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Development and assessment of a knowledge-based decision support tool for sustainable land management of sloping lands

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Abstract
Information is amongst the most important supporting components for productive, profitable and sustainable agriculture. In this respect, it should be useful, technical and practical with a focus on increased production and of a user friendly nature that would encourage farmers to use it. To be more effective, there should be closer collaboration among information sources or information providers to help the farmers making a sound decision. With this concept in mind, the International Board for Soil Research and Management (IBSRAM) and the Food & Fertilizer Technology Center (FFTC) initiated a joint project to develop a database containing information related to sustainable land management. The first phase of this project focused on the conduct of a survey on "Information flow in the national extension system and information needs of farmers" in the Philippines, Vietnam and Samoa from January – June 1999 (a report on this survey can be found in the FFTC Extension Bulletin 482).

Since August 2000, IBSRAM, in collaboration with the Center for Agroclimate Research (CSAR) in Indonesia, the Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD) in the Philippines, and the Land Development Department (LDD) in Thailand have been collaborating in the provision of contents to the structure of a database. The overall goal of the project is to provide users (extension workers and farmers) with meaningful and practical information on sloping lands conservation and management for sustainable agriculture. A prototype database on sloping lands conservation and management was designed in English in December 2000 and CSAR and LDD translated it into Indonesian and Thai languages, while PCARRD was asked to review and modify the database in English version for more clear and useful information. Assessments of the database were undertaken in Indonesia and the Philippines during January – February 2001 and in Thailand in March 2001 to validate its technical and non-technical aspects including the ability of the database to complement and support extension activities. The aim of this activity was to review and upgrade the materials in the database so that they would be more meaningful and useful to the target users. After the merger of the IBSRAM programs and activities with the International Water Management Institute (IWMI) in April 2001, IWMI has supported this database project. The prototype database in English was reviewed and upgraded at IWMI and the database content in Thai was revised for the second assessment in Thailand in September 2001. After assessment, the database was revised again and placed in the public domain through the IWMI website (www.agribase.org) in October 2001.

It was found from assessments undertaken in the three partner countries (Indonesia, Philippines and Thailand) that not only the extension workers would benefit from the information provided in the database, but also researchers, trainers, academicians, and students. The database is currently revised and updated to provide more farm level information on soil and water conservation practices for sustainable agriculture in sloping areas. In addition, the contents will not only be presented as necessary, but also as needed to be adequate for making sound decision by the farmers who are the end user. The IWMI's Asialand network on management of sloping lands for sustainable agriculture

project-phase 5 is operating this activity as a part of its attempt to promote widespread adoption of sustainable land management practices by farmers in 7 participating countries. The database will be accessible in 8 languages (Chinese, English, Filipino, Indonesian, Laos, Malaysian, Thai and Vietnamese) to complement and support extension work. An assessment of the impact of information transfer and utilization will be conducted and reported before the end of project in 2004.

Introduction

Soil erosion has been identified as the major problem affecting sustainable agriculture in sloping land areas. Without soil and water conservation measures, serious soil erosion can occur, resulting in land degradation, severely reducing productivity, increased runoff, and seriously impacting on off-site sedimentation of reservoirs or other storage structures. To overcome these problems, improved soil and water conservation and management practices should be introduced to farmers for widespread adoption as an integral part of their farming systems. The information technology which is instrumental in disseminating sustainable land management of sloping lands should be provided to complement and support the extension work. This computer-based tool will be valuable to extension workers in having useful, practical and methodological information to discuss with the farmers for their effective decision-making in solving soil and water conservation problems. Characteristics of good information are relevance, timeliness, accuracy, cost-effectiveness, reliability, usability, exhaustiveness, and aggregation level. Information has a great impact on decision making, and hence its value is closely tied to the decisions that result from its use (Babu, Singh and Sachdeva, 1997).

The database on sustainable land management of sloping lands was initiated by IBSRAM in collaboration with partner organizations in 3 countries, i.e. CSAR in Indonesia, PCARRD in the Philippines and LDD in Thailand since August 2000. The project goal was to provide users (extension workers, development workers and farmers/land users) with meaningful and practical information on sloping lands conservation and management for sustainable agriculture. It was expected that the database in English and other 3 national languages (Filipino, Indonesian and Thai) would be meaningful, useful and practical to the users, especially the extension workers who ordinarily provided alternative courses of action for farmer's decisions to solve soil erosion problems. The database could be downloaded and printed out for use as extension and training materials. Other information users, e.g. researchers, development officers, educators, trainers, students and interested persons would also benefit from this database.

Materials and Methods

Development of the database

There were 2 major phases in developing the database:

Phase 1: Designing the prototype database

This phase (August 2000 – January 2001) focused on the provision of contents to the structure of the prototype database on sustainable land management of sloping lands through the following steps:

1) Collection of technical information on sustainable land management, with a focus on soil and water conservation practices for sloping land agriculture from various sources. The information was reviewed, modified and digested for easy understanding by target users.
2) Surveying questions frequently asked by extension workers and farmers/ land users and provide answers to them.
3) Entering modified materials and frequently asked questions (FAQs) into a prototype database in English version.
4) The prototype database was translated into Filipino for the glossary and FAQs, while the database records and database index were still maintained in English. The entire database was translated into Indonesian and Thai by partner organizations and IBSRAM pooled them for reading on-line through the www.agribase.org with a search engine to be ready for the assessment. The prototype database in the form of a CD-Rom was also produced to facilitate assessment in Indonesia as the on-line website was not accessible in some areas where the assessments were conducted.

Phase 2: Upgrading the database

This phase (February 2001 – October 2001) focused on reviewing and upgrading the database based on results and recommendations made in the assessment phase (Phase 1) to make the database more meaningful, useful and practical to the users. The revised database in the national languages and English were pooled by IWMI and were made widely available through IWMI website (www.agribase.org).

