ザンビア国
農業実証調査技術移転セミナー報告書

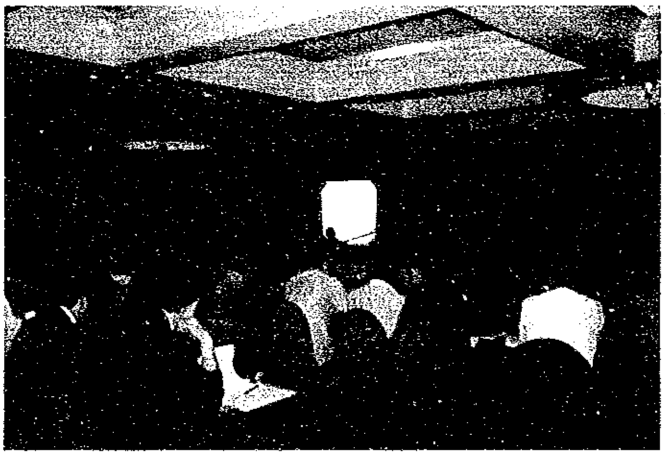
平成 4 年 12 月

国 際 協 力 事 業 団

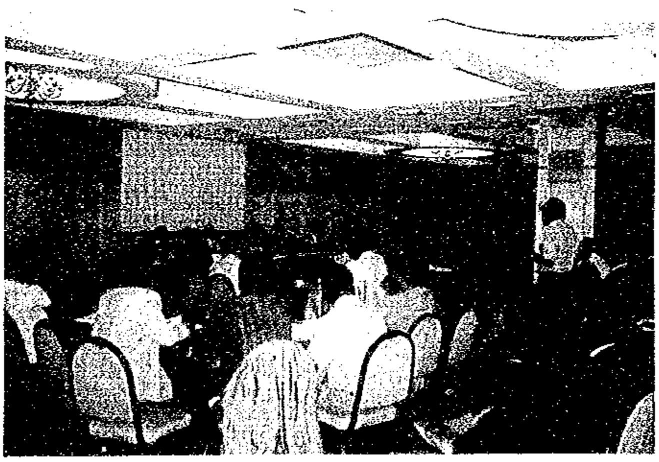
○堀内伸介　在ザンビア日本国大使スピーチ

○Mr. G. NKAUSU ザンビア国農業・食糧・水産副大臣スピーチ

○ザンビア国農業・食糧・水産省 Mr. MULELE 農業局長によるセミナー開会



○セミナー風景



○セミナー参加者による質疑応答

○セミナー講師による総括討議

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1. セミナー開催の背景・経緯

1983年以降のアフリカ諸国での旱魃に対処するため、日本国は1984年10月以降数次にわたる農業協力のための調査団の派遣を行ってきた。この中で現地における農業に関する情報不足が認識され、より現地の条件に適合した開発計画策定のため、農業実証調査を行うこととし、新たな予算措置が講じられた。

1986年から4か年にわたって行われた西アフリカのセネガル国に続いて、東アフリカにおける農業実証調査を、未利用地が多く、農業開発の可能性の高いザンビア国で実施することが1987年に同国政府との間で合意に達し、同国西部州モング周辺が調査地として選ばれた。

西部州はザンビア国の主要稲作地帯で、同州内ではモング郡が代表的である。モング郡の主な稲作地帯はザンベジ川氾濫原で、この地域に実証圃場を設け、稲作を中心とする総合農業技術の開発と、そのための生産基盤整備水準を確立し、将来のための作物生産技術指針と生産基盤整備指針を策定することとした。

農業実証調査の基本方針は以下のとおりである。

① 小農対象

② 灌漑条件を前提

③ 畜力および人力による低コストかつ安定した水稲と畑作の二毛作体系を主な対象

④ 作付体系として早生稲－冷涼乾期畑作物、晩生稲－高温乾期畑作物の二つを基本型

⑤ 土壌改良に重点を置き化学肥料の多用を避ける

⑥ 内陸漁業の重要性に鑑み、環境保全に留意し、農薬の使用を制限する

1988年2月～5月にモング周辺地区の調査により、ザンビア側から提示のあった8地区の候補地区から、ナムシャケンデ、リアルイの2地区の実証圃場地区を選定して1988年7月から1989年12月にかけて実証圃場を造成した。

1988年11月より、造成した実証圃場を利用して実証試験を行うとともに、周辺地区の調査を1992年6月まで実施した。

実証調査の結果を作物生産技術としての体系化技術指針、個別技術指針ならびに生産基盤整備技術としての灌漑／水管理指針および農地整備指針としてとりまとめるにあたり、ザンビア国側より本成果を公開セミナーとして開催するよう要請されたものである。

2. セミナー概要

1. セミナー開催の日時とプログラム

(1) 日　　時

1992年12月7日および8日

(2) プログラム

添付資料1に示す。

(3) 出 席 者

添付資料2に示す。

2. セミナー開催の成果

<概　要>

11月24日から農業・食糧・水産省農業局との間で5回に及ぶ打合せを実施し、セミナーに対するプログラムを調整・決定する一方、国際機関や第三国の援助機関からの出席も要請しセミナーに臨んだ。その結果、UNDP、FAO等の国際機関や英国、オランダ、アメリカ、フィランド、中国等の援助機関から出席者を得たほか、ザンビア側からも農業・食糧・水産省のみならず国家開発計画委員会(大蔵省)からの出席者もあり、全体として80名を超える参加者を得た。

また、各々の講演項目に対して活発な質問や意見の交換があり、ザンビア側の本調査に対する関心の強さが改めて認識されたほか、我が国の援助システムを国際機関や第三国の援助機関に知ってもらうというセミナー開催の目的も十分に達成された。

セミナー終了後に持たれたステアリングコミッティーでは、本セミナーは極めて有意義であった、という意見がザンビア側より多数出た。

添付資料 1.

PROG RAMME FOR GRZ/JICA SEMINAR ON "THE AGRICULTURAL VERIFICATION STUDY IN MONGU" AT PAMODZI HOTEL, LUSAKA. ON 7TH AND 8TH DEC.1992

7th (Monday)

0800	0900	Registration
0900	0930	Opening ceremony Ministry of Agriculture, Food and Fisheries Embassy of Japan JICA Zambia
0930	0945	Tea/Coffee break
0945	1030	Present situation and constraints of agricultural production in the Western Province (presented by Mr.Chingumbe. Act.PAO. Western)
1030	1120	Outline of the AVS (presented by Dr.Takahashi. JICA AVS Team leader)
1120	1230	Guideline for crop production technology (presented by Mr. Kurita. JICA AVS Team)
1230	1400	Lunch
1400	1500	Guideline of irrigation and water management (presented by Mr.Iwamoto. JICA AVS Team)
1500	1600	Guideline of farm land consolidation (presented by Dr.Masamba. JICA AVS Team)
1600	1620	Tea/Coffee break
1620	1700	Discussion
1830	1930	Reception

8th (Tuesday)

0900	0945	Agricultural development plan in Western Province especially in the Mongu district (presented by Mr.Muyapekwa. DAO Mongu)
0945	1115	Developing process and outlines of paddy field consolidation techniques (presented by Dr.Nakagawa. Prof. Tokyo University of Agriculture)
1115	1130	Tea/Coffee break
1130	1230	General discussion and conclusion of seminar
1230	1400	Lunch
1400	1630	Steering Committee Meeting

添付資料 2.

Perticipants List of the AVS Seminar

GUEST NAME	ORGANIZATION
1. LEROY SCHERER	USAID / ZAMBIA
2. A.K.MWANAMWARVOS	M.P.LIVWA
3. N.RNYIRENDA	ZIS
4. O.CHIWAYA	ZIS
5. Mr. THOMSEN	FAO
6. Dr. MUNYNDA	MOA
7. J.S.MULUGNSHI	PPU
8. L.J.MWALE	MOA
9. M.NDIYOI	R/W
10. C.CHEWE	MAFF, MONGU
11. L.K.SIKENA	MAFF, MONGU
12. A.E. DAKA	RESEARCH, MAZABUKA
13. I.S.K.SYANKWILIMBA	Rice Coordinator
14. P.SISUHO	Kafushi Rice Project
15. L.IKEGON	Kafushi Rice Project
16. Xu. DIXEN	Kafushi Rice Project
17. XIONG HYAIN	Kafushi Rice Project
18. MAKOTO INABA	JICA TOKYO
19. OSAMU TSUJI	JICA TOKYO
20. F.A.ISITEKETO	Dept. of Agric. Lusaka
21. A.N. TEMBO	Dept. of Agric. Lusaka
22. J.B.HAKANTU	NIKS
23. I.IIKAWA	JICA Expert
24. S.NAKAGAWA	Tokyo UNIV. of Agric.
25. A.SKORPEN	UNDP
26. P.M.WALUSIKU	Agriculture Mongu
27. K. TSURITA	Embassy of Japan
28. M.A.SITWALA (Mrs)	MAO.
29. T. DOKIYA	MAFF
30. S. MORINAGA	JICA
31. P.L.GOOREN	NETHERLAND Embassy
32. A.M.BUNYOLO	MT.MAKULU
33. J.U.LUBISO	FWNIDA / WPCU
34. C.BASTIAANSEN	LWMP / DOA / MONGU
35. I.M.AKAYOMBOKWA	Dept. of Agric
36. NAWA KWELEKA	JICA
37. KOJI KAMIYA	JICA
38. YASUHIRO DOI	JICA

GUEST NAME	ORGANIZATION	
39. KOJI YAMAGUCHI	JICA	
40. R.K.SHULO	Lusaka MAFF	
41. M.MUTALE	Dept. of Water Affairs	
42. JOHN HAWES	British High Commission	
43. Mr. MULELE	Dept. Minister / Director	
44. A.MBOZI	MAFF Planning DV	
45. G.SIKAZWE	MAFF Planning DV	
46. K.KAPEPULA	MAFF / PD	
47. M.MUKSRABAI	MAFF-M.A.I.S	
48. T. KALYATI	MAFF Planning DV	
49. H.AKAKULUBELWA	MAFF-N.A.I.S	
50. A.W.CHILEMA	MAFF-N.A.I.S	
51. K.DAKA	MAFF Planning DV	
52. R.K.CHUNGU	Dept. of Agric.	
53. D.C.CHIFURUSHI	ZANA	
54. B.Y.MAKUYU	M.O.A MONGU	
55. H.D. MTONGA	MAFF LUSAKA	
56. M.M. KANYEMBA	MAFF MONGU	
57. L.W. MUYAPEKWA	MAFF MONGU	
58. E.MUKOSHA	DOA (MAFF) MONGU	
59. J.CHINGUMBE	Agric. MONGU	
60. A.CHALABESA	Dept. of Agric MT. MAKULU	
61. AGNES BANDA	Times of Zambia-Lusaka	
62. CHOLA MAKA	ZNBC-Lusaka	
63. BOYD KANAUEGOLE	DANA	
64. B.B.O.KANYUNGU	Dept. of Agric. HQ	
65. M.MUANUBA	Z.D.MAIL	
66. DAVID SIMAUKI	MONGU	
67. FRASER MUSHIBWE	NCDP	Economist

Member List of the Steering Committee Meeting

8-Dec-92

NAME	ORGANIZATION	TITLE
1. JOSY.B.HAKAMTU	NIRS min. of MAFF	OIC / Irrigation Engineer
2. I.S.K. SYANKWILIMBA	NIRS.MA	Rice Coordinator
3. A.M.BUNYOLO	MT.MAKULU	Region III coordinator / Soils Team Leader
4. B.B.O KANYUNGU	Dept. of Agric. HQ	A/CAO (Crops)
5. F.MUSHIBWE	N.C.D.P	Economist
6. M.M.CHIINDA	Dept. of Agric.	PAO
7. M.R.MULELE	Dept. of Agric. Lusaka	Director of agric.
8. R.K.CHUNGU	Dept. of Agric. Lusaka	Assistant director of agric.
9. K.MUNYINDA	Dept. of Agric. Lusaka	ADA (RES)
10. C.M.M.CHEWE	Dept. of Agric. Mongu	Rice Agronomist
11. G.MBOZI	MAFF Planning division	Senior Agric Economist
12. L.J.MWALE	Dept. of Agric. Lusaka	Assistant director
13. M.M.KAMYEMBA	Dept. of Agric. Mongu	CHO
14. MUKELABAI NDIYOI	ARPT Team Leader	Agronomist
15. J.N.CHINGUMBE	Dept. of Agric. Mongu	Acting P.A.O
16. L.MUYAPEKWA	Dept. of Agric. Mongu	D.A.O
17. J.S MULUNGUSHI	Provincial Regional Planner	CRPO
18. L.K.SIKENE	Officer -In-Charge Mongu	O.I.C/Tree crops officer
19. T.DOKIYA	Dept. of Agric. MAFF	Agricultural Specialist
20. S. MIYOSHI	JICA Zambia Office	Staff
21. M.INABA	JICA HDQ Tokyo Japan	Staff
22. O.TSUJI	JICA	Leader of Advisory team
23. Y.TAKAHASHI	JICA AVS TEAM	Team Leader
24. Z.KURITA	JICA AVS TEAM	Rice agronomist
25. A.IWAMOTO	JICA AVS TEAM	Water management Expert
26. M.GUEYE	JICA AVS TEAM	Agrometeorologist
27. P.S.R.MAKUKISI	JICA AVS TEAM	

3. 質疑応答（SeminerならびにSteering Committeeで提起された質問および意見とその回答）

（質問および意見）	（回　答）
(1) 作物生産技術	
1) 稲藁の鋤込み。 ネガティブになる条件、鋤込み労力および量、土壌成分に対する影響。	ネガティブになるのは排水不良で嫌気分解し、有害成分の発生による根腐れ、および稲藁が稲の作付までに十分分解しないと分解のために窒素が消費されて、稲が窒素飢餓になる点である。この点については指針で排水良好な条件下で好気的に十分に分解させる必要があると解説している 鋤込み労力は、散布は人力で行うが、鋤込みは牛耕で行うので問題はないと説明。また、鋤込み量はその圃場でとれたものを鋤込み、鋤込みの深さは土壌表面に露出しない程度にすると説明。 土壌成分には、明らかな影響が出ていないが、植物体分析では枝葉の窒素濃度が高く、増収も裏付けていると説明。
2) 石灰施用に関連して、土壌pH測定の際の抽出法、草焼きと石灰施用との関連。	pHは$CaC\ell_2$抽出である。この点はレポートに明記する必要がある。草焼きないし、稲藁焼却灰は石灰の代用となり得る旨説明。この点はレポートに解説している。
3) 目標収量、作付体系、作物の種類等。 目標収量は農民レベルで可能か、指針に示された以外の作付体系や、作物、とくに豆科の可能性。	目標収量は、guide lineに従えば、農民レベルで可能と考える。指針以外の作付体系も将来検討されるべきものと考える。 豆科については実証試験の中で検討した限りでは十分な収量のものが得られなかったので採用しなかった。この点はレポートにも報告した。
4) Namushakende圃場はSishanjo地帯にあり、実証試験の結果はSishanjoに偏っているのではないか、汎用性はあるか。	実証調査の主な対象とした氾濫原縁辺部には多くのタイプの土壌が分布していることは十分に承知しており、現地試験や現地調査によって、また、各地区からの土壌を採取して試験を行う等、実証

調査の結果の汎用性については十分に考慮した。但し、この点はレポートに必ずしも十分に説明していないので、第1章の経過の項で解説する必要がある。

地耐力についてもSishanjoはMataba sitapaに比べて弱く、Sishanjoにおける牛耕を周年にわたって実施することは困難ではないかとの意見もあったが、実証調査の結果から0.8 kg／㎠の硬度で可能であると説明した。

5) "Mataba Sitapaは、Sishanjoより標高が高いという記述は正しくない" という指摘について。

Dutchは、Sishanjonの方が高いとしているが、常にそうであるとは言えない。dutchのSuveyを見ても高いとは言い切れない。記述の表現について検討し、データの出典等を追記する。

(2) 生産基盤整備技術。

1) 2か所の実証Sitesが氾濫原を代表し得るか。

作物生産技術の4)で述べた。

2) Water requirementの試算において地下水位を考慮すべきではないか。

「本ガイドラインは標準的な計算手法について提示したものであり、それぞれの地域に対する具体的な開発計画策定の段階で詳しく検討すべきである」と説明した。

3) Basic Intake Rateの定義について説明して欲しい。

Basic Intake Rateの定義等についてAppendixで追加説明する。

4) 圃場整備指針のコストは？

指針の作成にあたってはminimum costを第一として進めた。
即ち、動力灌漑、最低の土の移動、自然勾配に沿った排水路設置等々である。この指針をもとに具体的な開発計画策定の段階で、実際のコスト計算がなされる旨を詳しく説明し、概ね参会者は了解した。

(3) その他、セミナー、AVSに関する一般論。

1) ザンビア側の反応

a) セミナーは成功であった。

b) セミナーは有益であったが、大部分のザンビ

ア人はAVSのS／Wを理解していなかったため、コストについて多くの質問が出た。

c） ザンビア側の協力は必ずしも十分でなかった。

d） AVSは将来への発展の第一歩である。

e） Target areaは極めて広く、ザンビア、日本両者の協力が必要で、一方的な期待はよくない。

f） AVSのS／Wの理解は進んだと思うが、残った問題点は今後の協力で解決される必要がある。ザンビア側のCounterpartの協力が一層要請される。

2） 日本側の反応

a） AVS、F／Sの理解の不足が指摘される。

b） Chairman（圃場整備指針発表時）の議事運営について不満が残った。

c） 技術移転をより有効にするため、ザンビア側expertの一層の協力を要請したい。

4. セミナー関係資料

堀内大使スピーチ原稿

REMARKS MADE BY HIS EXCELLENCY DR SHINSUKE HORIUCHI AMBASSADOR OF JAPAN TO THE REPUBLIC OF ZAMBIA ON THE OCCASION OF THE SEMINAR ON THE AGRICULTURAL VERIFICATION STUDY IN THE REPUBLIC OF ZAMBIA, HELD ON 7TH DECEMBER, 1992

Distinguished Officials
Ladies and Gentlemen

I thank you most sincerely for inviting me here this morning to attend this seminar on the Agricultural Verification Study in the Republic of Zambia. I shall attend and participate for as long as time permits.

