \quad R\text{-}Square = 0.92 \text{ and } C(p) = 1.66 \tag{3}$$

where ACTIONS=index of pest and disease control actions, GRPS=number of groups joined as member, COMS=number of communication performed, TINFO=time required to arrive at information sources, and SINFO=number of information sources accessed. Coefficient of determination of 0.92 and C(p) of 1.66 indicated that most of data variations were well accounted by the equation. This equation shows that community members are more likely to take action to control pests and diseases of their crops if they are members of more groups, communicate more with other parties, have faster access information, and have access to more information sources.

Discussion

The results of this study show that analysis of social capital makes significant contributions to our understanding of community awareness, knowledge, and actions relating to biosecurity. Regression analysis shows that not all social capital variables are equally important in terms of close association with community awareness, knowledge, and actions. By identifying those social capital variables that show close association, efforts can be focused on a particular social capital aspect in enhancing community awareness, knowledge, and actions on biosecurity. A similar approach had been taken by Krishna & Uphoff (1999) in using social capital in their study on watershed development in Rajasthan, India, and by Isham & Kähkönen (1999) in their study on community-based water projects in Central Java, Indonesia.

Participation in joint actions and cooperation provide opportunities for community members to meet other people from whom information on pests and diseases in the village can be obtained. When this initial information is considered relevant to the problem they have in their own field, they can seek further information through engagement in communication with the colleagues they think are more knowledgeable on the subject or through deliberate efforts to access other information sources such as through reading brochures, listening to radio, watching television, or attending extension meetings. Because all of these information sources are cognitive in nature, it is not surprising that they do not necessarily have an ability to correctly identify pests and diseases they know by name. It is common among farmers when the invading pests and diseases are new that they fail to identify the correct identity of the pest or disease without help from outside experts. In Central Timor, Londingkene *et al*. (2004) found that even an officer responsible for monitoring pests and diseases of estate crops failed to correctly identify coconut hispid although he pronounced the Latin name fluently. Being able to correctly identify pests and disease in the field is mainly important as the first step for farmers to realize that there is a biosecurity problem hampering their crops and that there is a risk of crop loss associated with it.

To be able to both correctly identify and report crop pests and diseases, community members seem to need a more intense interactions with either their more knowledgeable colleagues or with other more trustworthy sources of information. In terms of social capital, such interactions require an involvement in a structural organization such as membership in farmer groups or regular contact with governmental and non-governmental organizations (Isham & Kähkönen 1999). Through these more intense interactions, community members have opportunities to obtain a more hands-on experience through regular field work provided by field extension specialists. It is during this field work that they have an opportunity to identify directly any pests or diseases they previously knew only by name. Field work was used as the primary way of learning to identify pests and diseases and their natural enemies at the so-called field school program of the Integrated Pest Management (IPM) implementation in Indonesia (Untung 1993). Such field work would also involve other people from whom each participant has an opportunity to learn in a joint-action way. Of course, in addition to field work activities, other ways are required to further cross check what they have already learned. In this case, available sources of information and time to arrive at those sources would be critical for them to achieve the required ability in pest or disease identification.

Knowledge of crop pests and disease is the prerequisite for effective management actions. Pest and disease management in Indonesia is based on an integrated approach (IPM) that preferred natural control mechanisms of pest and disease population dynamics over use of chemical pesticides. Within the IPM framework, pesticides are recommended as the last resort only when other measures are inadequate in providing pest or disease control (Royer *et al*. 2006). In this study, control actions were measured in terms of whether they are implemented by following or ignoring IPM principles. The ability of community members to adhere to this IPM approach in coping with pests and diseases of their crops is associated with their involvement in various groups as an active member, communications with other colleagues or institutions, and frequent use of available information sources. Again, as with knowledge of existing pests and diseases, time required to arrive at the various sources of information limits this ability. The role of information here is important since, as already discussed by Vayda & Setyawati (1998), IPM promotes not only new control measures but also a paradigm shift in viewing pests and diseases as a normal component of agro-ecosystems. Farmers in Noelbaki Village have been accustomed to the excessive use of pesticides for so long that organized efforts involving farmer groups and contacts with extension officers are necessary to counteract the lure of instant control being possible only with the use of chemical pesticides.

Social capital analysis provides a useful approach to enhance our understanding of biosecurity problems at the community level. However, as with other approaches, it is also prone to weaknesses. Apart from criticisms of the concept itself as already reviewed by United Kingdom Office of National Statistics (2001) and others (e.g. Navaro 2003), there are some methodological shortcoming that need to be carefully addressed. The lengthy questionnaire tends to take so much time that the respondents may refuse to cooperate unless compensation is provided. Such a complaint was widespread when the original draft of the model social capital questionnaire was tested in different developing countries worldwide (Onu *et al*. 2002). In addition, respondents were suspicious of the true motive of some questions, especially those questions they consider embarrassing or threatening their security (Adelabu 2002). Efforts have been made to make the questionnaire as simple as possible, for example by using words local people are most likely to understand and paraphrasing questions that are likely to be embarrassing. Data analysis was also carefully designed to overcome the intrinsic nature of the resulting data of variables that tend to correlate one to another.

At this very early stage of a long-term planned biosecurity study, the information gathered regarding the association of community awareness, knowledge, and actions is important for planning the next project activities. Referring back to the results, the following aspects need to be given attention in planning activities for the next stage of the study:

1) Awareness raising of pests and diseases threatening crop biosecurity should be promoted though capacity building of farmer groups, woman groups, irrigation user groups, and youth groups enhanced with improving supports from extension workers and pest monitoring officers.
2) Transfer of knowledge of pests of diseases of biosecurity importance should be carried out through field work activities involving informal leaders who should be

encouraged to promote the process with help from informal networks they have with both farmers as well as outside governmental and non-governmental organizations.
3) Efforts should be made to promote any indigenous pest and disease control actions and to convince farmers that resorting to excessive use of pesticides is not only costly but also risky in terms of health and the environment.

Conclusions and Recommendations

Referring back to the results and discussion already presented earlier, the following conclusions can be drawn:
1) Social capital offers a new way of understanding pest and disease problems threatening crop biosecurity at the community level by its ability to provide a straightforward yet comprehensive approach in gaining an overview of factors associated with community awareness, knowledge, and actions.
2) A number of social capital variables have been identified as being closely related to community-level biosecurity issues, but variables that are related to one variable are not necessarily related to other biosecurity issues.
3) Social capital variables found to be closely related with community-level biosecurity issues are useful as entry points in gaining an overview of biosecurity problems faced by the local community and as the basis for planning the necessary activities to be carried out at the next stage of the study.

Based on the results obtained during the phase I of the study, it is recommended that the following points be considered in the next phase:
1) Activities in the phase II should include facilitation for informal leaders to raise awareness and enhance their knowledge regarding pests and diseases threatening the biosecurity of crops in the region.
2) Activities with informal leaders should also include capacity building in organization management and development of networks.
3) Awareness raising and knowledge improvement should also be accompanied by facilitation for better compliance with the IPM approach with an emphasis on enhancement of indigenous control measures.

Acknowledgment

We would like to express our sincere gratitude to all respondents who have made their valuable time available and to community and village leaders who have provided their support for this study. This publication is part of a long-term study funded by CRC NPBS, Australia, and involving Charles Darwin University, Darwin, Australia, and Mahasaraswati University, Denpasar, Indonesia, as executing agencies. In East Nusa Tenggara Province, the research was carried out by Nusa Cendana University on behalf of the above executing agencies. Sincere appreciation is due to Prof. Ian Falk for his support, and inputs he has provided to the authors.

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