Assessments of the database

1) The assessments of the database were undertaken in Indonesia and the Philippines during January – February 2001 and in Thailand in March 2001 to validate the materials in the database in terms of topics covered, the quality of information presented, their effectiveness in communicating technical information to the users, feedback mechanism, and their ability to complement and support extension work. The respondents were extension workers, technical staff, information technology workers, and farmers, where ever possible. The database in the national languages was used by respective country to facilitate understanding by the respondents. In the Philippines, PCARRD used the database containing the information in English and some parts, i.e. the glossary and FAQs were in Filipino.
2) After each assessment, the materials in the database (in the national language) were reviewed and amended based upon the assessment results and recommendations.
3) The assessment reports were sent by partner organizations to IWMI in March 2001 for further action.
4) IWMI repeated the assessment in Thailand in September 2001 with assistance from the LDD Regional Office 6 and the Department of Agricultural Extension (DOAE) to revalidate the revised database contents and format. The results and recommendations were used in reviewing and upgrading the database.

Results and Discussion

Development of the database

Examples of the various pages in different languages are presented in Appendix 1 at the end of this paper. Readers are referred to these for clarification during the reading of the following sections.

The prototype database on sustainable land conservation and management practices was developed in collaboration with partner organizations. It comprised of 4 major components: (i) data flow diagram (DFD) that covered 85 topics on sloping land conservation and management practices, (ii) database search function, (iii) glossary of sloping land conservation and management systems, and (iv) Frequently Asked Questions (FAQs) and answers. After the revision of the materials upon the assessment results and recommendations from the respondents (extension workers, technical staff and farmers), the materials in English, Filipino, Indonesian and Thai were pooled and widely available through IWMI website (www.agribase.org) for reading, or they can be downloaded and printed out for use as extension and training materials. A computerized record of the number of visits to website is also kept.

One important development is the DFD accessibility; it was improved and renamed to database index. Due to the limitations of computer screens and printed material sizes, DFD is particularly difficult to fit into the aforementioned formats. In contrast a database index is designed in a form that items are kept into a compressed form and can be expanded or shrunk easily using Windows Explorer. As a consequence of this change to a database index, the database could be directly accessed in 3 ways: (i) users could manually search through a database index that grouped records by subheadings according to management type, (ii) search under a single keyword for a particular conservation practice and the search engine would gather all the techniques listed under that heading, and (iii) scroll through the entire list of records at the click of a button.

Assessments of the database

Prior to the latest version of the database, partner organizations conducted assessments in their respective country to get feedback from the users for reviewing and upgrading the database. A guide questionnaire was used. It contained the following parameters as a basis for validation: (i) scope and format of the database, (ii) quality of information presented, (iii) usefulness of the database, (iv) accessibility and easy of operation, (v) problems that might be encountered in using the database, and (vi) other suggestions to improve the database. The results and recommendations from the assessments were brought for the revision of the prototype database before pooling all languages for wide accessibility by the users.

In Indonesia, the off-line website was used for validation in February 2001. The first one-day validation workshop was done with 38 respondents (24 extension workers and 14 technical staff) in Bangko, Merangin District, Jambi Province to validate the materials in the database. After orientation to familiarize the respondents with the database development background and the overall structure and contents, the respondents were divided into 10 groups to validate the database in Indonesian language. Aside from validating database searching function, glossary and FAQs, each respondent selected 12 topics for validation by following a guide questionnaire mentioned above. The assessment results and recommendations were used for revising the database and the second one-day workshop was undertaken with a different group of respondents. A total of 36 respondents (7 extension workers and 29 farmers) at Kubang Ujo, Pamenang District joined the revalidation workshop. Since 81% of the respondents were farmers, therefore an average of 7 topics per person could be validated. Questionnaire, observation, dialogue and discussion were used as the instruments for collecting data from the respondents. After the workshop, the database was revised again and sent to IWMI (CSAR, 2001).

In the Philippines, the first one-day validation workshop (23 February 2001) was done with 21 respondents (12 extension workers and 9 researchers and information technology workers). The respondents were grouped into four, with 5 members in each group. Twenty two topics/records were randomly selected and assigned to each group. Out of the 22, each group subjectively selected one more record/topic for validation. The basis for the member's choice of a topic was (i) his/her interest on the subject matter and (ii) his/her knowledge of the subject matter. Since, not all respondents were subject matter specialist, majority chose a topic on the basis of interest, not on their expertise. In evaluating the contents of the database, respondents assumed themselves to be users of information. Aside from validating one topic per member, each group selected one more topic for group validation. The total number of topics validated was 23 and they were evaluated based on a guide questionnaire. Each group was assigned a computer with Internet connection to view the website. The instruments used for collecting data from the respondents were questionnaire, observation, group presentation and discussion. After the revision of the database upon the assessment results and recommendations, the second one-day workshop was undertaken with a different group of respondents. A total of 19 respondents (8 extension workers, 5 researchers, 2 training officers, 3 information management officers and 1 planner) attended and the revalidation process was the same as the first assessment. After review and modification of the database, the revised database and report were sent to IWMI (ARMRD, PCARRD, 2001).

In Thailand, IWMI conducted the assessments in March and September 2001 with assistance from the LDD Regional Office 6 and the Department of Agricultural Extension (DOAE). A computer was provided for each respondent to access the database at the Internet Cafe in Chiang Mai. The first one-day validation workshop was done with 11 respondents (5 extension workers, 2 researchers and 4 information technology workers). After orientation period, the respondents validated the database by using a guide questionnaire. Each of them was asked to select the topics of his/her interest at least 6 topics for validation. The results and recommendations from this event and from the reports from CSAR and PCARRD were brought for reviewing and upgrading the database. The materials in the database both in English and Thai were adjusted, modified and refined, while the DFD was changed

and renamed as the "Database index". It contained a list of soil and water conservation practices available in the database, arranged in a hierarchical manner by which a list of broad headings was firstly shown and then under each broad heading was a listing of sub-categories. The colors were also changed to be more attractive and more comfortable to read. This took about 5 months and the second one-day validation workshop was done with 19 respondents (17 extension workers and 2 information service worker) to assess the revised database. The instruments used for collecting data from the respondents were questionnaires, observation and discussion. The results were eventually taken for reviewing and upgrading the database.