This seminar follows a study carried out in Mongu, Western Province, by Japanese consultants in conjunction with Zambian experts, over the past 5 years. The object of the study was to collect and analyse basic data relating to the present and future development of agriculture in the Western Province, with emphasis on the development of rice production. We will today learn of the results of the study.

Farmers in Zambia are classified in four categories.
The first is the large-scale commercial farmer with over 40 hectares. Second is the medium-scale commercial farmer with between 10 and 40 hectares. Third is the small-scale semi-commercial farmer with between 1 and 10 hectares and lastly there is the traditional or subsistence farmer with 1 to 5 hectares. The third and forth categories represent over 90% of the Zambian farmers, who are the most vulnerable in the present economic situation.
I hope that this sector of the farming community will be facilitated to play an active role under the liberalized economy.

The Government of the Republic of Zambia is said to be fully committed to the implementation of the Structural Adjustment Programme, with the assistance of the donor countries, the World Bank and the International Monetary Fund.
During the past one year since MMD came into power, various institutional changes have been seen in such form as privatisation, new investment act, decontrol of maize price, cutting subsidies, etc., while the numerical figures of the economic sectors still indicate hardships.
Having said that, however, I have been impressed by the comments from the Zambian leaders expressed in the donor's meeting at State House last Thursday to proceed the economic recovery programme with determination, as well as the Zambian people's will to support the programme as shown in the results of the Local Government elections.

I arrived in Zambia just a month ago to take up my tenure of office. Since my arrival I have had the opportunity to visit several projects extended by the Japanese Government, and have met with a number of Zambian officials as well as members of the diplomatic corps. Through these meetings and conversations, I think I have come to a conclusion that what is most needed in Zambia is the creation of job opportunities for both the urban and rural jobless.

President Chiluba recently announced that the crime rate in this country is on the increase, which I am sure will most definately discourage investors to Zambia. The obvious solution for curbing this trend would be to increase employment possibilities in all sectors such as agriculture, industry, commerce, services and so on. When every Zambian holds a job, their efforts and labour will automatically contribute towards Zambia's economic recovery, by utilizing the abundant natural resourses. In this context, I think agriculture, if well managed, is the very sector capable of absorbing the majority of the Jobless, thus contributing to the economic recovery of this country.

Finally, I end off by wishing you a successful seminar.

Thank You.

農業省　副大臣（Mr. G. NKAUSU）スピーチ原稿

DRAFT OPENING SPEECH AT THE RESULT PRESENTATION OF THE AGRICULTURE VERIFICATION STUDY CARRIED OUT IN MONGU BY JICA FROM 1988 TO 1992
PAMODZI HOTEL, 7TH DECEMBER, 1992

THE RESIDENT REPRESENTATIVE, JICA
REPRESENTATIVES OF MISSIONS BASED IN ZAMBIA
INVITED GUESTS
LADIES AND GENTLEMEN.

IN THE FIRST PLACE, I WOULD LIKE TO EXPRESS MY GRATITUDE FOR HAVING THE HONOUR TO OFFICIATE AT THIS VERY IMPORTANT OCCASSION WHEN RESULTS OF THE MONGU AGRICULTURE VERIFICATION STUDY WILL BE PRESENTED.

MR. CHAIRMAN, CONSIDERING THE LOW AVAILABILITY OF PRODUCTIVE AGRICULTURAL LAND IN WESTERN PROVINCE AND MONGU IN PARTICULAR AND THE LACK OF TECHNOLOGY THE RELEVANCE OF THE VERIFICATION STUDIES CONCERNED WITH THE IMPROVEMENT OF THE WATER MANAGEMENT SYSTEM IS EVIDENT.

AGRICULTURE PROVIDES FOOD TO THE EVER GROWING URBAN POPULATION. IT ALSO IS A SOURCE OF LIVELIHOOD FOR MORE THAN HALF OF THE ZAMBIAN POPULATION. WITHIN A DECADE AGRICULTURE WILL HAVE TO SUPPORT A POPULATION OF OVER 10 MILLION PEOPLE.

NOTABLY COPPER HAS FOR A LONG TIME PLAYED AN IMPORTANT ROLE AS ZAMBIA'S GROWTH ENGINE, DOMINATING BOTH THE BALANCE OF PAYMENTS AND PUBLIC FINANCE.

2/...

SINCE THE BEGINNING OF THE DECLINE IN COPPER PRICES AND PRODUCTION IN MID '70'S ZAMBIA HAS BEEN EXPERIENCING A DETERIORATING ECONOMIC SITUATION. THIS PROMPTED THE GOVERNMENT TO THINK OF OTHER EXPLOITABLE RESOURCES FOR ITS ECONOMIC SURVIVAL. ZAMBIA HAS THE LABOUR AND ABUNDANT LAND WHICH COULD PROVIDE SUSTAINABLE AGRICULTURE. HAVING RECOGNIZED THIS FACT, MR CHAIRMAN, THE ZAMBIAN GOVERNMENT HAS TAKEN FRONTIC EFFORTS IN PROMOTING AGRICULTURE THROUGH FINANCIAL STABILIZATION, DIVERSIFICATION OF PRODUCTION, EXPORT ORIENTATION, IMPROVED MARKETING THROUGH LIBERALIZATION AND OTHER FARMER TARGETED INCENTIVES.

MR. CHAIRMAN, IT IS WITH THESE FACTS IN MIND THAT I CONSIDER THE PURPOSE OF THIS SEMINAR EXTREMELY IMPORTANT. ANY EFFORT AIMED AT EITHER INCREASING YIELD OR CROP PRODUCTION THROUGH EXPLOITATION OF LOCAL POTENTIAL WILL RECEIVE THE FULL SUPPORT AND CO-OPERATION OF THE GOVERNMENT OF ZAMBIA. THE MONGU AGRICULTURE VERIFICATION STUDY WHOSE RESULTS WILL BE PRESENTED DURING TODAYS SEMINAR IS SUCH AN EFFORT.

MR. CHAIRMAN, THE AIMS OF THE AGRICULTURAL VERIFICATION STUDY WAS TO INVESTIGATE AGRICULTURAL DEVELOPMENT POTENTIAL AND FUTURE PERSPECTIVES IN THE WESTERN PROVINCE THROUGH THE COLLECTION AND ASSIMILATION OF DATA AND INFORMATION CONCERNING THE ACTUAL CONDITIONS PREVAILING IN THE AGRICULTURAL SECTOR. I HAVE ALSO BEEN INFORMED THAT THE STUDY ALSO INVOLVED MULTILATERAL COMPARATIVE CROP CULTIVATION TRIALS.

PARTICULARLY FOR RICE. INVESTIGATIONS ON LAND CONSOLIDATION AND RECLAMATION STANDARD FOR PADDY FIELDS, TARGETED AROUND MONGU DISTRICT. THE OBJECTIVES OF THE STUDY ARE TO ESTABLISH LOCALLY ADAPTED AGRICULTURAL TECHNOLOGY FOR RICE CULTIVATION ALTERNATED WITH UPLAND CROPS AND PROPER LAND CONSOLIDATION.

I AM AWARE MR CHAIRMAN, THAT LIKE ANY OTHER PROVINCE IN ZAMBIA W.P IS FACED WITH CONSTRAINTS THAT HAVE A DIRECT BEARING ON PROJECT IMPLEMENTATION. SOME OF THESE FACTORS ARE: -THE MACRO -ECONOMIC SITUATION, INPUT SUPPLY AND MARKETING, AGRICULTURAL RESEARCH AND EXTENSION. THE GOVERNMENT OF ZAMBIA HAS BEEN AND WILL CONTINUE TO TACKLE THESE PROBLEMS IN ORDER TO STRENGTHEN THE DEVELOPMENT PROSPECTS OF THE PROVINCE.

ADDITIONALLY, WESTERN PROVINCE, MR CHAIRMAN IS BESETTLED BY PROBLEMS PERCULAR TO THE PROVINCE. I BELIEVE THAT THE RESULTS OF THE STUDY WILL MAKE IT POSSIBLE TO UTILIZE THE LIMITED FERTILE WETLANDS FOR RICE CULTIVATION.

I NOTE WITH GRATITUDE, MR CHAIRMAN, THAT THE OBJECTIVES OF THIS STUDY ARE IN LINE WITH GOVERNMENT POLICY OF CROP DIVERSIFICATION. WE HAVE ALL BEEN TAUGHT A LESSON BY THE LAST SEASONS DROUGHT.

4/..

MR. CHAIRMAN RICE IS A GOOD ENERGY ALTERNATIVE TO MAIZE. WHERE AGRO-ECOLOGICAL CONDITIONS FAVOUR RICE PRODUCTION, THIS SHOULD BE ENCOURAGED, ALTHOUGH CONDITIONS DO NOT FAVOUR MAIZE PRODUCTION IN MOST PARTS OF WESTERN PROVINCE AND MONGU IN PARTICULAR THE POTENTIAL FOR RICE PRODUCTION APPEARS TO BE UNLIMITED.

I BELIEVE MR CHAIRMAN, WESTERN PROVINCE HAS THE POTENTIAL TO PRODUCE ENOUGH RICE TO MEET OUR NATIONAL REQUIREMENT, ONE OF THE MAIN LIMITING FACTORS TO EXPLOIT THIS POTENTIAL IS LACK OF PRODUCTION TECHNOLOGY.

MR CHAIRMAN, CONSIDERING THE AVAILABILITY OF PRODUCTION AGRICULTURAL LAND IN WESTERN PROVINCE AND NON MONGU IN PARTICULAR, THE RELEVANCE OF THE VERIFICATION STUDIES CONCERNED WITH THE IMPROVEMENT OF THE WATER MATER MANAGEMENT SYSTEM IS EVIDENT.

MR. CHAIRMAN, I FEEL OBLIGED TO COMMEND THE INVOLVEMENT IN THIS STUDY OF JAPANESE GOVENMENT THROUGH THE JAPAN INTERNATIONAL CO-OPERATION AGENCY. THEIR FINANCIAL AND TECHNICAL INPUT HAS MADE IT POSSIBLE TO UNDERTAKE THE STUDY TO ITS COMPLETION. I HAVE EVERY CONFIDENCE THAT THE RESULTS OF THE STUDY WILL PROVIDE THE NECESSARY EXTENSION MESSAGES THAT WILL RESULT IN INCREASED AGRICULTURAL PRODUCTION IN MONGU DISTRICT AND THE WESTERN PROVINCE IN GENERAL.

5/...

BEFORE I END MY SPEECH, I CONSIDER IT EQUALLY IMPORTANT TO OBSERVE THAT THERE ARE OTHER DONORS WHO HAVE BEEN ASSISTING US IN THE WESTERN PROVINCE AMONG AGRICULTURAL PROJECTS SUPPORTED BY THE NETHERLANDS GOVERNMENT ARE:- KALABO AGRICULTURAL PROJECT, SENANGA WEST AGRICULTURAL DEVELOPMENT AREA PROJECT, THE MASESE AGRICULTURAL DEVELOPMENT PROJECT, THE LAND AND WATER MANAGEMENT PROJECT AND ARPT. THE NORAD HAS BEEN ASSISTING IN THE FIELD OF URBAN AND RURAL WATER SUPPLY WHEREAS THE FINNIDA HAVE BEEN INVOLVED IN SUPPORTING THE CO-OPERATIVE MOVEMENT. WE HAVE AND WILL CONTINUE APPRECIATING THIS SUPPOTIVE GESTURE FROM FRIENDLY COUNTRIES. AS A DEVELOPING COUNTRY WITH AN AILING ECONOMY THE NEED FOR EXTERNAL ASSISTANCE TO RESUSCITATE THE ECONOMY CANNOT BE OVEREMPHASIZED.

BY WAY OF CONCLUDING THE SPEECH, MR. CHAIRMAN, I WISH TO THANK ALL THE INVITED GUESTS FOR ATTENDING THIS OPENING CEREMONY AND HOPE THAT THEY WILL BE AVAILABLE FOR THIS REST OF THE SEMINAR.

IT IS NOW MY PLEASURE TO PRIVILEDGE TO DEEFARE THE MANY AGRICULTURAL VERIFICATION STUDY SEMINAR OFFICIALLY OPENDED.

*****   ***   ***   ******

JICAザンビア事務所　神谷所長スピーチ原稿

SPEECH DELIVERED BY THE RESIDENT REPRESENTATIVE OF JICA MR KOJI KAMIYA DURING THE JICA AGRICULTURAL VERIFICATION STUDY SEMINAR ON 7TH DECEMBER 1992 PAMODZI HOTEL AT 08.30 HOURS

THE DEPUTY MINISTER OF AGRICULTURE FOOD AND FISHERIES, MR G. NKAUSU
HIS EXCELLENCY THE AMBASSADOR OF JAPAN
DISTINGUISHED INVITED GUESTS
SEMINAR PARTICIPANTS
LADIES AND GENTLEMEN

IT IS A GREAT HONOUR FOR ME TO SAY A FEW WORDS AFTER MY AMBASSADOR HAS ALREADY ADDRESSED YOU. HOWEVER, ON BEHALF OF JICA I ONLY WISH TO PAY TRIBUTE TO ALL THE PEOPLE WHO CONTRIBUTED IN ONE WAY OR ANOTHER TO THE SUCCESS OF THE AGRICULTURAL VERIFICATION STUDY UNDERTAKEN IN MONGU. THE OBJECTIVES OF THE STUDY WERE FULFILLED. JICA IS THEREFORE, LOOKING FORWARD TO THE CONTINUITY OF THE FARM ACTIVITIES WHEN THE FARMS, THEIR EQUIPMENT AND MANAGEMENT OF ACTIVITIES THERE ARE TRANSFERRED TO THE GOVERNMENT OF THE REPUBLIC OF ZAMBIA. JICA WILL BE PROUD IF THE FARMS WILL ENSURE CONTINUED CONTRIBUTION TO THE INCREASED RICE PRODUCTION AND AGRICULTURAL DEVELOPMENT IN GENERAL IN THE WESTERN PROVINCE THROUGH PROFITABLE CROPPING PATTERNS OF BOTH CEREALS AND VEGETABLES.

I WISH TO INFORM YOU THAT THE NEGOTIATION FOR ANY FURTHER JAPANESE COOPERATION IN THIS AGRICULTURAL PROJECT WILL DEPEND UPON THE SUCCESS OR FAILURE OF THIS SEMINAR.

IN THIS REGARD, I HOPE THE SEMINAR WILL BE BOTH SUCCESSFUL AND FRUITFUL.

BEST REGARDS

THANK YOU.

GRZ/JICA SEMINAR

ON

THE AGRICULTURAL VERIFICATION STUDY

IN

MONGU

PROG RAMME FOR GRZ/JICA SEMINAR ON "THE AGRICULTURAL VERIFICATION STUDY IN MONGU" AT PAMODZI HOTEL, LUSAKA. ON 7TH AND 8TH DEC.1992

7th (Monday)

0800	0900	Registration
0900	0930	Opening ceremony Ministry of Agriculture, Food and Fisheries Embassy of Japan JICA Zambia
0930	0945	Tea/Coffee break
0945	1030	Present situation and constraints of agricultural production in the Western Province (presented by Mr.Chingumbe. Act.PAO. Western)
1030	1120	Outline of the AVS (presented by Dr.Takahashi. JICA AVS Team leader)
1120	1230	Guideline for crop production technology (presented by Mr. Kurita. JICA AVS Team)
1230	1400	Lunch
1400	1500	Guideline of irrigation and water management (presented by Mr.Iwamoto. JICA AVS Team)
1500	1600	Guideline of farm land consolidation (presented by Dr.Masamba. JICA AVS Team)
1600	1620	Tea/Coffee break
1620	1700	Discussion
1830	1930	Reception

8th (Tuesday)

0900	0945	Agricultural development plan in Western Province especially in the Mongu district (presented by Mr.Muyapekwa. DAO Mongu)
0945	1115	Developing process and outlines of paddy field consolidation techniques (presented by Dr.Nakagawa. Prof. Tokyo University of Agriculture)
1115	1130	Tea/Coffee break
1130	1230	General discussion and conclusion of seminar
1230	1400	Lunch
1400	1630	Steering Committee Meeting

CHAIRING PERSONS FOR THE SEMINAR

7th (Monday)

			Chaired by
0900	0930	Opening ceremony	(Mr.Mulele)
0945	1030	Present situation and constraints of agricultural production in the Western Province	(Mr.Mwale)
1030	1120	Outline of the AVS	(Dr.Munyinda)
1120	1230	Guideline for crop production technology	(Dr.Munyinda)
1400	1500	Guideline of irrigation and water management	(Mr.Akayombokwa)
1500	1600	Guideline of farm land consolidation	(Mrs.Chungu)
1620	1700	Discussion	(Mr.Banda)

8th (Tuesday)

0900	0945	Agricultural development plan in Western Province especially in the Mongu district	(Mr.Mulungushi)
0945	1115	Developing process and outlines of paddy field consolidation techniques	(Dr.Inaba)
1130	1230	General discussion and conclusion of seminar	(Mr.Mulele)
1400	1630	Steering Committee Meeting	(Mr.Mulele)

Present Situation and Constraints of

Agricultural Production in the Western Province

PRESENT SITUATION AND CONSTRAINTS OF AGRICULTURAL PRODUCTION IN WESTERN PROVINCE.