The opinions of the respondents toward the prototype database

1. Scope and format of the database

It was found from the assessments in the 3 partner countries that the respondents considered the database as a documentation of technologies, tools and techniques on soil conservation, soil erosion management, and sloping land management for sustainable agriculture. The majority of the respondents (63%, 70% and 71% in Indonesia, Philippines and Thailand, respectively) who assessed the database indicated that the topics in the database were sufficient to answer the users' need, especially the extension workers, and 55% of them mentioned that the information was presented in a user-friendly format. However, respondents considered that the database was not necessarily presented in a user-friendly format and suggested that procedures should be presented in a step-by-step format, there should be more visual aids or illustrations with proper input and label, and the use of simple words (avoid jargon). Other topics that could be included or provided in more details in the database were soil fertility improvement techniques, potential plants for sloping land agricultural production (cut flowers, vegetables, fruit trees, fast growing trees, sericulture, apiculture, agro-silvo-pastural system, silvipasture and others), integrated farming systems, integrated pest management, water management systems, indigenous knowledge and practices on sloping land conservation and management, and sub-topics on main topics e.g., green manure, mulching, cover crops.

2. Quality of information presented

With respect to the quality of information provided in each of the data fields under each topic in the database (see example in Figure 9), there was a diverse range of opinions from the respondents in the three partner countries. In this respect, respondents indicated that the most clear data fields were keywords and sources; moderately clear data fields were descriptions, advantages, disadvantages, and limitations; and the least clear data fields were procedures, areas where applicable, requirements and recommendations. In addition, it was found that 69 % of the topics assessed were technically precise. Therefore, all data fields were revised and adjusted and these weak data fields were improved for more clear presentation and understanding. However, based upon the revalidation of the database undertaken by IWMI in Thailand with extension workers, it was still found that while other data fields were more clearly presented, the 'procedures' data field still needed to be improve (32 % of the respondents confirmed this situation).

In respect to the glossary that contained over 250 terms, the respondents determined that most terms were presented clearly and only a 9 % had inaccurate descriptions. Some terms were incompletely defined and unclear, and the description should be consistent with the database search. The respondents also suggested that additional terms should be added with clear explanations.

The FAQs part of the support system was given most favorable comments by the respondents in partner countries due to its simple presentation. Though there had been only a few questions posed at the time of assessment as the site was still under development, it allowed users to see each others questions and answers. This means it might not be necessary to submit a question to get an appropriate answer. By selecting a question similar to his/her own and then viewing the answer, a user might also find the information he/she needs.

3. Usefulness of the database

The majority of the group respondents who are extension workers indicated that the database was informative and useful for extension work and also for their profession (90%, 86% and 91% in Indonesia, Philippines and Thailand, respectively). They also mentioned that other users would benefit from the information provided in the database as well, especially researchers, trainers, academicians, students and interested persons. In general, 79% of extension workers who attended the assessment in partner countries gave feedback that the database materials were applicable, while 57% of the farmers who attended the assessment in Indonesia agreed. They commented that the benefits of the database to farmers were limited unless simplified. It is evident that the presentation might be too technical for farmers to understand and the farmers still need more detailed explanation. In addition, farmers do not normally use computer and the Internet, and they are invariably not computer literate. Hence, the database should be emphasized as a tool for extension workers to update them on new developments as well as useful and practical information to discuss with farmers so that sound decisions can be made. Farmers will benefit from the database by having technology options and more alternatives in improving their farm practices for productive agriculture.

4. Accessibility and ease of operation

The majority (74 %) respondents found the database easy to maneuver. Fifty eight percent indicated that the database would be available to users, once introduced in their work places. However, their concern became the issue of availability of computers and Internet facilities. Normally, extension workers do not have a computer and many of them need skills in their operation. This is supported by the evidence that 100 %, 62 % and 48 % of the respondents who joined the assessments in Indonesia, Philippines and Thailand, respectively had never used the Internet. In addition, more than 80 % of the respondents who were extension workers had never used the Internet, and for the ones who had experience in using it, they relied on some other persons to help them due to a lack of computer and Internet literacy.

5. Problems that might be encountered in using the database

The problems that might be encountered in using the database, as cited by the respondents, can be categorized into 3 aspects: manpower support, technical support, and financial support. Most of the respondents (96%) indicated that training is necessary to equip extension workers in operating computers, using the database and in mechanisms of delivering the information to farmers. Similarly, technical problems with respect to hardware and software facilities and interconnectivity might be a problem in some areas where Internet facilities are lacking. Moreover, there might be differences in the interpretation of information, if the content is not qualified and clarified. Funding is important because of the maintenance of accessibility to the Internet. Other aspects such as uncontrolled electricity or power failures were also deemed to limit the use of this technology.

6. Other suggestions to improve the database

The following are suggestions from the respondents for the improvement of the database to be more effective, attractive and productive:

- Improve the database design in terms of format and layout by adding more graphics and illustrations, accuracy and consistency of the contents, translation of contents into layman's terms, and more color combination.
- Include in the database structure, LINKS to related websites or a directory of related websites.
- Include cost and benefit analysis of a particular technology or practice in the database. Farmers are more interested in monetary benefits that could be gained from adopting the technology.
- For effective feedback mechanism (FAQs), the webmaster team should be organized to address promptly any inquiries. Immediate answers should be provided to inquiries.

- Mailing address should be added aside from e-mail address for those who do not have e-mail address to send their inquiries by mail for answers.
- Putting the database in a CD-ROM format, so that others without Internet connection can still have access to the database.

Conclusion

The database on sustainable land management of sloping lands was developed by IBSRAM and then IWMI with assistance from the partner organizations in Indonesia, Philippines and Thailand. It was found from the assessments in partner countries that not only extension workers would benefit from the information provided in the database, but also researchers, trainers, academicians, and students. Farmers would also benefit from the database by having useful and practical information and more alternative courses of action for solving soil erosion problem and improving their farming practices for productive sloping land agriculture. After the assessment of the database in these countries in terms of topics covered, the quality of information presented, their effectiveness in communicating technical information to users, feedback mechanism, and their complement and support to the extension work, the database materials were revised and updated for more technical preciseness, usefulness and practicality. It has been widely accessed through www.agribase.org from November 2001 and as a consequence become an activity of the IWMI's Asialand network on management of sloping lands for sustainable agriculture project-phase 5. The database is currently revised and updated to provide more farm level information about soil and water conservation practices for sustainable agriculture in sloping areas. In addition, the contents will not only be presented as necessary, but also as needed to be adequate for making sound decision by the farmers who are the end user. The database is being developed into 8 languages (Chinese, English, Filipino, Indonesian, Laos, Malaysian, Thai and Vietnamese) to complement and support the extension work in 7 network participating countries (China, Indonesia, Lao PDR, Malaysia, Philippines, Thailand and Vietnam). An assessment of the impact of information transfer and utilization will be conducted to get feedback from extension workers and farmers and reported before the end of project in 2004.

It is important to stress that this computer-based tool is a knowledge-based decision support tool that will complement extension work by providing meaningful, practical and methodological information on sloping lands conservation and management. The tool will be valuable to extension agents in disseminating information and technology to the farmers for their effective decision-making in solving soil and water conservation problems. Though it has been developed to be responsive to the farmers' requirements and changing situation, communication between extension agents and farmers is needed to clarify and supplement the information for more productive decision-making by farmers.

Acknowledgements

The work discussed in this paper would not have been possible without the collaboration of staff from CSAR in Indonesia, PCARRD in the Philippines, and LDD and DOAE in Thailand. Special thanks to Ms. Adoracion B. Amada, Dr. Djoko Santoso, Mr. Sawatdee Boonchee and Mr. Phithag Inthaphan for their strong support. Thanks Food & Fertilizer Technology Center (FFTC) for its cooperation and support, and also thanks Dr. Andrew Noble, the IWMI-SEA Regional Office for his kind editing assistance.

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1. Agricultural Resources and Management Research Division (ARMRD), Philippine Council for Agriculture, Forestry and Natural Resources (PCARRD), and the Department of Science and Technology (DOST). 2001. Database on sustainable management of sloping lands. Project Accomplishment Report. Los Banos, Philippines.

2. Babu, A. R., Singh Y. P. and Sachdeva, P.R. 1997. Establishing a management information system (pp 161-169) in Swanson, B. E. et al, (eds). Improving Agricultural Extension: a reference manual : FAO.
3. Center for Agroclimate Research (CSAR). 2001. Database on sustainable management of sloping lands. Project Accomplishment Report. Bogor, Indonesia.
4. Food and Fertilizer Technology Center. 2000. The flow of information in the national extension system and current information needs. Extension Bulletin 482.