INTRODUCTION:

The province is located in Western Zambia between 22 degrees and 25 degrees East and 13 degrees and 17 degrees South. It is bordered to the West by Angola, the South by the Namibian Caprivi strip to the East by the Tsetse infested Kafue National Park. The long distance to line of rail (Lusaka) contributes to the isolation of the Province.

Western Province covers an area of 126,386 Sq. km. The Province consists of vast, sandy upland plain which slopes gently from North-Western to South East. This upland plain is intersected by the flood plain of the Zambezi river. The river effectively bisects the Province into two parts. Putting Kalabo in the West while Lukulu, Senanga and Sesheke are located in the East. Kaoma and the greatest part of Mongu are wholly located on the Eastern side of the river.

Communication to the Western area is quite difficult especially during the flood periods.

The population of the Province (as at 1990 census) stands at 487,988. The fastest growing population is found in Kaoma whilst the lowest growth rate is in Kalabo (source: 1990 census of population).

Westrtn Province has four climatic seasons while the distinct ones are the wet and dry season.

Rainfall usually starts in November and ends in March or April. Largest % of rain falls between November and March, with peak period between December and February. Lukulu in North receives 1021mm while Sesheke in the South receives an average of 730mm.

The flooding of the Zambezi river usually controls the pattern of a large number of the people and their cattle. Both cattle and people traditionally follow the transhumance subsistence economy moving to the plains when floods recede. They go back into the uplands when the plains start to fill up again.

PRESENT SITUATION:

1. Soils and Crop Production:

More than 95% of Western Province is not suitable for cultivation of food crops. The Province is covered by the deep Kalahari sands. The dambo soils which are darker in color contain both sand and loam particles and have a higher fertility. The upland Barotse sand and sandy soils are generally poor due to low fertility and moisture holding capacity (Source: Provincial Medium Term Plan 1991-96). Millet, Sorghum and Cassava yield reasonably in the sandy upland areas while maize, and rice are more suited to the darker dambo soils.

In Kaoma soils are more loamy and some times contain clay particles. In Luampa and Luena valleys, red clays exist.

The Zambezi Plain is an Agriculturally important Zone. It contains the redeposited sand and darker sandy laoms often rich with surface peat.

These areas have a high potential for annual crops especially for small scale farmers.

Presently crop production is being encouraged in districts with soil potential. These are Kaoma, Sesheke, Senanga West and Lukulu East. Various on farm trials and demonstrations have been conducted in these areas and have shown that there is potential to increase production by the introduction of improved technologies (Source : ARPT. and Lima Demonstrations).

The crop production policy in the Province is aimed at encouraging increased production in order to achieve a higher level of self sufficiency in foodstuff. At the moment the Province has an approximate shortfall of 50 % (Source : 1991/92 Annual Report for Department of Agriculture Western Province.).

Crops commonly grown by farmers throughout the Province include Maize, Rice, Sorghum, Cassava and Millets. In order to achieve high level of production farmers are advised by field Extension workers to practice improved cultural practices such as timely land preparations, weed control, timely planting, use of manures or fertilizers and also use of appropriate improved varieties.

Agroecological Zones have continued to determine the varieties of crops grown in a particular area. On maize, MM 603/MM 604 is recommended for the medium rainfall areas while MMV 400 is recommended for low rainfall areas.

On rice, areas prone to high flood levels, deep water varieties such as malawi faya - and Angola crystal are encouraged. Areas of low flood levels are recommended for medium maturing varieties such as Supa, Burma and IITA. Planting of pure stands of rice varieties is encouraged in order to maintain uniformity in polishing quality.

On Sorghum farmers are encouraged to use early maturing varieties in order to beat the short rainfall season.

Crop performance and output in the last three years has been as follows:-

Crop	YEARS			
	1989	1990	1991	1992 (FORECASTS)
Maize (90 kg Bags)	284,764	96,983	60,636	35,948
Paddy Rice (80 kg Bags)	18,568	30,237	44,257	18,495
Sorghum (90 kg Bags)	264	63	634	606
Bulrush Millet (90 kg Bags)	3,902	1,210	766	931

CONSTRAINTS OF AGRICULTURAL PRODUCTION :

1. Crop Production.

Western Province is far away from both Copperbelt and Lusaka Town.

These are the centres of Political and Economic life of the Country (Source: Provincial medium Term Development Plan 1991-1996).

High transportation costs to these centres narrow the profit margins for the farmers.

Following are constraints to increased crop Production in Western Province, beginning with lack of credits. At the moment there are only two major Banks in the Province viz. Zambia National Commercial Bank and the Standard Bank of Zambia.

Barclays Bank Ltd., which is more less reckoned as the founder member of the Lima Programme is not operational in the Province.

Most small scale farmers in the Province are not able to meet the type of collateral like insurance, house mortgage etc... demanded by the two Banks.

The Lima Bank gives loans to fish Farmers in Mongu, Senanga, Sesheka and crop farmers in Kaoma, Lukulu and Senanga West.

Inadequate supply of inputs such as fertilizers and seeds is also one constraint in the Province. The Province has only one major supplier which is the Cooperative Union. The Union is unfortunately poorly represented in most districts. This then makes it difficult for small scale farmers to procure seeds of their liking. The National Home Stores and the Primary Health Care stock vegetable seeds in limited amounts. These are purchased by the Back yard vegetable growers in the townships.

Therefore farmers growing maize in the Lizulu, and Sishanjo, depend on F2 generation of seeds which give low yields,

The inadequate marketing arrangements in the Province force farmers to market their produce such as rich in Lusaka and Livingstone where, becouse of transport costs, they get only marginal profits for their produce.

In addition, crop like cassava and sorghum are marketed outside the Province since there are no processing plants in the Province. This discourages the would-be farmers in sorghum and cassava crops.

The poorly funded Research and Extension Services results in organizing of few on-farm-trials and farm demonstrations. In fact the Lima Programme came to an end in Western Province in 1987 when the FAO and SIDA Projects phased out. Presently the Extension Services are not carrying out any demonstrations due to lack of funds. The limited countervalue funds on part of GRZ makes the ARPT install very few on farm trials. The few that are carried out in Senanga West are through Donor Funds.

JICA Agricultural Verification Study had also in the past three years undertaken verification studies in Lealui and Namushakende areas with external funds. Hence the Research and Extension Services are so poorly funded that they have limited technological messages to disseminate to farmers in the Province.

Western Province also lacks crop impact projects like the Mpongwe Wheat Scheme in Ndola Rural and Gwembe Scheme in Southern Province. The available schemes under the newly formed Resettlement Department have no impact yet from which the rural farmers could learn. Hence farmers in this Province are practicing farming with very limited experience or examples from which to learn the trade.

Poor road network coupled with unnavigable rivers makes it difficult for farmers in this Province to transport their produce to the nearest market. Except for the Lusaka - Mongu - Senanga far road feeder road in Western Province require Fore Wheel drive vehicles because of the nature of the terrain.

During the flooding months of the year, the Western part of the Province i.e. Kalabo and Lukulu West are completely cut off from the rest of the province. The Zambezi River, unlike other rivers in some countries, is not navigable due to several rapids and swift currents down stream; making it difficult to utilize it for transportation of farmers' produce.

2. LIVESTOCK PRODUCTION:

Some of the constraints mentioned under crop production also apply to livestock production but others are:-

(i) Lack of reliable drinking water supply at convenient locations for livestock:

(ii) Poor animal nutrition due to

- Poor grazing lands:

- Poor grazing systems:

- Lack of supplementary feeding.

(iii) Poor Health due to the above problems as well poor health management systems:

(iv) Lack of investment capital to meet large investment outlays like diptanks, spray equipment, proper padlocking etc...

(v) Lack of agro-processing facilities at the local level including various labor saving equipment (*i.e. applicable to both crops and livestock.
e.g. - Grain processing equipment
- Milk Products processing equipment;
- Meat products processing equipment;
- Improved land preparation equipment;
- Improved farm storage facilities etc...

INTRODUCTION

Programmes aimed at encouraging or supporting the establishment of feasible agro-processing industries should be promoted after their identification.

FISHING INDUSTRY

This is another very important industry that has not been studied clearly, though it looks it has potential in the area due to the available natural water ways. So far this area needs attention and increased investment.

CONCLUSIONS

As earlier discussed, Crop and livestock Production increase in Western Province is possible if sound production techniques are extended to districts which have the soil potential and room for expansion. Research and Extension need to be intensified and funded in these areas.

Integrated Agricultural Projects that include improvement of Research and Extension in Agriculture, improved infrastructure in particular credit supply, inputs supply marketing, irrigation and drainage should be encouraged. Single production Projects should be discouraged because they give marginal benefits and sometimes create a host of other problems.

Outline of the AVS

Outline of the AVS

The Agricultural Verification Study Team

Yasuo TAKAHASHI

Introduction

Since 1980 the Zambian Government has given highest priority to agricultural development and has taken various measures. Under such circumstances, the Japanese Government agreed with the Zambian government, in October 1987, to conduct an Agricultural Verification Study (AVS) in the Mongu area, Western Province.

The main and the most important crop in Zambia is maize representing more or less one million ha planted area recently showing more than about ten times the planted area of even the second ranked crop. In the Western province although the planted area of maize is the first rank its value is not so large as representing only 5% of the total planted area of the country. On the other hand, the Western Province occupies 40% of the rice planted area of the total county representing one of two rice main producing provinces with the Northern Province occupying 36% (1990).

Food production in the Western Province is not enough for self sufficiency, and moreover, because of the little suitable production area for maize except Kaoma District, rice production is considered to be very important.

Mongu district ranks first in rice production in the Western Province, and the Province itself is, as said before, the main rice producing province. It can be said that Mongu area is the appropriate area for the AVS.

1. Objectives and the principles of the study

   The objective of the AVS is to establish a stable agriculture in the target area by formulating guidelines for farming practices, irrigation and water management, and farm land consolidation through the trials and surveys to be proceeded on the verification farms and surrounding local fields and also through the collection/assimilation of data and information concerning the actual condition of the agriculture in the target area.

In the targeted areas, agriculture is managed almost by small farmers and the development plan of the area is also emphasized on the development of small farmers. The main agricultural area is the edge of the flood plain and rice is the main crop of this area. In the flood plain, at present, there are no facilities for land consolidation resulting in unstable agricultural production owing to fluctuations in rainfall. However, under the condition of land consolidation, there is a possibility of establishing stable agriculture centered on rice cultivation. Considering these circumstances, the principle of the study is decided as follows.

(1) Small farmers are the main subjects of the system.

(2) The system is the technology under irrigation facilities.

(3) The system aims at a low cost and steady technology with rice-upland crops double cropping using animal draft and man power.

(4) Two basic cropping patterns are considered in this system.

- Early rice - Cool dry season upland crops
- Late rice - Hot dry season upland crops

(5) Soil improvement is emphasized for the improvement of plant growth. Heavy application of chemical fertilizers should be excluded.

(6) In consideration with the importance of inland fishery, the use of agricultural chemicals should be restricted for environmental conservation.

2. Progress of the study

The study is conducted in three stages: The first one concerns the general survey, data collection and selection of verification farm sites; the second one is the construction of the verification farms; and the third one is the conduction of verification trials and surveys on verification farms and surrounding local area.

(1) Stage I (March 1988 - June 1988)

Eight candidate sites were proposed by the Zambian side as shown in fig. 1. The general survey was conducted for natural conditions, socio-economic conditions, and farming practices of the surrounding area of the candidate sites, and also collection of the useful data offered by the Zambian side was conducted. Based on these surveys and data and also after consultation with the Zambian side, the two sites, Namushakende and Lealui, were selected. Both sites are located in the Zambezi flood plain.

Besides the flood plain, many dambos are located on the table land and are considered as important agricultural production areas as the ones included in the candidate sites, but because of little data of hydrology and meteorology, it seemed difficult to determine the consolidation standard for the construction of a verification farm. Therefore, the selection of a dambo as verification farm was abandoned. However, considering the agricultural utilization of a dambo in the future, the Mweke Dambo, having good access from Mongu, was selected for data collection of meteorology, hydrology, topography, and soil, although not included in the original candidate sites.

(2) Stage II (July 1988 - December 1989)

After deciding on the land-consolidation standards for the verification farms, topography and soil survey for two selected sites were conducted during July to August 1988. Construction of the farms were planned to be implemented over two years period, considering the feasible construction pace.

The first year	:	2.3 ha out of 4.9 ha in Namushakende farm. All of 2.0 ha of Lealui farm. Road, levee, irrigation canal, and drainage ditch of both farms. Observation pipe, and access road in Mweke Dambo.
The second year	:	Remaining 2.6 ha in Namushakende. The warehouse of both farms.

(3) Stage III (November 1988 - June 1992)

Using the verification farms constructed, cultivation trials for paddy rice in the wet season and upland crops in the dry season which constitute the cropping systems with paddy rice and also water management trials concerning these crops, have been conducted. On the other hand, with these trials, investigation for equipments in the verification farms, and surveys for hydrology, topography, and soil in the areas which are considered to be the appropriate areas for agricultural development in the future, have been conducted.

From the data obtained from the above mentioned trials and surveys, guidelines for farming practices, irrigation and water-management, and farm land consolidation are determined.

The process of the study is summarized in Fig. 2 and precisely in Fig. 3. The study is composed of two major items, the one is the crop production technology and the other is the land consolidation technology.

1) Crop production technology

a) Trials for component technologies of the farming system will primarily be carried out.

b) Depending on the component technologies and related information, the farming system will be tried and verified. Problems in the system, if found, would return to component technology trials.

c) Production cost, efficiency, income, etc. in the farming system will be calculated for evaluation of the system

d) Adaptability of the farming system may be investigated by the means of on-farm trials.

e) Depending on the established farming system and supplementary component technologies, guideline for farming practices will be formulated.

2) Land consolidation technology

a) The irrigation and water management trials, and the survey for structure and functions of facilities will be proceeded at the constructed verification farms and the data will be utilized for determining the land consolidation standard.

b) Survey for topography, hydrology, soil, and existing agriculture will be conducted in the area of the flood plain where somewhat different conditions from the verification farms are found and traditional agriculture is practiced. Thereby the land consolidation standard will be investigated by selecting the area, as a model.

c) Finally, the guideline for the land consolidation standard applicable to the agricultural development in the flood plain will be determined.

d) Survey for meteorology, hydrology, topography, and soil will be practised and standard land utilization will be investigated for determining the suitable crops and their location in Mweke dambo.

It is important to note that Namushakende verification farm is located on the edge of the flood plain, where, at present, traditional agriculture is practiced widely despite the lack of land consolidation. The results of the verification study could be applied if some land consolidation is practiced in this area. On the other hand, Lealui verification farm is located on the center of the flood plain, Saana, and consists of an entirely sandy soil with difficulties of water control. Considering these circumstances the priority of the study is set on the trials and surveys in Namushakende and surrounding edge of the flood plain. In Lealui, only the component technologies trials are performed for water utilization under sand condition.

3. Results

(1) Crop production technology

1) Guideline for farming system

Based on the findings through the component technologies and cropping system trials, guidelines for farming system are formulated. These are the main guidelines of the crop production technology. The prerequisite for these guidelines are considered as follows:

① Management strategy : Diversified farming of paddy rice and upland crop with 5 - 6 heads cattle raising

② Scale of cultivation land/farm-household : 2 - 5 ha

③ Family workers : 3 - 4 members

④ Basic means to work : Farming by using hoe except for plowing and harrowing operations by oxen which is ordered outside

⑤ Cropping system:

Single cropping system of paddy rice
Double cropping system of "Rice - cool dry season crop"
Double cropping system of "Rice - hot dry season crop"

⑥ Field condition:

Double cropping system of "rice - upland crops" is suitable to the area of the flood plain edge where peat-muck soils dominate (thickness of the said soil is around 20 cm) and the area of sandy loam soil which are equipped with drainage and irrigation functions.

Rice single cropping system is suitable to the area associated with insufficient drainage condition at the beginning and end of dry season.

Actually the following three major guidelines are formulated.

① Guideline of rice single cropping system

Early rice single cropping system	(in good field condition)
" "	(in poor field condition)
Late rice single cropping system	(in good field condition)
" "	(in poor field condition)

② Guideline of double cropping system of "Early rice-cool dry season crops"

Early rice - Wheat cropping system
Early rice - Onion cropping system
Early rice - Cabbage cropping system

③ Guideline of double cropping system of "Late rice - hot dry season crops"

Late rice - Maize cropping system
Late rice - Tomato cropping system

Each guideline shows target yield, operation sequence figure, cropping pattern (operation items and operation details), and cost return analysis. A cropping system can be completed when each operation item is practiced following its operation details.

In the actual farmer's field, owing to his field and labor conditions, combination of cropping systems will be practiced. As an example, a model is shown in Chap 2.2.4, and the results calculated from the on-farm trials are shown in Chap 2.2.5.