Appendix 1

Figure 1. www.agribase.org language selection page

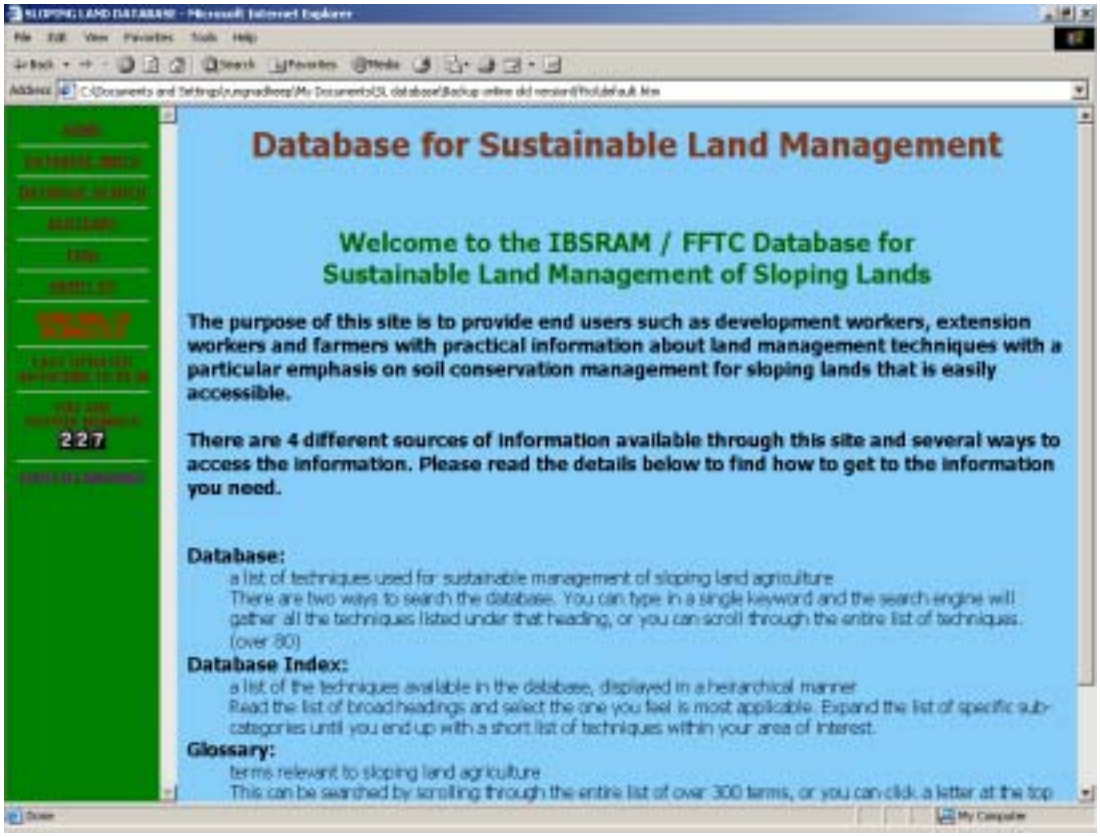


Figure 2. Home page of English version

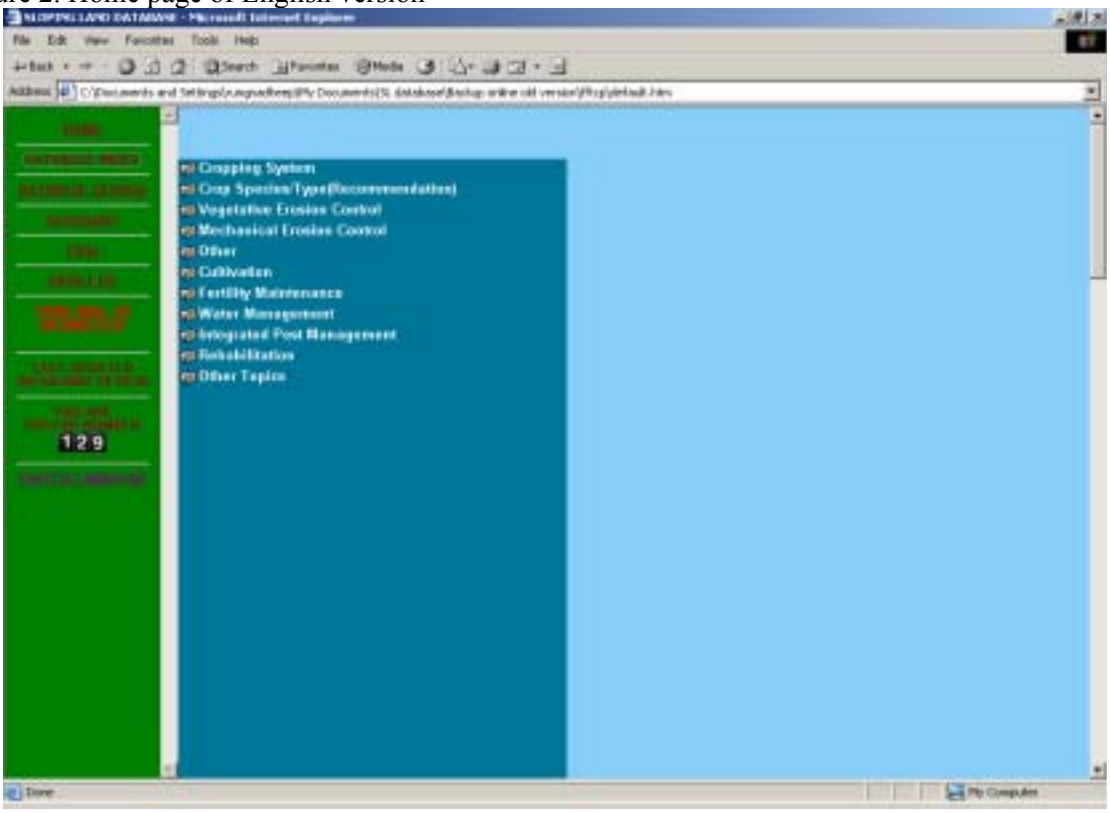


Figure 3. Database Index page

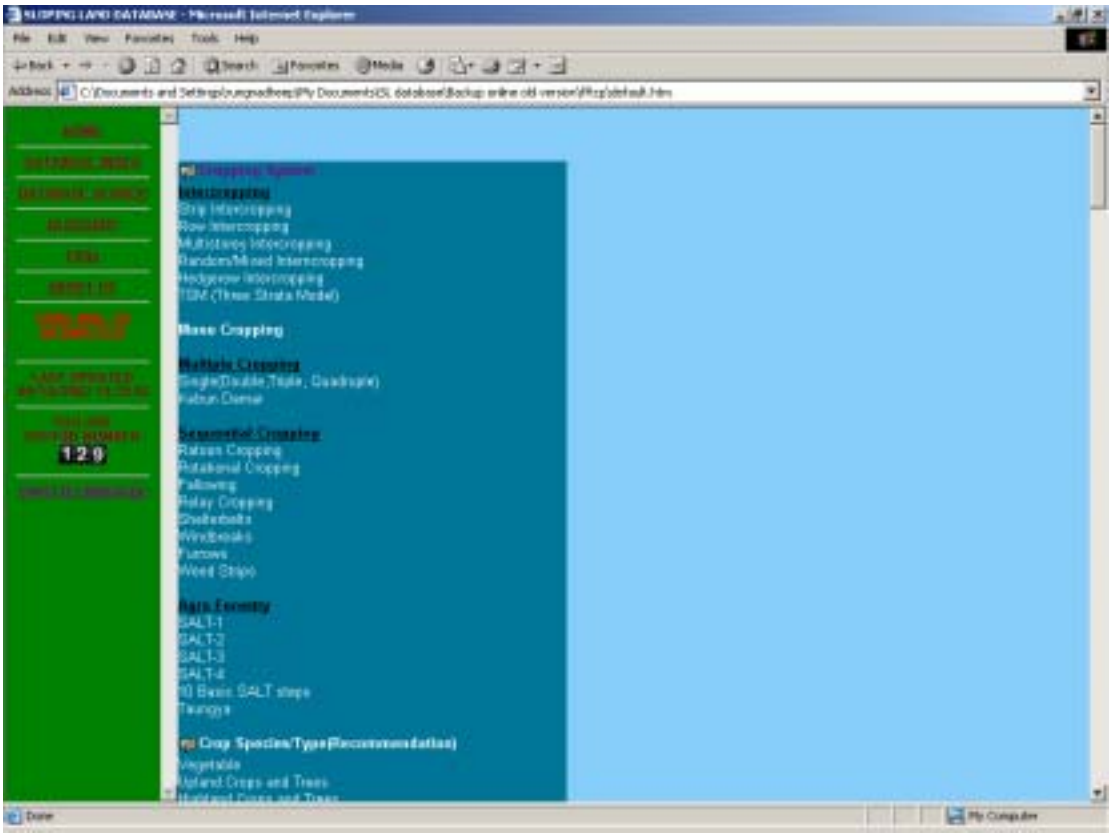


Figure 4. A part of Database Index item list

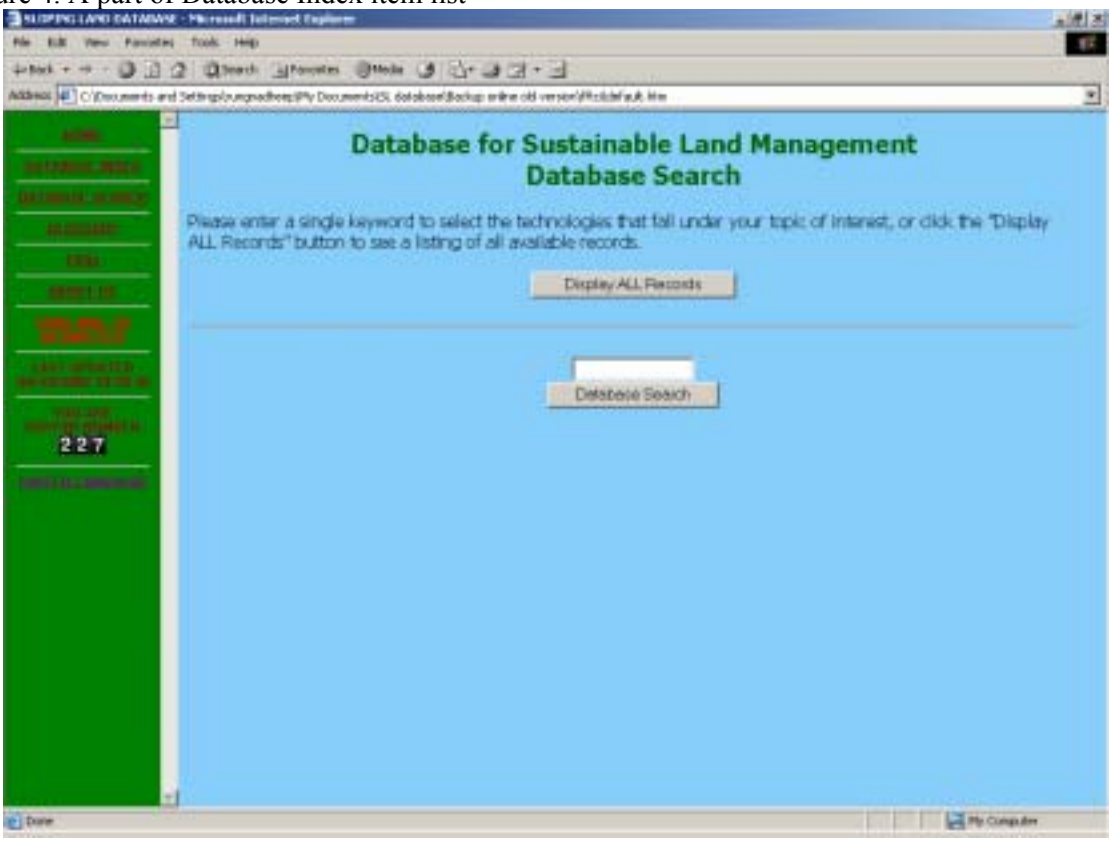
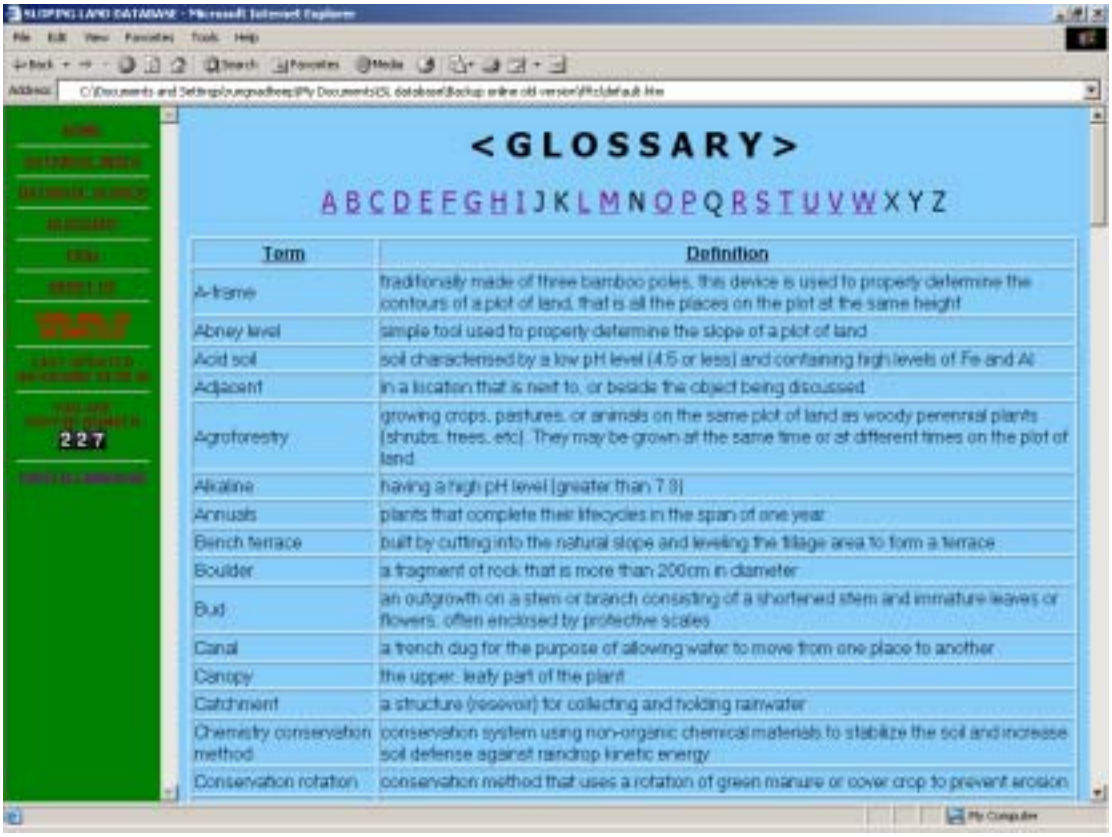