2) Guideline for useful component technology

Although the above mentioned guidelines for farming systems are the main ones of the crop production technologies, some component technologies, which were verified during the component technology trials, were considered to be useful not as an system technology but as an individual technology to be readily applicable.

a) Line maker and Drill Seeder for paddy rice

For stripe seeding, line maker and drill seeder for paddy rice which can be manufactured locally recommended.

b) Sowing methods on sandy soil

For securing the seed emergence on sandy soil, constructing deeper seeding ditches and mulching of dried grass after seeding were recommended.

c) Fertilizer application on sandy soil

Concerning method b), a fertilizer application method along with the deeper-ditch method was applied to prevent germination difficulties as well as to inhibit fertilizer loss.

d) Sowing methods on peat-muck soil with burning grass

The conventional method for burning weeds and weed roots before cropping was verified as effective in pH correction and mineral supply.

e) Utilization of rice straw ash in rice cultivation

Rice straw ash can replace lime in terms of pH correction. Even after due consideration of the importance of rice straw as a fooder for livestock, its importance as a substitute for lime is recognized.

f) Rice straw incorporation in peat-muck soil

When paddy rice is grown on the peat-muck soil of the area, it often experiences helminthosporium leaf spot in its latter stage of growth. When rice straw is applied and aerobically and adequately resolved during the dry season in which a farmland is under dry condition, less helminthosporium leaf spot occurs and, eventually more yield is attained. This method is applicable to single-cropping fields which become dry enough in the dry season. Alternations of double - cropping and single - cropping as well as applying the above method help enhance soil fertility.

(2) Land consolidation technology for agricultural production

1) Guideline for water control

Based on the data obtained from the AVS farms, the meteorological data of the area, and the proposed farming system models, actual water management guidelines were formulated.

2) Guide line for farm land consolidation

Considering the actual farm size and the possibility of grouping several farm blocks into one farming system unit, guidelines for farm land consolidation were formulated considering a minimum cost.

4. Recommendation

The agricultural verification study resulted in the elaboration of technical guidelines for crop production and production infrastructure improvement. In order to achieve a stabilized production at the edge of the flood plain of the Zambezi river as well as in similar areas throughout Zambia, it is necessary, based on the above guidelines, to make agricultural technology come to stay in the areas and further to spread and strengthen training systems for the enhancement of technology transfer. It is also required, along with the above, to establish a development plan for the project area and to implement the project. It is desirable that a development plan includes, in addition to the items included in the agricultural verification survey, social and financial surveys in the project area to examine necessary facilities and organizations for obtaining post harvest that adds value to the negotiability of harvest and harvest itself. It is also desirable that the plan is such that it serves for the organization of infrastructures in framing villages as well as for the establishment of continuous agriculture. It is desirable that the implementation of the development project of agriculture and farming villages be accomplished through the effort of the government of Zambia, and the aid from foreign countries. We also proposed to the government of Zambia to immediately start studies on the operation of the project after implementation and maintenance of facilities along with the establishment of a guiding system.

These guidelines were made based on the results obtained from surveys and studies included in the agricultural verification tests performed over the period of four years. However, as surveys and experiments were limited to aforementioned two farm areas, further surveys into expanded areas are required. It is strongly recommended that the proposed guidelines are revised based on the added surveys.

The issues to be dealt with are categorized in the following two groups:

(1) Issues requiring short or middle-term review

1) Selection of paddy varieties adaptable for the flood plain soil (depending on soil types)

2) Selection of such varieties as wheat, maize and tomato that are adaptable for double-cropping with paddy on the flood plain soil

3) Promotion of hydrological and soil survey for the farmland improvement

4) Development of simple apparatus including man-operated threshers and transporters

5) Spread of agricultural technology and strengthening of training systems

6) Promotion of construction of farmers organization

(2) Issues requiring middle or long-term review

1) Breeding of excellent varieties of paddy and that of field crops that constitute two-crop system with paddy

2) Grading and evaluation of potential areas for development

3) Promotion of farmers organization and establishment of reinforcement system

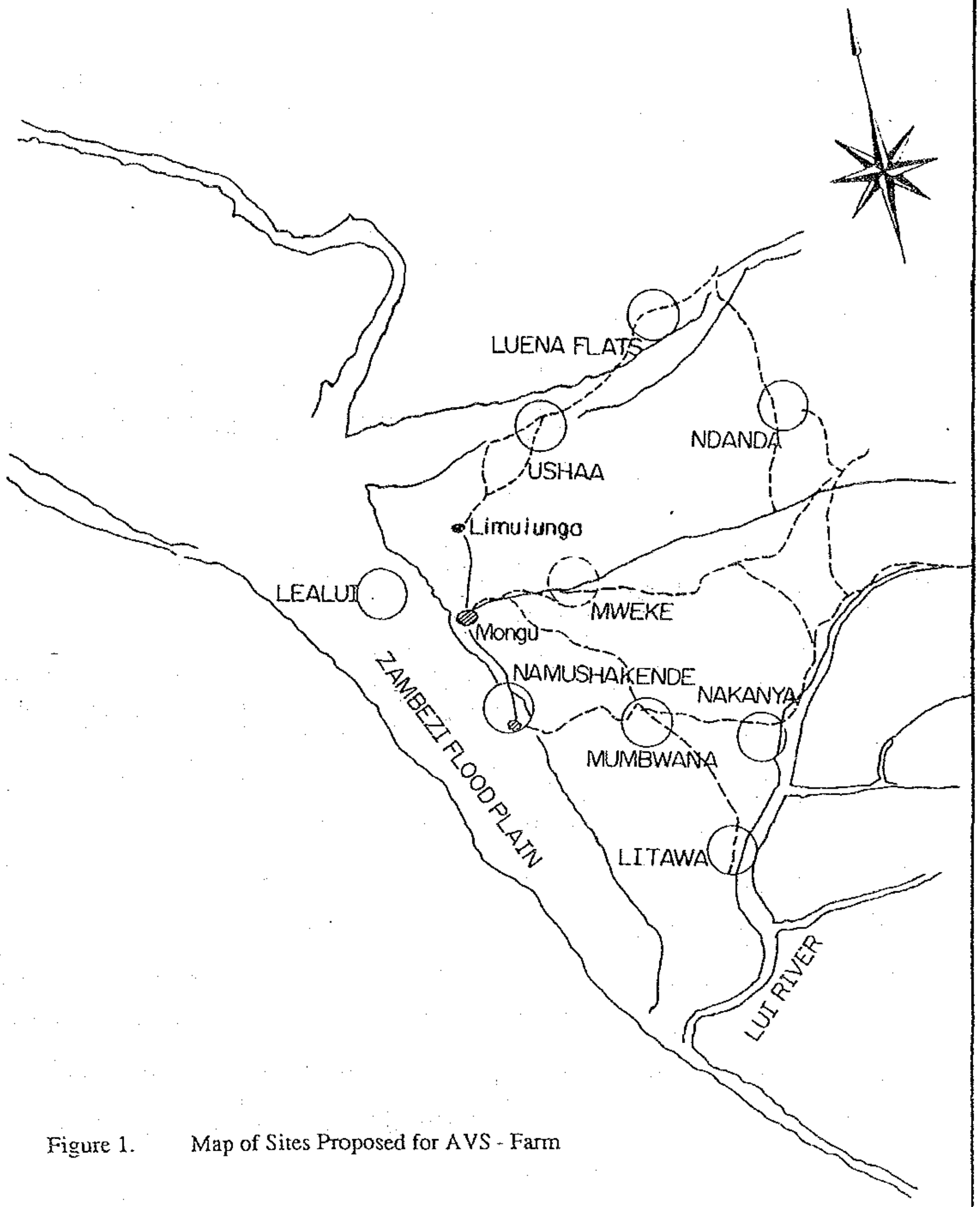
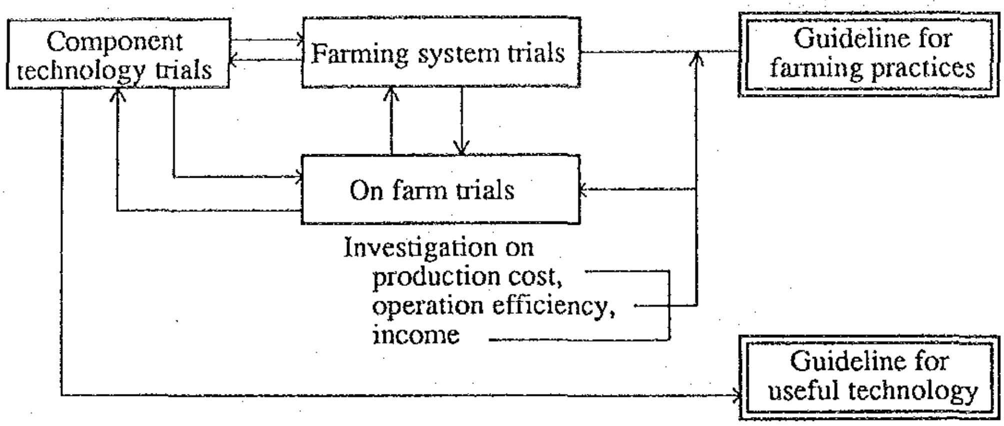


Figure 1. Map of Sites Proposed for AVS - Farm

① Crop production technology



② Land consolidation technology

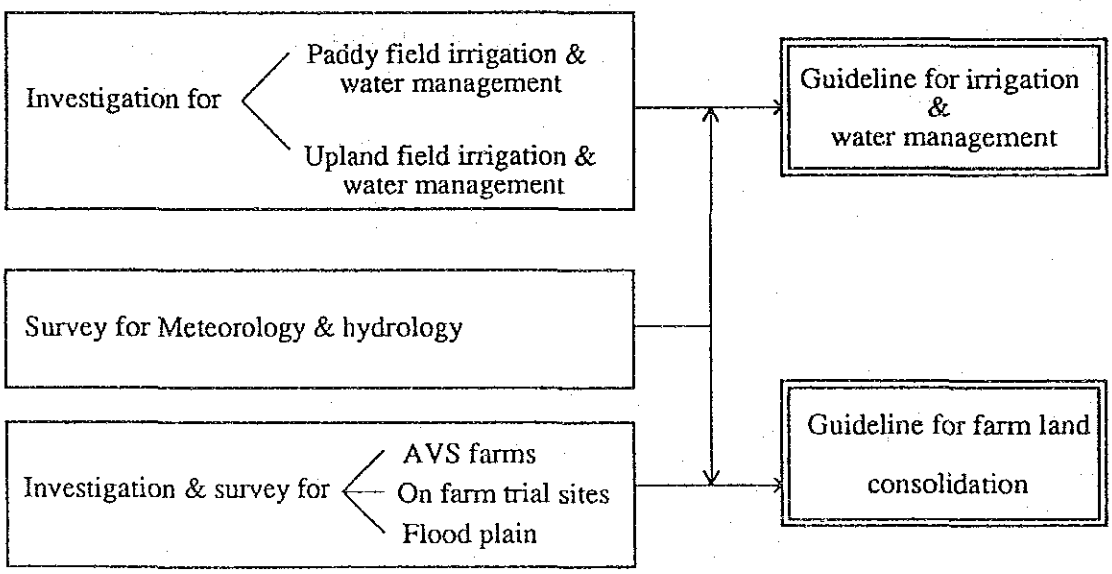


Figure 2 Process of the Study

Crop Production Technology

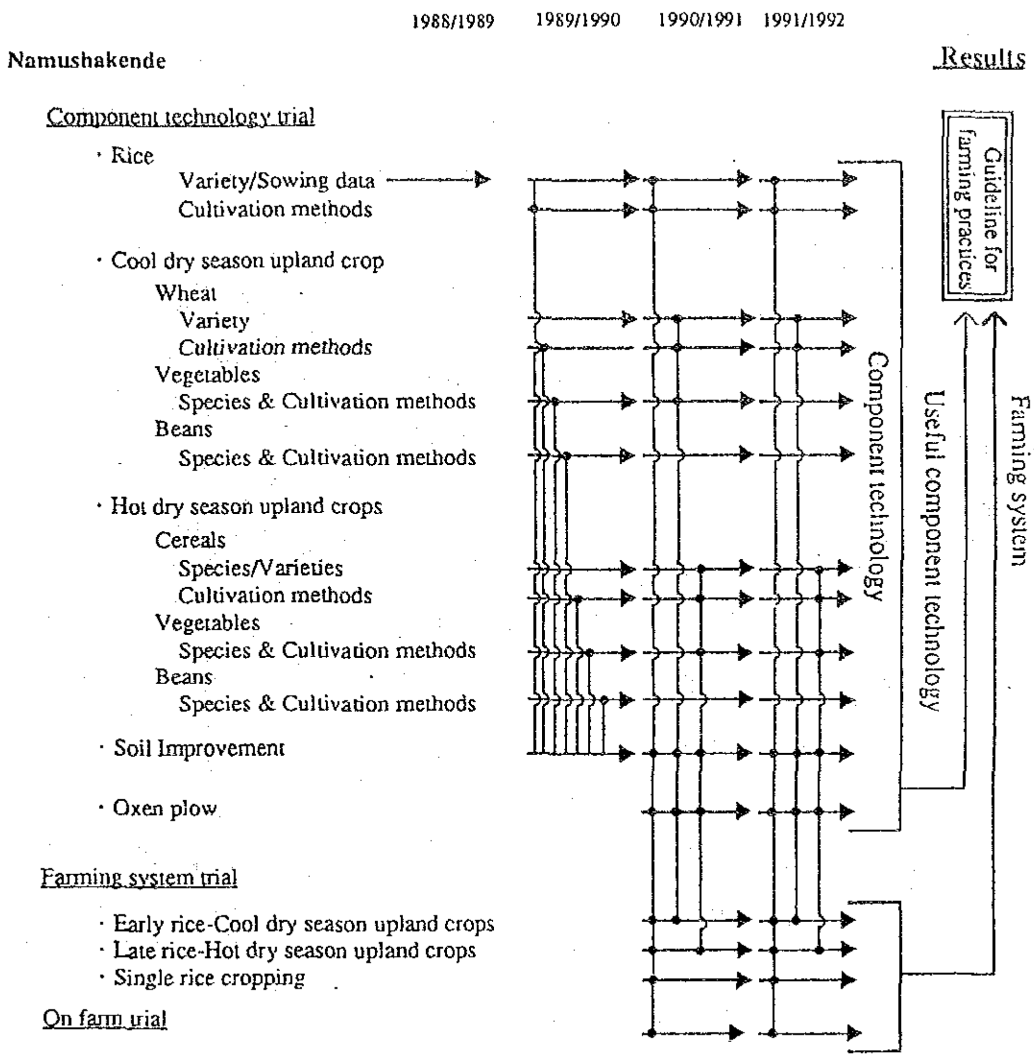


Figure 3. Progress of the Study (No.1)

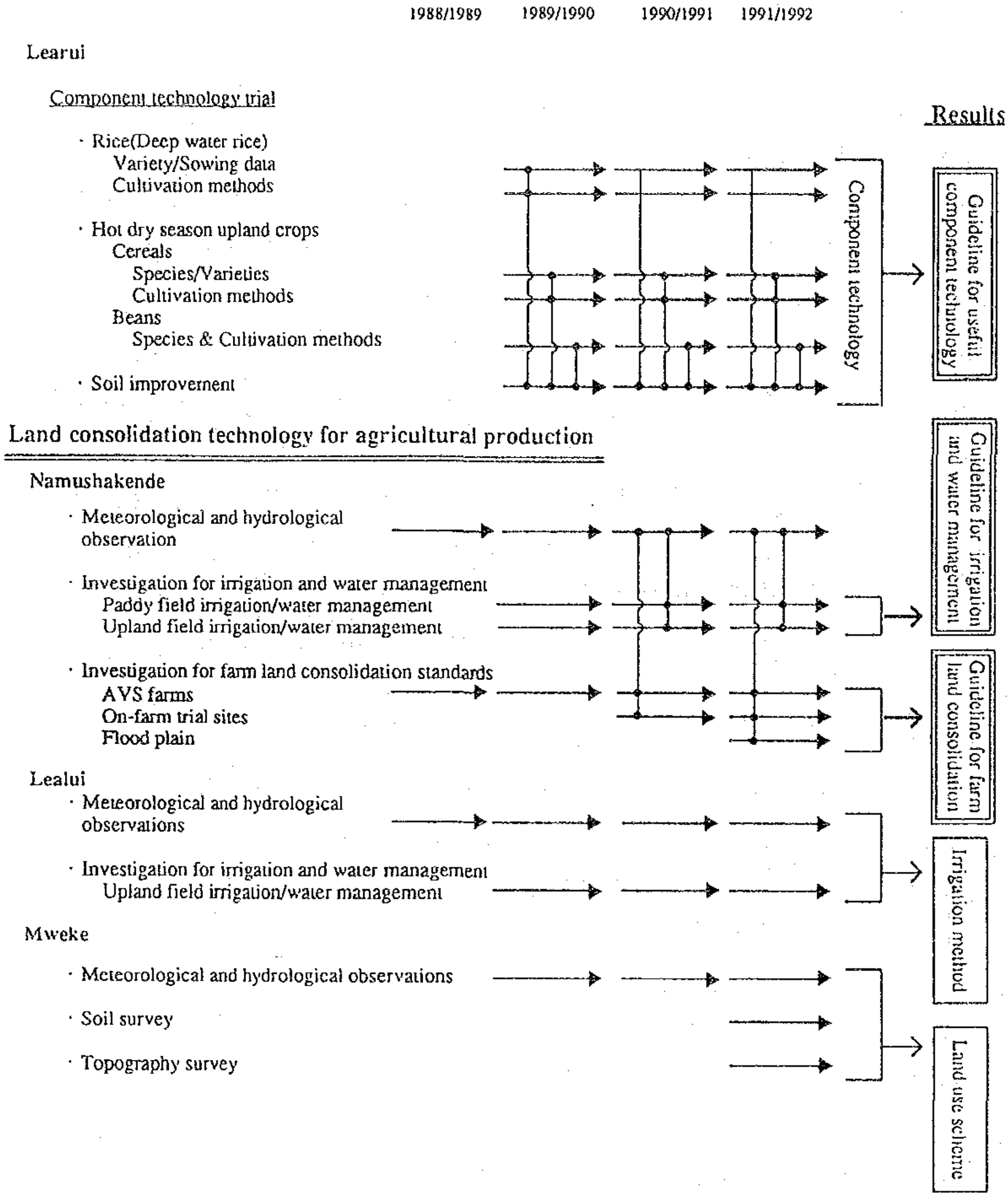


Figure 3. Progress of the Study (No.2)

Guideline for Crop Production Technology

Guideline for Crop Production Technology

The Agricultural Verification Study Team

Zetsugaku KURITA

1. Introduction

2. Production Constraints

3. Policy to Conduct Agricultural Verification Study

4. Summary of Agricultural Verification Study

4.1 Guideline of the Farming System

- 4.1.1 The Prerequisite Conditions of Agricultural Management for Small Scale Farm-household
- 4.1.2 Guideline of Rice Single Cropping System
  - (1) Early rice
    - 1) Good field condition of water regime
    - 2) Poor field condition of water regime
  - (2) Late rice
    - 1) Good field condition of water regime
    - 2) Poor field condition of water regime
- 4.1.3 Guideline of Double Cropping System for "Early rice - Cool Dry Season Crop"
  - (1) Early rice - Wheat
  - (2) Early rice - Onion
  - (3) Early rice - Cabbage
- 4.1.4 Guideline of Double Cropping System for "Late rice - Hot Dry Season Crop"
  - (1) Late rice - Maize
  - (2) Late rice - Tomato
- 4.1.5 Combination of Cropping Pattern and Its Profitability

4.2 Verification of Component Technology in Farmer's Land

4.3 Guideline of Useful Component Technology
- (1) Line maker & Drill Seeder for paddy grains
- (2) Rice straw incorporation of paddy field
- (3) Use of rice straw ash on paddy rice in peat-muck soil
- (4) Use of grass ash on upland crop in peat-muck soil
- (5) Effective sowing methods in sandy soil
- (6) Fertilizer application method in sandy soil

4.4. Countermeasure of Production Constraints
- (1) Methods to improve Sishanjo soil (peat-muck soil)
- (2) Method to improve sandy soil
- (3) Plant protection
  - 1) Rat damage
  - 2) Weed damage
  - 3) Pest & disease damage

1. Introduction

Western Province in Zambia is one of major rice-producing province in where Mongu district is a major rice-belt. Having established the agricultural verification farms in Zambezi floodplain (Namushakende & Lealui), the agricultural verification trials and survey of the surrounding area were carried out since the rainy season of 1988 in order to develop a rice-based farming system and establish its farm land consolidation standard. Furthermore, the guideline of crop production technology and farm land consolidation standard for this region were attempted to formulate for future agricultural development.

2. Production Constraints

Generally speaking, production constraints existed here Western Province are mainly grouped into three of institutional related factors such as low Government investment in the promotion of rice growing, ecological and biological related factors. In this regards, the small scale farmers are facing mainly lack of proper information for cultural practice of crops associated with timely input supply. Standing on this points, Agricultural Verification Study by JICA was carried out to accumulate know-how of crop production technology in the area facing ecological constraints.

3. Strategy to Conduct Verification Study

The agricultural verification study was attempted to approach the fixed goal under the following policy.

(1) It is focused on development of technology for small scale farmers

(2) This technology is valid in irrigable field condition.

(3) Target cropping system to develop is a double cropping system of rice - upland crops with low input and stable production based on animal draught power and manpower.

(4) It is fundamental types that cropping pattern is the two of "early rice - cool dry season crops" and "late rice - hot dry season crops".

(5) It is focused on soil improvement aspect to improve crop growth, and use of chemical fertilizer is lessened in this policy.

(6) In the light of importance of inland fishery, it confines chemical use to minimize, paying attention to environmental conservation.

Standing on the above mentioned policy, the said verification study had been carried out up to June 1992 over 4 years. These results were compiled to the guidelines of crop production technology and farm land consolidation like irrigation and water management.

4. Summary of the Verification Trials

4.1 The Guideline of Farming System

Based on the findings through the component technology and cropping system trials over 4 years span, several cropping patterns have been verified and formulated to the following 3 major farming systems based on crops and field conditions.

4.1.1 *Prerequisite Conditions for the Formulated Cropping Systems*

These cropping systems are required the following prerequisite conditions for farming.

(1) Management strategy : Diversifying farming of rice and upland crop with 5 - 6 cattles raising

(2) Scale of cultivation land : 2 - 5 ha

(3) Labor force/farm-household: 3 - 4 members

(4) Basic mean to work : Framing by using hoe except for plowing and harrowing operations by oxen which is ordered outside.

(5) Cropping system:

Rice single cropping system
Rice - cool dry season crop
Rice - hot dry season crop

(6) Field condition:

Double cropping system of "Rice - upland crop" is suited to the area of flood plain edge where the peat-muck soils dominate (thickness of the said soil is around 20 cm) and the area of sandy loam soil which are equipped with drainage and irrigation functions.

Rice single cropping system is suited to the area associated with insufficient drainage condition at the onset and end of dry season.

4.1.2 Guideline of Rice single Cropping System

1) Early Rice single cropping system in good field condition

Incorporation of rice straws is possible during cool-hot dry season under good drainage condition.

2) Early Rice single cropping system in poor field condition

Due to poor drainage condition at onset and end of dry season, rice straw incorporation may play a negative role.

3) Late Rice single cropping system in good field condition

Incorporation of rice straws is possible during cool-hot dry season under good drainage condition.

4) Late Rice single cropping system in poor field condition

Due to poor drainage condition at onset and end of dry season, rice straw incorporation may play a negative role.

4.1.3 Guideline of Double Cropping System of "Early rice - Cool Dry Season Crops"

1) Early rice - Wheat Cropping system
2) Early rice - Onion Cropping system
3) Early rice - Cabbage Cropping system

4.1.4 Guideline of Double Cropping System of "Late rice - Hot Dry Season Crops"

1) Late rice - Maize Cropping system
2) Late rice - Tomato Cropping system

4.1.5 Combination of Cropping Pattern and Its Profitability

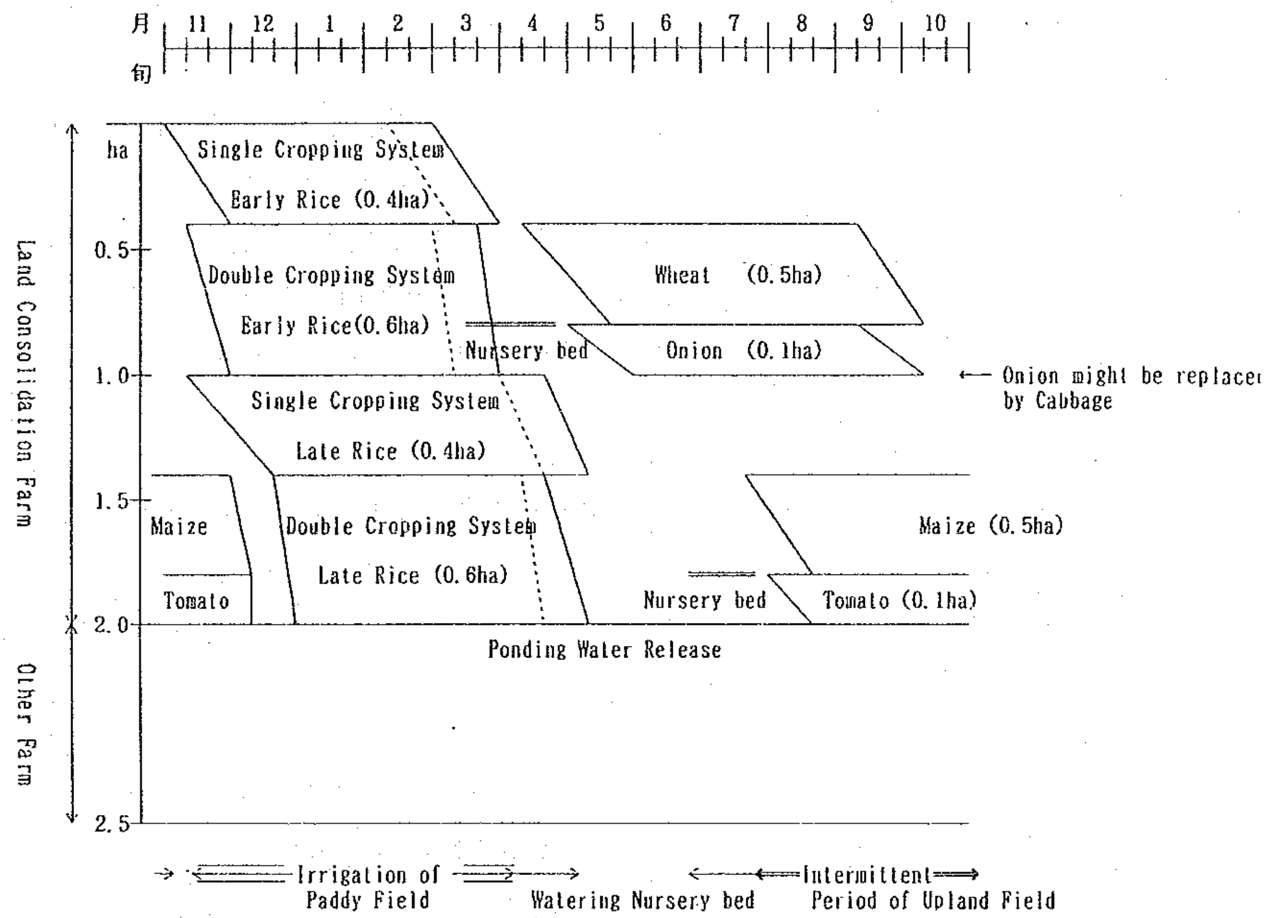


Figure 1 Model Plan of Utilization for the Consolidated Farm

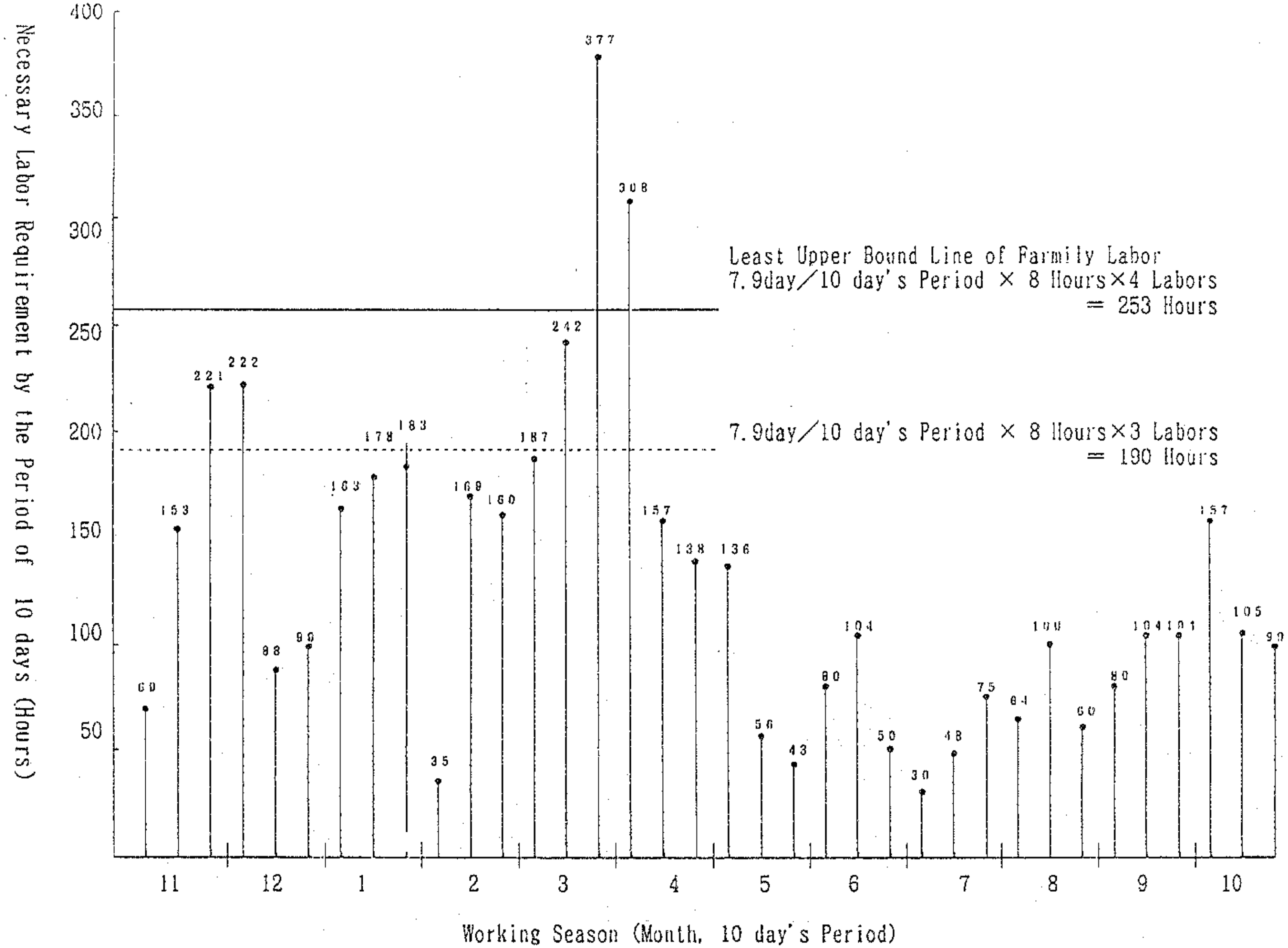


Figure 2 Total Labor Requirement(Hours) by Priod of 10 Days in the Combination Model of the Farming System

Table 1 The Profitability of the Combination Model among the Cropping Systems

Cropping pattern & its crops		Presented in the guideline			The combination model among the cropping system	
		Target yield (t/ha)	Working hours (hrs/ha)	Balance (kw)	Cropping area (ha)	Balance (kw)
Single cropping of paddy rice						
Early rice	(GFC)	6	2,282	150,109	0.4	60,044
	(PFC)	4.5	2,102	102,157		(40,863)
Late rice	(GFC)	5.5	2,262	132,181	0.4	52,872
	(PFC)	4.5	2,102	102,157		(40,863)
Double cropping (Early rice - cool dry season crop)						
Early rice		5	2,132	122,199	0.6	73,319
Wheat		2.2	1,160	26,994	0.5	13,497
Onion		20	3,200	1,250,270	0.1	125,027
Double cropping (Late rice - hot dry season crop)						
Late rice		5	2,125	122,399	0.6	73,439
Maize		4	940	44,796	0.5	22,398
Tomato		30	8,940	2,107,090	0.1	210,709
Grand total					2.0	631,305

Note : 1. The working hour mentioned in the guideline does not include the farm operation of the outside order like oxen plowing or harrowing operation.

2. ( ) refers to a balance of the poor filed.

3. GFC: Good field condition, PFC: Poor field condition

4.2 Verification of the Component Technology in Farmer's Land

Based on the results achieved so far via the component technology trials, on-farm trial was started in the floodplain edge and outer plain of Zambezi river since 3rd year of the agricultural verification study.

By applying some of component technology like weeding, fertilization, and line sowing with promising variety, a grain yield was markedly increased in farmer's land. The grain yield of Xiang Zhou 5, short culm variety, ranged from 5.3 to 6.9 t/ha, while Angola Crystal was 3.8 to 5.6 t/ha. Computing the cost and return analyses, a balance was closed to the marginal level indicated in the guideline of single rice cropping system.

4.3 The Guideline of Useful Component Technology

(1) Line maker and Drill Seeder for rice seeds

Drilling rice seeds has the advantage of easiness on farm operations like weeding, fertilization and harvesting practices. However, this advantage is difficult to convince most of farmers because of its time-consuming methods. Thus solving this problem, line maker was invented to make seeding furrow efficiently. Furthermore, adding grain hoppers to this line maker, drill seeder of 3 rows for rice grains was made by using locally available materials in order to solve backache via sowing operation.

(2) Rice straw incorporation in Peat-muck soils

Rice plants grown in Sishanjo soil band usually show brown spot in late growth stage due to deficiency of nutrient elements. To countermeasure this problem, incorporating rice straw during dry season was quite effective with increasing grain yield. However, this method should pay attention to soil moisture condition related to aerobic condition for rice straw decomposition.

(3) Use of rice straw ash in peat muck soil

Burning rice straws of ex-rice cropping has an effect to substitute lime.

(4) Use of grass ash in peat-muck soil

Burning grass and grass roots collected following plowing operation has a significant effect to supply mineral elements and to amend soil pH. This method is quite effective with D'mix.

(5) Effective sowing method in sandy soil

In sandy soil with low water holding capacity, sowing grain seeds at onset of rainy season often face poor emergence or disuniform emergence. To solve this problem, it was effective for uniform emergency by making deep seeding furrow (5 - 6 cm depth) and mulching after sown.