Figure 5. Database search page

Figure 6. A part of the database record/topic list

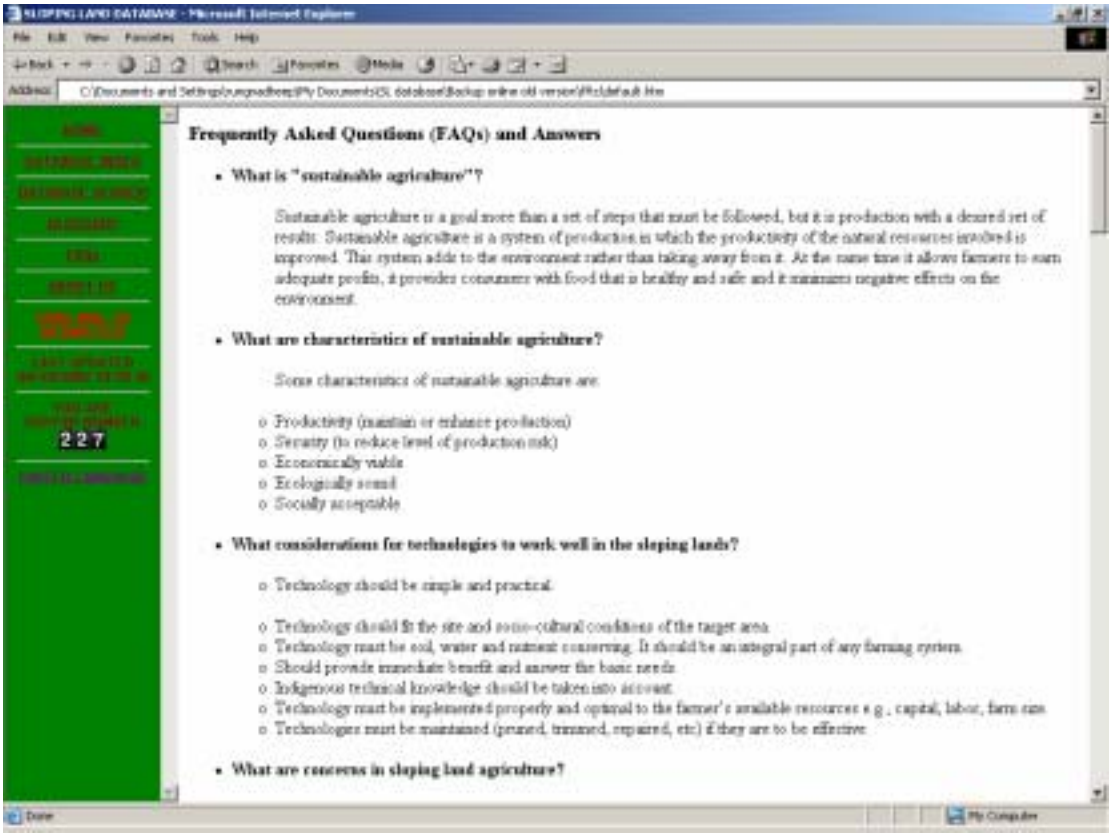


<GLOSSARY>

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

Term	Definition
A-frame	traditionally made of three bamboo poles, this device is used to properly determine the contours of a plot of land, that is all the places on the plot at the same height
Abney level	simple tool used to properly determine the slope of a plot of land
Acid soil	soil characterised by a low pH level (4.5 or less) and containing high levels of Fe and Al
Adjacent	in a location that is next to, or beside the object being discussed
Agroforestry	growing crops, pastures, or animals on the same plot of land as woody perennial plants (shrubs, trees, etc). They may be grown at the same time or at different times on the plot of land
Alkaline	having a high pH level (greater than 7.9)
Annuals	plants that complete their lifecycles in the span of one year
Bench terrace	built by cutting into the natural slope and leveling the tillage area to form a terrace
Boulder	a fragment of rock that is more than 200cm in diameter
Bud	an outgrowth on a stem or branch consisting of a shortened stem and immature leaves or flowers, often enclosed by protective scales
Canal	a trench dug for the purpose of allowing water to move from one place to another
Canopy	the upper, leafy part of the plant
Catchment	a structure (reservoir) for collecting and holding rainwater
Chemistry conservation method	conservation system using non-organic chemical materials to stabilize the soil and increase soil defense against raindrop kinetic energy
Conservation rotation	conservation method that uses a rotation of green manure or cover crop to prevent erosion

Figure 7. A part of glossaries from Glossary page



Frequently Asked Questions (FAQs) and Answers

- **What is "sustainable agriculture"?**

  Sustainable agriculture is a goal more than a set of steps that must be followed, but it is production with a desired set of results. Sustainable agriculture is a system of production in which the productivity of the natural resources involved is improved. This system adds to the environment rather than taking away from it. At the same time it allows farmers to earn adequate profits, it provides consumers with food that is healthy and safe and it minimizes negative effects on the environment.

- **What are characteristics of sustainable agriculture?**

  Some characteristics of sustainable agriculture are:

  - Productivity (maintain or enhance production)
  - Security (to reduce level of production risk)
  - Economically viable
  - Ecologically sound
  - Socially acceptable

- **What considerations for technologies to work well in the sloping lands?**

  - Technology should be simple and practical.
  - Technology should fit the site and socio-cultural conditions of the target area.
  - Technology must be soil, water and nutrient conserving. It should be an integral part of any farming system.
  - Should provide immediate benefit and answer the basic needs.
  - Indigenous technical knowledge should be taken into account.
  - Technology must be implemented properly and optimal to the farmer's available resources e.g., capital, labor, farm size.
  - Technologies must be maintained (pruned, trimmed, repaired, etc) if they are to be effective.

- **What are concerns in sloping land agriculture?**

Figure 8. A part of Frequently asked questions and answers from FAQs page

Topic	Relay Cropping
Description	A fertility maintenance and management practice of growing two or more annual crops simultaneously in the same field such that the second crop is planted after the first crop has flowered. This practice optimizes use of a short growing season allowing fast-maturing crops to grow while the previous crop matures.
Procedure	The second crop is planted after the first crop has flowered. These crops are planted on the same plot of land. For example, planting maize as the first crop and black bean as a relay crop. Maize is planted in May and the black bean will be planted into it 60-70 days later. The crop that takes longer to mature must be planted first.
Areas where applicable	This practice is good for both upland and lowland agriculture.
Advantages	- Provides adequate and continuous ground cover during most of the year so that rainwater does not hit the soil directly, hence, reducing erosion. - Enhances farm productivity by growing two or more annual crops. Since there is overlap of production and harvest is done one after another, the chance of obtaining two crops during a limited growing season is increased. - Eliminates the period between crops when the soil would otherwise be bare.
Disadvantages	Competition effect is pronounced. The species compete not only for sunshine and carbon dioxide in the air, but also for water and nutrients in the soil. Thus, species that absorb soil nutrients more efficiently, or that intercept more solar energy in the canopy, reduce the resources available to, and the yields of, their competition.
Limitations	It does not work in areas with high slope, climate must be suitable for growing crop over a longer period of time.
Requirements	Plants must be used that can grow together, and the climate must be suitable for a longer growing season.
Recommendations	Relay cropping usually combine an early summer cereal or legume relay-cropped with a similar crop. It is more common for the 2 crops grown to comprise one legume and one non-legume than two or either type; for example, a corn-soybean in Indonesia. In northern Thailand on poorer upland soils, relay cropping of maize and black bean is founded to be effective in increasing maize yield while maintaining soil fertility. In the Philippines, rice and legume crop such as cowpea, mungbean and peanut is recommended. Legume crop is relayed about one week before rice harvest.
Source	(1) Catalogue of Conservation Practices for Sloping Land Agriculture. Gomez, Arturo and Ma. Theresa A. Baril. January 1997, SEARCA College, Laguna Philippines (2) Annual Cropping Systems in the Tropics: An Introduction. 1979. M.J.T. Norman. University Press of Florida. Gainsville, Florida
Keywords	LEGUME; MAIZE; RELAY CROPPING; MUTIPLE CROPPING
Illustration	View image