(6) Application method of fertilizer in sandy soil

Sandy soil is low CEC and fertilizer was easily leached out. To encounter this problem, applying fertilizer combined with deep seeding method is effective to reduce a rate of leaching out.

4.4 Countermeasure of Production Constraints

(1) Improvement of Peat-muck soil

Dominant soil extended in Sishanjo band of floodplain edge shows strong acidity, thus requiring amendment for crop cultivation; because this soil chemical aspect usually causes Zn deficiency in Maize and Cu deficiency in wheat. To overcome, applying copper sulfate or zinc sulfate at rate of 30 kg/ha is recommended with liming.

(2) Improvement of Sandy soil

The soils in Lealui is mostly sandy soil with low CEC, but it is possible to increase CEC by dressing black soil gathered from the surrounding low land.

(3) Protection of Crops

1) Rat damage

Rat usually causes damage over various crops at emergence and ripening stages. Reducing this damage, there are several methods to reduce rat density by cleaning grassy area surrounding the field or placing rat traps around the field. On the other had, scattering rice grains around the field as lure crop is also effective in blocking rats to enter the field. But chemical method needs careful attention.

2) Weed infestation

It is useful to suppress weed infestation at early time by enforcing intertillage cultivation. Regular plowing in fallow period is also effective.

3) Pest and 'Disease damage

Black maize Beatles on direct sown paddy rice cause a chewing damage during upland condition but easily controlled by flooding the field. But only chemical method is valid to prevent maize/sweetcorn from maize stalk borer, self-topping of cabbage from moss (Hellula undalis fabricius). White Leaf Spot (Phytophthora porri foister) of onion is mostly infested under excess moisture condition of the field, thus being important to select field with good drainage condition.

Guideline of Irrigation and Water Management

Guideline of Irrigation and Water Management

The Agricultural Verification Study Team

Akira IWAMOTO

Introduction

This presentation is to explain the guideline of irrigation and water management, depending on the Agricultural Verification Study at Namushakende and Lealui on the Zambezi flood plain.

1. General Characteristics of the Target Areas for Land Consolidation Guideline

The adequate area for development should satisfy the following natural conditions in relation to rice production in a double cropping system with upland crops:

- Available water resources exist in the dry season
- Inundation depth is relatively small
- Irrigation water supplied by gravity from water resources to the farm
- Natural main slope is moderate (below 1/200)
- Soil condition is adequate for cultivation
- Soil permeability is not high
- Micro meteorological condition is adequate for cultivation

The Mataba seepage zone, which is located along the Zambezi flood plain edge and includes 2 main soil types or areas, Sishanjo and Mataba Sitapa, with a high development potential for rice, is the indicated area for development.

The followings are general characteristics relating to the Sishanjo and Mataba Sitapa areas.

(1) Sishanjo area

This area covers a shallow swampy zone of approximately 0.2 - 1.0 km wide along the flood plain edge. It receives a steady lateral subsurface supply of seepage water from the sandy uplands. Groundwater table is high throughout the year. The soils of this area include very poorly drained, decomposed muck and mucky peat with loamy muck topsoils. The main crops are early Maize, Cassava, Sweet potatoes and Rice. They are mainly fed through rain, groundwater, or the main lateral canal Musiamo running along the entire plain edge. The area commonly forms a pond during heavy rains and is locally flooded by the Zambezi towards the end of the wet season. The Namushakende verification farm is part of this area.

(2) Mataba Sitapa area

This area is mainly confined to the transitional zone between the Sishanjo area along the plain edge and the somewhat elevated saana sand terrace. The topography is flat with an elevation comparable or slightly higher than the Sishanjo area. Soils are mucky loam and sandy loam overlying sand. This area is part of the Mataba seepage zone and is flooded during the flooding period also. The fluctuation of the groundwater table is considerable as compared to the Sishanjo area. The main crop is early Maize which is planted in August - September following the recession of the floods and harvested in December - February before the onset of the next floods. Other crops include rice, pumpkin, cucumber and finger millet. Maize production is unstable due to fluctuation in flood regime and rainfall. As for rice, it is generally planted in November - December using the early rains and harvested in May. - June. In some places, rice is grown through irrigation utilizing water form the Sefula river and the Namitome canal.

The model areas selected for the investigation of land consolidation standards belong to the Sishanjo and Mataba Sitapa areas. They were identified as:

1) Sefula model area located at the right bank of the Sefula river, and

2) Limulunga model areas located at the right bank of the artificial canal, Namitome.

The natural conditions relating to these models areas are described in details in the text and are common to the Sishanjo and Mataba Sitapa areas.

2. Guideline of Irrigation and Water Management

The guideline is referring to the development of small scale farming in 2 target areas, the Sishanjo and Mataba Sitapa, located at the Mataba seepage zone in the Zambezi flood plain edge. The accepted cultivation systems involve paddy rice as a single or double crop associated with upland crops under irrigation. Farm works are carried out by manpower and animal draft. Considering the actually existing farm size (0.5 ~ 2 ha) and the targeted cropping systems, a farm block of 2 ~ 5 ha is recommended as a basic unit of farming scale. A typical farming system will group several farm blocks (10 ~ 50 ha).

1. Present Conditions regarding Water Management and Crop Production in the Area

   a) Paddy rice

   Paddy rice cultivation in the Zambezi flood plain edge area occurs in traditional rice farms and is solely commanded by the natural annual flooding and receding of the Zambezi which are in return affected by the rainfall pattern. Therefore, if this seasonal fluctuation is upset by rainfall conditions in the upper river basin, rice production may be subsequently affected. Farmers of the area are still using traditional low yielding varieties whose longer culm is more adapted to the water variable level, for there is no levee and no land leveling. Variety diversification to boost yield and fit market needs is not yet tempted.

   b) Upland crops

   These crops are rainfed and the lack of established irrigation system associated with erratic conditions, namely rainfall, makes yield unstable.

2. Materials and methods

   a) Basic principles

   The development of the areas will be geared towards the establishment of an irrigation and water management systems involving the cultivation of paddy rice and upland crops that can secure stable and high yield under adverse variations of rainfall and river water level.

b) Premises of the system

1) An irrigation plan is prepared, that takes into consideration an adequate and stable supply of irrigation water requirement for better crop production. In the Zambezi flood plain where there is no experience in irrigation, the plan takes also in consideration water losses due to poor management and failure of the irrigation facilities.

2) A drought year with three to five years return period is targeted as reference year for design. Probabilities of non-exceedance computed for 13 years of annual rain recorded at Mongu Meteorological Station led to the selection of 1983 as the reference year for design.

3) Required data to determine relevant irrigation elements are either obtained form the AVS or collected where necessary. In case of shortage of data, estimations are performed when possible or additional survey is carried out.

4) A water management plan is prepared to decide on the irrigation interval, irrigation method and farming plan. The operation and management of the irrigation facilities not including the water resources facilities is to be carried out by beneficiary farmers who should be supervised by the district agricultural office.

3. Paddy Rice Irrigation and Water Management

a) On-farm water management plan

For the plain edge area direct seeding in dry field is recommended for rice. The applying time of initial ponding should be determined in the planning stage because the water requirement at this period corresponds to the maximum water requirement. Generally, the initial ponding application time is recommended at the three or four leaves apparition stage which occurs approximately one month after seeding. From the AVS results, intermittent irrigation and seven to ten days irrigation interval are selected as the irrigation method.

b) Management organization and irrigation facility plan

A water requirement plan is set, which considers not only the water requirement of paddy rice but accounts also for water delivery loss and delivery water requirement. The delivery water requirement depends on management organization, scale of irrigation facility and management method. It is important that this situation be considered in the planning stage.

There are no established irrigation farms at this moment in Zambia, except for few commercial or public organizations run experimental farms. Therefore, there is no clear example of management organization to base recommendations of water management system or rules on. This should be the object of future research activities, but at this stage it can be recommended that farmers carry out operation and management under the guideline of the public organization such as the District Agricultural Office.

c) Paddy field daily water requirement

Daily water requirement which is a portion of irrigation water is expressed as a water discharge per unit area or daily water depth. In the plain edge area where there is no available data of actually measured water requirement rate, daily field water requirement will be calculated using the elements shown in Figure 1.

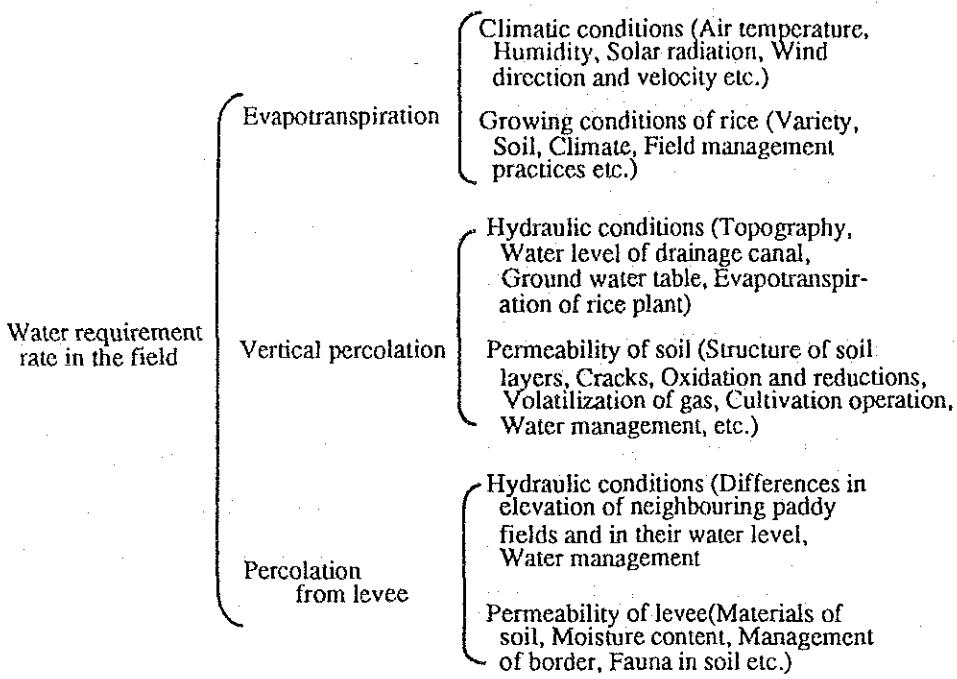


Figure 1 Primary Elements involved in the Daily Field Water Requirement Rate.

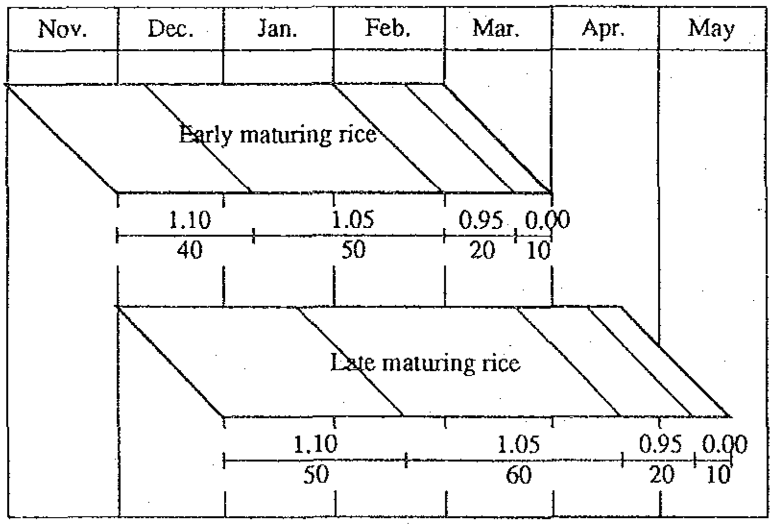


Figure 2 Crop Coefficient for Paddy Rice

4. Upland Crop Irrigation and Water Management Plan

a) Upland crop water requirement plan

The amount of water necessary at each irrigation depends on the crop consumptive use, effective rainfall and soil moisture characteristics in the target areas. These processes are shown in the following Figure 3.

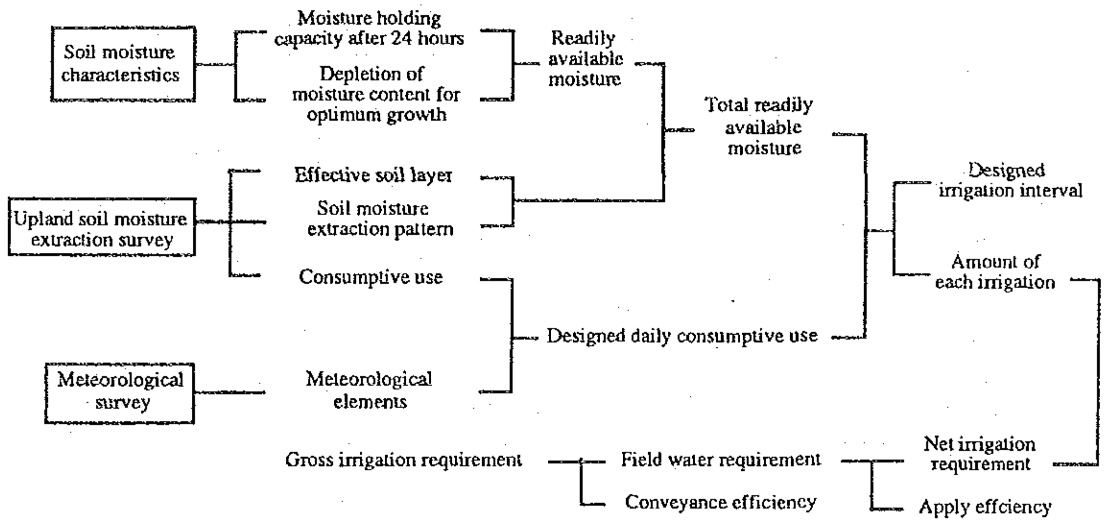


Figure 3 Calculation Process of Upland Water Requirement for Soil Moisture Supply

b) Determination of irrigation method

Upland irrigation methods vary depending on specific purposes. Determination of methods should be made in due consideration of such conditions as natural, farming, water utilization and financial level of objective areas, as it is closely connected with on-farm water use, and, moreover, it affects on-farm facility expenses and maintenance cost.

According to the results obtained from cylinder intake rate survey carried out at Namushakende AVS farm, soil intake rate is small. Surface irrigation is therefore an appropriate method in the flood plain edge area. Surface irrigation is represented by furrow irrigation and border irrigation, After due consideration of flow and groundwater level, furrow irrigation is selected for this plan.

Table 1 Intake Rate at Namushakende AVS Farm

	1989	1990	1991
Initial Intake Rate	21.3 (mm/hr)	153.2 (mm/hr)	243.6 (mm/hr)
Basic Intake Rate	14.9 (mm/hr)	3.6 (mm/hr)	20.9 (mm/hr)

Table 2 Determination of Irrigation Method by Intake Rate

Soil Permeability	Basic Intake Rate	Optimum Irrigation Method
High	More than 75 mm/hr	Spray Irrigation
Medium	50 ~ 75 mm/hr	Spray/Surface Irrigation
Low	Less than 50 mm/hr	Surface Irrigation

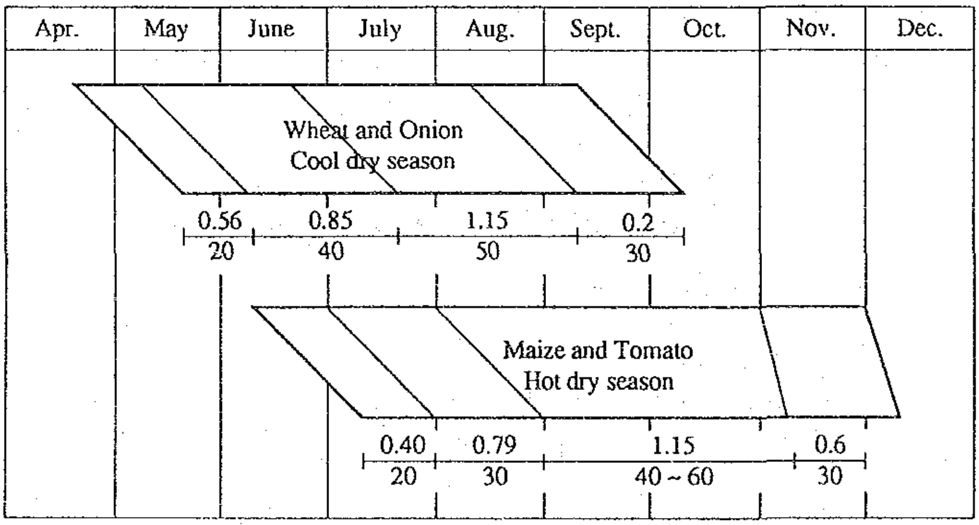


Figure 4 Crop Coefficient for Upland Clops

Concluding Remarks

This guideline is established based on the Agricultural Verification Study which was carried out in the last 3 years study period and a few sites in the Zambezi flood plain. We suppose that it is an optimum irrigation and water management guideline for the present condition at the target area. Eventually, all guideline and standards should be revised to correspond to variable conditions in the target area and market needs.

Therefore this guideline is defined as a first edition, which will be improved through the effort of the government of Zambia and through the methodology used to determine the relevant irrigation factors which are mentioned in the guideline. This can be applied to fit future marketing situation and other areas with different conditions.

Guideline of Farm Land Consolidation

Guideline of Farm Land Consolidation

The Agricultural Verification Study Team

Gueye Massamba

1. Objectives of Farm Land Consolidation

The main objective of farm land consolidation is to increase agricultural productivity through comprehensive consolidation of agricultural lands which are the basis of agricultural production.

Farm land consolidation will result in the rearrangement or consolidation of farm lots, improvement or construction of irrigation/drainage facilities and farm roads with the aim of ensuring highly productive conditions for effective farming and rationalized water management to meet future agricultural requirements.

2. Aim and Scope of the Guideline

(1) This guideline specifies general and basic technical terms to be considered in the planning and design of farm land consolidation which can be applicable to the potential agricultural development areas of the Zambezi flood plain. Especially, this guideline is aimed to these areas for which it anticipates a small scale farming system with paddy rice as a single or double crop associated with upland crops under irrigation.

(2) This guideline is to be mainly applied to the Sishanjo and the Mataba Sitapa soil type areas selected as the potential development areas in the Zambezi flood plain considering topography, hydrology, soil conditions, and present agricultural practices.

(3) Farm works are carried out by manpower and animal draft. A farm block of 2 ~ 5 ha is recommended as a basic unit of farming scale. In one farm block, farm work management and water management are to be performed in the same condition.

3. Elements of Farm Land Consolidation

It is difficult to introduce a high level of farm land consolidation in these areas considering natural conditions and present social, economic and agricultural standards. The basic concept for establishing the consolidation level should consider the following elements:

1) Land consolidation here is aimed at a farm land which groups several farm blocks, and its scale should cover areas of 10 to 50 ha considering the average village size in the targeted area.

2) A proposed farm land (herein referred to as "the farm land") is to be surrounded by a farm road, peripheral road, which is useful for farming and water management and is also effective for flood protection, serving as an embankment. Width of the peripheral road is proposed in a range of 3.0 to 3.5 m considering the introduction of small-sized agricultural machineries and trucks in accordance with farm land consolidation in the future. The maximum embankment height of the peripheral road is determined at a standard value of 1.8 m from a 3 ~ 5 year return period flood depth. It is proposed to include some impervious layers of clayey soils in the structure of the peripheral road.

   In addition, field roads should be provided as farm roads inside the farm land, serving for efficient farming operation. It is preferable to make these roads by widening the embankment of irrigation canals, the ditch border of drainage canals and levels instead of constructing them separately in order to maximize space in the farm area. The top width of the main field road should be planned in a range of 2.5 ~ 3.0 m considering the travel of a single vehicle. The height of the field road surface should be more than 30 cm above the field surface. Taking into account the passage of farming oxen to the field lots and the openness over the fields, 30 ~ 40 cm height is deemed appropriate.

3) Since direct seeding of paddy rice in dry condition and irrigation are proposed in the farm land, minimum land grading and leveling are required. It is recommended that the allowable limit of land levelling by finishing works on the paddy fields in the proposed area be at ± 10 cm. The standard size of a field lot should be 25 m by 50 m (half a lima) considering the present field sizes in the area

and the means of farming. In order to minimize the earth works involved in the cutting and banking, field lots should be laid following the natural topographic slopes of the area as much as possible. And levees are to be provided at the borders of the field lots. Surface soil handling to keep the top soil intact is recommended during the earth work of farm land consolidation in case the thickness of the top soil layer of the area is small.

4) Gravity irrigation system is introduced and a minimum number of irrigation canals are planned to minimize costs depending on the present topography and the grouping conditions of farm blocks in the farm land, and plot-to-plot irrigation is basically applied in the farm block.

5) Among irrigation canals, the most economical earth canal is selected, however, adoption of lining method by using cohesive soil is desirable considering the high permeability of the ground in the area. Considering the soil condition of the area, a maximum and minimum allowable flow velocities in the canal are set to 0.6 m/sec and 0.3 m/sec, respectively. And a minimum freeboard value is set to 0.3 m. Considering the potential for sliding, scouring and erosion, inside slopes were set to 1:15 in case of cutting and to 1:15 ~ 1:20 for banking.

Drainage canals are to be provided at necessary portions in the farm land in order to eliminate the surplus irrigation water as well as rainwater. In case of a double cropping system, the drainage should fulfill two functions, that is, the elimination of surface water and the elimination of groundwater. The canal section and density should be minimized to reduce the space used by the installations. The drainage canal is constructed without lining with a standard depth of 0.8 m considering the elimination of groundwater to prevent wet injury in dry field farming and the soil condition of the area. A side slope gradient of the drainage canal is typically determined, considering its depth and primary texture to 1:1.5. The performance of sodding is desirable to prevent slope erosion caused by rainfall. A base width is typically set to 0.3 m. On the farm land side, a ditch border with a width of 0.5 m and a height of 0.3 m is equipped to secure a path within a farming area.

6) The number of ancillary structures in the farm land such as hydraulic facilities and other structures should be minimized. And there structures are to be structurally

simple to allow easy operation and maintenance with low costs. Such ancillary facilities include water diversion and water control devices, road culverts, and drainage sluice.

The water diversion device includes the diversion from the branch canal to the ditch and from the ditch to a farm lot. For the diversion from the branch canal to the ditch, when a flow amount is small, pipe diversion which is economical and of a simple structure is used. Moreover, it is desirable to equip a check gate inside the branch canal in order to maintain adequate water level required as well as to enable easy diversion.

The simplest diversion from the ditch to a farm lot or canal is attained by setting a notch at a ditch-side border or burying a pipe and controlling water using sand-bags. For a more strict water control, an intake is desirably to be of a fixed structure, such as concrete blocks, with stop logs or a gate.

In case a canal crosses a road, a pipe culvert of crossing structure, concrete or asbestos, will be provided.

A sluice is equipped on the peripheral road on the branch drainage if the drainage operation is to cover the entire planned area. The sluice should be of water tight construction including concrete blocks or reinforced concrete, and be equipped with a simple steel gate or a steel framed wooden gate.

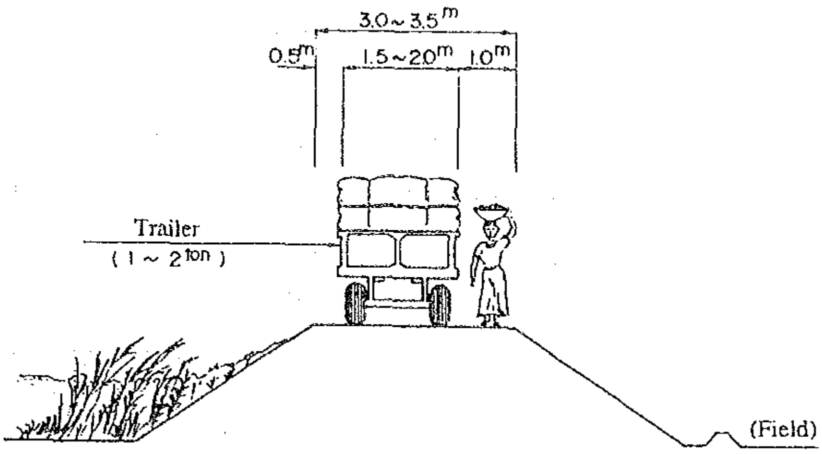


Figure 1 Top Width of Peripheral Road

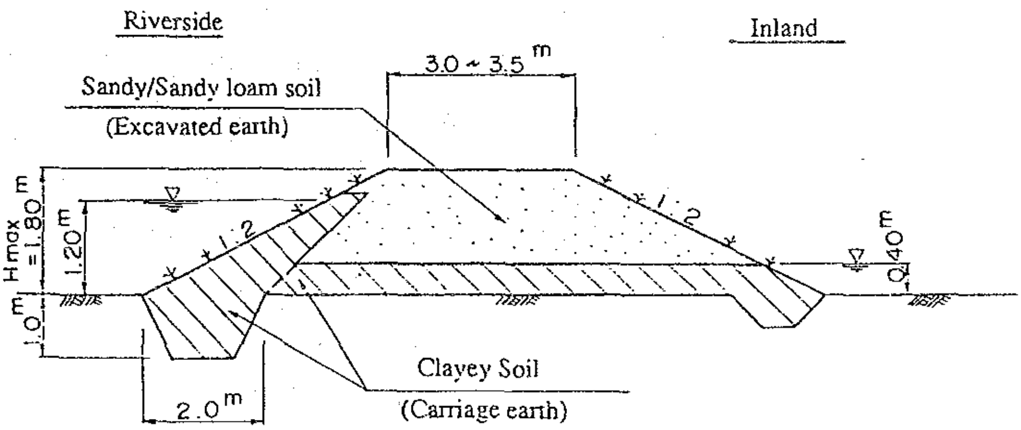


Figure 2 Typical Cross Section of Peripheral Road

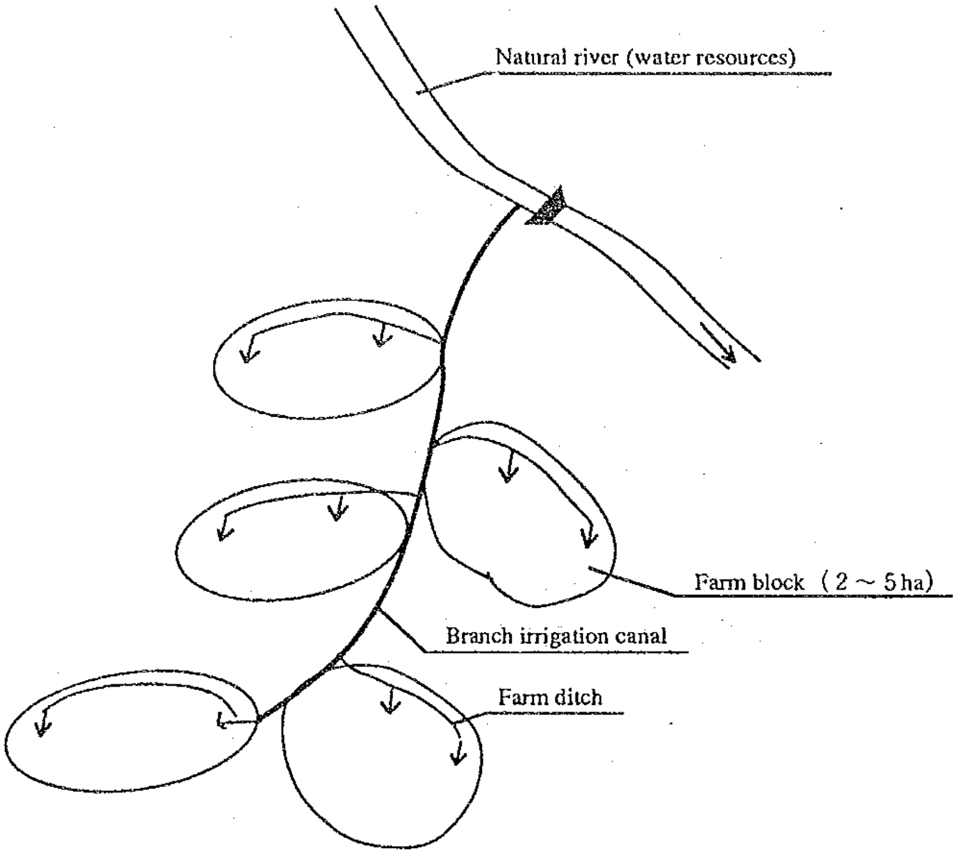


Figure 3 Typical Layout of Irrigation Canal System

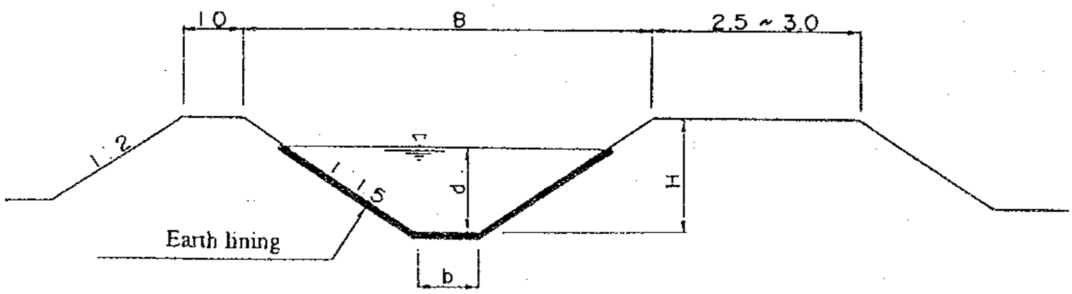


Figure 4 Typical Cross-section of Branch Irrigation Canal

Agricultural Development Plan in Western Province

Especially in the Mongu District

AGRICULTURAL DEVELOPMENT PLAN IN WESTERN PROVINCE ESPECIALLY IN MONGU DISTRICT

The Agricultural Development Plan aims at achieving a higher level of sustainable self-sufficiency in food production more especially this will entail:

1. The reduction of the District/provincial shortall in staple food production by increasing the level of self- sufficiency in food deficit areas.

2. The intensification of the production for surplus selling in areas with good agricultural pontential.

In urban areas, the cereal deficit will be made up by the surplus produced in the Kaoma areas. In rural areas, the deficit will be compensated by an increased production of cassava also an increased production of rice along the edge of the Zambezi flood plain especially from Limulunga Northern flood plain edge of Mongu District township to Namushakende Southern flood plain edge where there is high population density could definitely compensate for the cereal deficit.

Attention will be given to the self-sufficiency levels in both quantitative terms (staples) and qualitative terms (proteins).

Both in research and in extension activities, the main focus will be on increasing the productivity of small scale farms and on the role of women in achieving food self-sufficiency.

TARGET AREAS:

Taking into account the limited availability of both human and physical resources in the institutions supporting agricultural development, priorities have been set for activities aimed at promoting and supporting crop production in the Western Province. Support services and development agencies will agree on a concerted effort for action in the target areas.

In relation to the two objectives outlined above, two groups of target areas have been deliverated:

* Potential surplus production areas
* Deficit production areas.

01. POTENTIAL SURPLUS PRODUCTION AREAS:

The areas already have some surplus production because in general they are better endowed with natural resources. Especially in the case of major potential surplus production areas, higher production has been encouraged by the opportunities offered by good communications with central places (consumer markets). Adequate communication infrastructure similarly facilitates the provision of Agricultural inputs.

The identification of the major potential surplus production areas has been based not only on available data on agro-ecological potential (Land Use Planning, Adaptive Research Planning Team - ARPT - Western Province) and on infrastructure, but also on socio-economic considerations such as population density. One of the main selection criteria has been that; the potential arable area should exceed 10,000 ha. These areas surpluses will be used to compensate deficits in other parts of the province. The selection of only a few major "Potential surplus production areas" in western province might obscure the fact that a large number of other areas not mentioned in the plan do offer albeit limited potential for increased food production, enough however, to contribute to the improvement of the local food balance. The identification of such areas will be part of the district level planning, within the frame work of the District plan preparation exercise in Mongu, have identified such areas:

(a) Northern flood plain edge area of Mongu District Township, (Mongu to Limulunga covering an area of 4,000 ha.).

(b) Southern flood plain edge area of Mongu Township, (Mongu to Namushakende covering an area of 4,500 ha.) and

(c) Dambo area on the terrace of Mweeke plain, covering an area of 3,500 ha.

These are the most densely populated rural areas of Mongu District, ranging from 40 to 60 people per square kilometer, and not currently covered by other donor funded activities.

02. MAJOR POTENTIAL SURPLUS PRODUCTION AREAS - MONGU DISTRICT : LUI RIVER VALLEY :

This valley is earmarked for rice production, both for food and for cash. It is located within the areas of the Imalyo, Nakanya, Mutondo and Lui ward. It covers an area of approximately 50,000 ha. about 10,000 ha. of which can be planted with rice. The fact that this crop has a good potential in the Lui valley is mainly due to the favorable flooding regime of this valley. Flooding, indeed starts early and variations in the maximum flood level are limited, allowing the farmers to venture into intensified rice production. It is to be noted however, that in order to obtain good yields on all these soils measures have to be taken to increase their fertility. As the local production of manure will remain insufficient, the Lui River valley potential will not be realized unless adequate quantities of chemical fertilizers are supplied. An economic sustainability analysis will be carried out as a matter of first priority.

03. LOW POTENTIAL PRODUCTION AREAS :

Low potential production areas are areas with substance farming often with a negative food balance (deficit). The objective is to reach an acceptable level of self-sufficiency over the years. This will be attained by optimizing the use of the limited resources. Wherever possible farmers will be induced to produce crop surpluses for marketing within a limited radius.

Low potential areas have been targeted for which strategies will be further developed for increasing the level of food production, on the basis of low inputs. During the plan period the level of assistance will be lower than in surplus production areas.

Research concerning these areas will focus on locally adapted crops (e.g. goats).

03.1. HIGH PRIORITY AREAS :

The major population concentrations in Western Province occur along the Zambezi flood plain and on the banks of the Zambezi south of kalongola. These areas have been given priority in the efforts to improve food security. Extension and provision of Agricultural inputs will aim at increasing food, and livestock production and achieving a higher degree of self-sufficiency.

Flood Plain edge from Limulunga to Namushakende :

Following wards are located along the Eastern Plain edge:

Lealui, Mabumbu, Limulunga, Katongo, Yeta (Sefula), Namushakende.

These areas can support integrated crop-livestock production in a sustainable way. The main crops are maize, rice and fruits with cassava on the uplands near the plain edges, mostly maize is planted mainly on litongo soils, but also on lizulu.

The production of maize covers only very small % of the total household needs.

Increased food self-sufficiency will be achieved through crop intensification.

Risks involved in the flood plain are already identified and the project AVS/JICA will design techniques to combat such risks to put to use fertile flood plain soils. The project will also revitalise the use of the fertile sishanjo soils which are currently water logged which have not been exploited for many decades because of lack of drainage works on the plain edge.