Back

Figure 9. Example of a record in English

Topik	Penanaman berurutan
Uraian	Penanaman dua atau lebih tanaman semusim di mana penanaman tanaman kedua dilakukan setelah tanaman pertama berbunga, atau dilakukan menjelang panen tanaman pertama.
Prosedur	Tanaman kedua ditanam setelah tanaman pertama berbunga, keduanya ditanam pada hamparan lahan yang sama. Misalnya, tanaman pertama adalah jagung dan kacang hitam sebagai tanaman berikutnya. Jagung ditanam pada bulan Mei dan kacang hitam ditanam 60-70 hari kemudian. Tanaman pertama dipilih tanaman yang mempunyai umur/pemasakan yang lebih lama.
Area penerapan teknologi	Cara ini cocok dilaksanakan pada lahan kering dan lahan sawah.
Kelebihan	Produktivitas dapat ditingkatkan melalui pertumbuhan dua jenis tanaman pada musim tanam yang lebih pendek, dapat mencegah erosi sebab lahan penutupnya berkelanjutan. Jika digunakan tanaman kacang-kacangan dapat meningkatkan kadar nitrogen, meningkatkan kelembaban dengan memperpendek masa tanam dan mengurangi bahaya erosi.
Kekurangan	Tanaman memerlukan sinar matahari, air, atau hara dalam jumlah yang banyak
Keterbatasan	Tidak dapat dilakukan pada lahan yang curam, dibutuhkan iklim yang memungkinkan pertumbuhan tanaman lebih panjang.
Syarat	Membutuhkan tanaman yang dapat ditanam secara bersamaan, dan iklim harus dapat mendukung pertumbuhan yang lebih lama.
Saran	Di Thailand Utara pada lahan kering yang kurang subur, tanaman berurutan antara jagung dan kacang hitam efektif meningkatkan hasil jagung, selain itu juga mempertahankan kesuburan tanah. Di Filipina, padi dengan tanaman kacang-kacangan seperti kacang tunggak, kacang hijau dan kacang tanah. Kacang-kacangan tersebut ditanam sebagai tanaman kedua yang ditanam satu minggu sebelum padi dipanen.
Sumber	Catalogue of Conservation Practices for Sloping Land Agriculture. Gomez, Arturo, and Ma. Theresa A. Baril, January 1997. SEARCA College, Laguna Philippines.
Gambar	View image

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Figure 10. Example of a record in Indonesian

ชื่อเจ้าข้อเรื่อง	การปลูกพืชเหลื่อมฤดู
ความหมาย	การปลูกพืช 2 ชนิดต่อเนื่องกัน โดยจะปลูกพืชชนิดที่ 2 หลังจากพืชชนิดที่ 1 ได้ออกดอกหรือใกล้ระยะเก็บเกี่ยวแล้ว เช่น ปลูกข้าวหรือข้าวโพด เหลื่อมด้วยการปลูกถั่วแปบ เป็นต้น
ขั้นตอนการปฏิบัติ	ปลูกพืชรุ่นที่ 1 เช่นข้าวโพด ต้นฤดูฝน เมื่อข้าวโพดอายุได้ 60-70 วัน จึงปลูกถั่วแปบ หรือถั่วดำระหว่างแถวข้าวโพดแล้ว โดยบุดหลุมหยอด เมื่อเก็บเกี่ยวข้าวโพด ถั่วจะเจริญคลุมดินและเก็บเกี่ยวผลผลิตจากถั่ว และเก็บเกี่ยวผลผลิตจากถั่วได้
พื้นที่ที่เหมาะสม	ใช้ได้ดีทั้งที่ดอน ที่ลาดชัน และที่ราบลุ่ม หลังปลูกข้าว
ข้อดี	มีรายได้เพิ่มขึ้นจากการปลูกพืชทั้ง 2 ชนิด (มีการคลุมดินตลอดฤดูฝน) ช่วยป้องกันการพังทลายของดินเพราะมีพืชคลุมดินต่อเนื่อง พืชตระกูลถั่วช่วยเพิ่มไนโตรเจนให้แก่ดิน เพิ่มความชื้นในพื้นที่ ทำให้ดินคงความอุดมสมบูรณ์อยู่เสมอ
ข้อเสีย	อาจมีการแก่งแย่งปัจจัยที่จำเป็นต่อการเจริญเติบโตระหว่างพืช 2 ชนิด ในระยะแรก เช่น แสงแดด น้ำ หรือธาตุอาหาร ถ้าปัจจัยเหล่านี้มีอยู่ในดินในระดับต่ำ (ความลาดชันอยู่ในระดับต่ำกว่า 35%)
ข้อจำกัด	1. ไม่มีประสิทธิภาพด้านการอนุรักษ์ดินในพื้นที่ที่มีความชันสูง (ความลาดชันมากกว่า 35%) 2. ต้องมีฤดูปลูกที่เหมาะสมและยาวนานพอสำหรับพืชที่ 2
สิ่งจำเป็น	จะต้องเลือกพืชที่เจริญเติบโตร่วมกันได้ และฤดูกาลต้องเหมาะสมยาวนานในการเจริญเติบโต
ข้อเสนอแนะ	ในพื้นที่สูงภาคเหนือของประเทศไทย การปลูกพืชเหลื่อมฤดูโดยปลูกข้าวโพดและถั่วดำ ในดินมีความอุดมสมบูรณ์ต่ำ พบว่ามีประสิทธิภาพในการเพิ่มผลผลิตของข้าวโพด ในขณะเดียวกันก็ยังช่วยดินให้คงความอุดมสมบูรณ์ ในประเทศฟิลิปปินส์ แนะนำให้ปลูกข้าว ข้าวโพด และพืชตระกูลถั่ว เช่น ถั่วพุ่ม โดยให้ปลูกพืชตระกูลถั่วก่อนการเก็บเกี่ยวข้าวโพดหรือข้าว 1 สัปดาห์
แหล่งที่มา	Catalogue of Conservation Practices for Sloping Land Agriculture. Gomez, Arturo and Ma. Theresa A. Baril. January 1997, SEARCA College, Laguna Philippines
คำสืบค้น	การปลูกพืชเหลื่อมฤดู ถั่ว ข้าวโพด ธัญพืช
รูปภาพประกอบ	ดูภาพประกอบ

กลับไปหน้าก่อนหน้า

Figure 11. Example of a record in Thai