03.2 OTHER DEFICIT AREAS :

Two more major areas have been identified in Western Province which experience food deficits. The population however, is more thinly spread as along the flood plain.

Dambo farming systems (East of the Zambezi Valley) :

These dambo farming systems are mainly found in Mongu District, as well as in the Western part of Kaoma District and in the North-Eastern part of Senanga. In Mongu it concerns Ushaa, Ndanda, Nangula (includes Mweeke), Nakato wards and Lwambuwa, Namafulo wards in Kaoma District.

About 40,000 people are involved in this type of farming systems.

In the dambo farming systems only a limited amount of arable land is available for cereal production. Appropriate sistes for matongo gardens along the edge of dambos are relatively scarce. Only 2,000 ha. are actually planted with maize, 4,000 ha with cassava and 1,000 ha. with millet. Cassava forms the main staple crop.

The potential to grow rice in the wetter parts of the dambos is much more limited than generally believed. Annual variations of the level of standing water indeed can be considerable, making it risky to grow rice in certain dambos.

Food problems in the zone are mostly of a qualitative nature.

There is a shortage of vegetable protein deficiency which is serious. This is due to the absence of fish and milk and to the low production of food legumes. Cattle indeed is hardly found and little potential exists for livestock production.

03.3 EXTENSION AND TRAINING :

Geographical coverage of the province by the combined staff of the extension branch of the Department of Agriculture and the Department of Veterinary and Tsetse Control services is relatively large; 218 Agricultural Assistants and 77 veterinary Assistants cover a total of 136 wards (137 wards in western province). The present serious economic restrictions and their limiting effect on transport, supply of inputs for course, field days and demonstrations, commands as shift of policy and strategy. Basic services, however, such as the supply of information have to be maintained at the present level. Some gradation will be created within the extension activities. The extension activities will be adapted to the specific circumstances in each of the target areas. It is expected that by so doing the efficiency of the extension work will be increased.

Target areas for suplus production will be identified at Provincial, District and Ward level in accordance with the present plan. They will draw more services like input supply and credit and will therefore, require more intensive support from extension workers. The extension service will supply much information on marketing, on the availability of credit, on implements and on other production factors. Since this was not the case in the past, Provincial and District structures for co-ordination of development efforts, such as sectoral steering committees, will compile and feed such information to the extension services of both departments, (e.g. on production of food legumes and other locally adapted crops like millet of cassava)

Activities in food security areas will concentrate on the mobilization of farmers and on creating awareness concerning the availability of information.

In the future, more importance will be given to the contribution of farmers to the formulation of development aims. The extension services will not only increase the collection of information but communicate information provided by the farmers themselves about their needs to the departments. Where for instance the farmers' view conflict with the statements of the present plan concerning the target areas, the extension services will communicate such views to the planners.

Training courses will aim at the improvement of (vertical) communication between the factors (i.e. staff, contact farmers, village extension workers) within the agricultural knowledge system and at increasing their ability to analyse the farmers) situation, their constraints and their needs.

The extension services will continue to provide that kind of information which is indispensable for the farmers decision making even in these cases where the requested information is not directly related to government activities.

Increased efforts will also be devoted to the stimulation of horizontal, i.e. information exchange between members of the target community. This implies that unwavering attention will be given to the selection and monitoring of contact farmers, to ensure that they will adequately play their role as channels of information. Further emphasis will be given to the proper identification of the target group, which will include the growing percentage of female headed households.

Farmers groups (crush pen association threshing groups, co-operative societies seed banks etc.) will be stimulated.

The formation of women groups in particular will be encouraged. women and women groups will receive special attention from the extension workers. The groups will be requested to appoint a village extension worker from amongst their members, who will bear responsibility for extension tasks. Where groups have been identified to receive tangible assistance from projects or institutes, the establishment of such an extension function will be made condition to the actual assistance.

<u>L.W.MUYAPEKWA</u>

<u>DISTRICT AGRICULTURAL OFFICER</u>

Developing Process and Outlines of

Paddy Field Consolidation Techniques

Development Process and Outline
of Paddy Field Consolidation Techniques in Japan
- Considering the application to the Mongu Area -

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Introduction

This presentation is intended to introduce the developing process and outline of paddy field consolidation techniques in Japan based on the experience of Japan which, living on rice, has developed the agriculture in paddy fields for long years, and I wish this introduction will contribute to the future development of the paddy field agriculture in the Mongu area. This report will be made also using slides and OHP.

The experience and techniques of Japan described from now on include those which may not be used immediately in Zambia greatly different from Japan in climate and other natural features and also in the history of social development. For future development of paddy field agriculture in the Mongu area, it is needless to say necessary to develop the peculiar paddy field agriculture and establish the rice culture techniques respectively suitable for the regional situations, while also referring to the experience and techniques of Japan.

I. Rice cultivation in the world and features of paddy fields

At present, rice is produced in 111 nations in the world as shown in Table 1, and the paddy field area amounts to about 140 million hectares. Every year, about 454 million tons of rice is produced. Rice producing areas are mainly located in Asia, and the rice production in the other regions is very small. The rice producing area in the entire Africa accounts for only 3.9%, and the production there, only 2.2%. However, in recent years, the superiority of rice as an item of cereals is being recognized, and the production is gradually growing in areas with available water.

Among the cereals produced in the world, three major items of wheat, rice and corn account for 80% of the total production, and rice is an essential item accounting for 27% to take the second position. As for the average yield per unit area in the world, rice shows the largest rate of 2.5 tons/ha, compared to 1.8 tons/ha of wheat and 2.0 tons/ha of corn.

In paddy fields, rice is cultivated in flooded water on the ground for a certain period of time, and so the injury by continuous cropping does not occur, unlike upland farming. The same crop can be cultivated every year, or even two or three times a year in tropical areas as an excellent feature of paddy farming. In addition, rice has excellent properties compared to wheat, that one seed can yield a very many number of grains and that the nitrogenous fertilizer required for a certain yield can be about one third. Japan, China, Indonesia, etc. located in the Asian monsoon region and actively engaged in paddy farming are high in population density, to suggest that paddy farming can highly support people. It can be said that paddy is a very advantageous crop as far as water is available.

Paddy fields spreading from mountains to plains present fields of rice cropping, and also function vaiously for flood control, conservation of water resources, soil conservation, purification of water pollution, climate control, etc., playing an important role also for preserving the local environment.

II. Paddy farming in Japan.

1. General conditions of rice cropping

In Japan located in the Asian monsoon region, paddy farming has been practised from ancient times, and rice has supported many Japanese as their staple food, in great contribution to today's economic growth and to the formation of the peculiar culture.

Japan has a national land area of 370,000 km^2 (about 1/2 of that of Zambia) and a population of 120 million (14 of that of Zambia). Its agricultural land area is 5.3 million hectares, accounting for about 14% of the national land, of which 2.8 million hectares are paddy fields. Japan has many sloping lands and forests, and is narrow in the area available for people, but paddy fields are widely distributed in sloping land and plains.

In the total agricultural production of Japan, rice production accounts for 29% and so, rice is the most essential crop as important as livestock and horticulture. The domestic self-supply rate is 100%, and the annual per capita consumption of rice is 70 kg, though smaller compared to the consumption in the past.

In Japan, paddy farming has been practised since more than 2000 years ago. At first, it was practised near small rivers in mountains, but according to the increase of population and the progress in reclamation and irrigation techniques, paddy fields gradually spread into the alluvial cones in the middle reaches of rivers and into the plains in the lower reaches. The yield of rice which stood at 1.5 to 2 tons/ha in the year 1000 or so increased to 3.5 tons/ha about 1850, and now reaches 7 tons/ha thanks to the progress of agricultural techniques. At present, partly because of decline of consumption, rice is now overproduced in Japan.

The paddy farming of Japan can be summarized by the following three major features; <1> it has been practised from old times to introduce water from small reservoirs and rivers and to build levees in efforts to secure irrigation, <2> it has been practised from old times to supply fertilizers such as artificial manure obtained from nearby forests, etc., and <3> carefully through-out cultivation management such as water management has been practised because agricultural works must be suited to the distinct seasonal changes peculiar to Japan; these practices are greatly different those in other countries in Southeast Asia where rain-fed paddy fields resorting to rain only are usually adopted still now. The present irrigation intensity in Japan is almost 100%. The importance of irrigation is suggested by the statistics of Fig. 1, and it can be seen that a higher irrigation intensity results in a higher rice yield.

2. Rice cropping techniques

The present standard rice culture and water management in Japan are approximately as shown in Fig. 2. The water management and cultivation management are planned carefully for respective stages of paddy growth, to achieve a high yield.

Now, let me introduce you the present situations of rice cropping techniques in Japan, using slides for further about 20 minutes.

III. Land consolidation, irrigation and drainage in paddy fields

1. Description of consolidation

To enhance the productivity of paddy, the paddy fields as the foundation for it must be consolided in good conditions. There are two major categories of consolidation; consolidation of the water inevitable for paddy farming and consolidation of the land where paddy is grown.

In general, to achieve a higher productivity, as for water, irrigation works such as dams, reservoirs, weirs, gates, irrigation canals and inlets must be consolidated, and drainage works such as outlets, drainage canals, gates and pumps must also be consolidated. For land, required consolidation includes land readjustment for adjusting land blocks in form and size, subsoil improvement for enhancing fertility, pipe underdrainage for reformation into well-drained paddy fields, farm road construction for traffic and transport, etc.

2. Consolidation of paddy fields and technical progress

The basic difference between a paddy field and an upland field is that the former is almost leveled in ground surface, to retain water at a certain depth by the levees, etc. built on the ground. In the primitive ages, natural swamps were used as they were, and later, levees were built to suit the respective topographical features, for using natural rain and transudation water incoming from upper reaches. Furthermore, efforts seem to have been made to make the levees higher for keeping more water and to compact subsoil for preventing water leak.

However, the rain-fed paddy fields simply resorted to rain, and it was difficult to achieve a certain yield stably every year. So, irrigation works such as artificial canals were gradually consolidated, and in the beginning, flowing irrigation using easily available mountain stream water was mainly adopted. However, gradually, reservoirs as sources, weirs for taking water from rivers, canals for carrying water to remote areas, etc. were constructed, and in the 1800s, highly advanced water utilization techniques were used. After the world war II, i.e., after 1945, large-scale irrigation and drainage projects and paddy field reclamation projects were promoted to avoid the shortage of foods, for remarkably developing agricultural techniques, and the yield of paddy improved dramatically and reached a high steady level.

In the old ages, ill drained paddy fields had been considered to be rather desirable, since water shortage had been feared. However in recent years, surface drainage was improved and the ground water level was lowered, to make paddy fields well-drained, and the pipe underdrainage for improving the properties of soil began to be preferred. More recently, for lower cost paddy farming, projects of land block expansion and subsoil improvement are actively being implemented to allow adoption of larger machines for agricultural works, and in addition, subsurface drainage is being intensified to allow paddy fields to be converted into multipurpose fields as required, in integrated efforts.

IV. Structure and blocks of paddy fields

1. Structure of paddy fields

A paddy field, unlike an upland field, must keep water on the ground surface at a certain depth. So, it requires subsoil with a hardness to allow the access of animals and machines without causing excessive water leak and levees to keep water in them. If the subsoil is clayey soil low in water permeability, it can be used as it is. However, in the case of sandy soil or peat soil high in water permeability, plowsole for inhibiting water permeation must be prepared as shown in Fig. 3.

When a paddy field is reclaimed from badland or upland field, it often occurs that land leveling cannot be effected well to form undulation as shown in Fig. 4. Unless the insufficient leveling is corrected by using an animal or machine, the paddy grows unevenly and weeding is difficult, not allowing a sufficient yield to be obtained. Especially in the case of direct sowing, the land leveling is decisively important for the germination of seeds and the growth of paddy. In Japan, it is aimed at to keep the level of paddy field surface within ±5 cm, and if the level is in this range, small seedlings or direct sowing does not cause any problem in growth. If a large volume of earth must be moved to achieve land leveling, it is inevitable to keep each paddy field small with many levees built.

Levees should not collapse or allow water leak. So, when they are built, they are sufficiently compacted or as the case may be, they are covered with a PVC sheet or sided by concrete blocks, to prevent water permeation and weed growth.

2. Blocks of paddy fields

In general, blocks of paddy fields are not required to be regularly rectangular, and it is also practised to build levees along contour lines, according to the gradient of land.

However, in Japan, for higher mechanical working efficiency, less waste of land and clearer ownership of land, blocks as shown in Fig. 5 are adopted as standard. Blocks include the following types; a farm block surrounded by roads, a field block (half of a farm block) surrounded by roads and a drainage canal, and a field lot as a minimum arable land unit surrounded by levees, etc.

The standard sizes of field lots are as shown in Table 2. The most general field lot size is 30 m × 100 m = 0.3 ha. However, the recent farm land consolidation for large mechanization promotes the adoption of larger field lots of more than 1 ha corresponding to conventional field blocks by removing levees to secure larger leveled land. For reference, a standard block of 0.3 ha is large enough to allow the use of a 30 to 40 HP tractor or a combine with a swath of about 4 m.

The size of a block is decided by the following four factors; <1> efficiency of agricultural works (plowing, preparation of soil, harrowing, seeding, fertilization, disease and pest control, weed control, harvesting, etc.), <2>topographical gradient and soil conditions (earth volume required to be moved for land leveling, soil properties, depth to bad soil, etc.), <3> water management (easiness of water management such as irrigation to and drainage from field lot), and <4> owned land area and management scale of farmer (necessity of dividing the land of a farmer into several field lots for dispersing the risk of weather disaster and disease and pest damage, and also for dispersing labor peak). These factors must be examined in reference to the conditions of the district, for deciding the sizes and forms of blocks.

V. Water management of paddy fields

1. Water management methods

To enhance the productivity in paddy farming, the water required for growth and cultivation of paddy must be supplied and the excessive water fed by rainfall must be removed. In modern farm land consolidation, as shown in Fig. 5, irrigation canals are perfectly separated from drainage canals, to allow independent water management in each field lot. However, paddy fields on a slope or a poorly consolidated region still adopts flowing irrigation for allowing water to flow from one field lot to another sequentially. In most paddy fields of Asia, this flowing irrigation is rather general. This method has advantages such as less investment in irrigation and drainage canals and easy management, but has a disadvantage that independent water management suitable for the growth of paddy in each field lot cannot be effected.

2. Consumption mechanism of irrigation water

The water supplied into paddy fields is consumed in two actions of evapotranspiration and percolation.

(1) Evapotranspiration

Evapotranspiration includes two actions; the evaporation from water surface and the transpiration from leaves of paddy, and these two actions are usually handled together as evapotranspiration. The evapotranspiration refers to the water lost in air, and so cannot be repeatedly used unlike the percolation described later. The standard value in Japan depends, to some extent, on the season, weather, paddy growth stage, etc., but is approximately 3 to 7 mm/day in terms of water depth. Even in a tropical region high in air temperature, this value is not so different and can be considered to be about 5 to 10 mm/day.

(2) Percolation

Percolation includes two factors; vertical percolation through plowsole and horizontal percolation through levees.

The vertical percolation greatly depends on soil, cultivation method, etc. among the consumption actions of water from paddy fields, and the consumption by vertical percolation almost decides the water guantity of a paddy field.

The percolation mechanism through soil is as shown in Fig. 7, and the velocity of percolation water is expressed by the following formula (Darcy's law).

$$v = k \cdot l/h$$

v: velocity (cm/sec) K: coefficient of water permeability (cm/sec) h: water head difference (cm) l: length of the streamline (cm)

That is, the velocity of percolation (v) is decided by the product of the coefficient of water permeability (k) and the hydraulic gradient (h/l). The coefficient of water permeability is decided by the properties of soil (sandy soil, loamy soil, clay soil, etc.) and the structure in soil (existence of large pores, etc.), and the hydraulic gradient is decided by the ground water level in the surrounding land and the water levels of drainage canals and rivers.

Therefore, if both the coefficient of water permeability and the hydraulic gradient are large as on a plateau with sandy soil, the percolation is very large, and if a paddy field is constructed on such a plateau, it will leak water, to get water exhausted soon. However, when the hydraulic gradient is small due to a high ground water level in flatland, the percolation is not so large even if the coefficient of water permeability is large. On the contrary, even when the hydraulic gradient is large on a plateau, the percolation is not so large if the soil is clayey and small in the coefficient of water permeability.

If it is intended to construct paddy fields good in water holding capability in the Mongu area, it is first of all necessary to select soil zones low in water permeability. If the subsoil is high in water permeability like sandy soil or peat soil, any measure such as the compaction of plowsole should be examined, or if circumstances allow it, any measure for raising the water level of drainage canals should be taken.

The vertical percolation means water consumption in each paddy field, but considering widely extending paddy fields, it can turn into ground water and spring up in the lower reaches for reuse as irrigation water.

The horizontal percolation greatly depends on the soil properties of levees, execution of compaction, presence of holes of small animals, etc. However, since the water oozes into the adjacent paddy fields and canals, it can be used as irrigation water again. So, even though it is an important factor for the water management of each paddy field, it can be almost disregarded in view of consumption of irrigation water.

(3) Water requirement in depth

The water lost in a paddy field expressed in water depth is called water requirement in depth, and it expresses the lost quantity of water in reference to the drop of flooded water level in cm per day. The water requirement in depth is decided by the evapotranspiration and percolation described above, and depends on various factors such as soil, crop growth, weather, etc. These factors are listed in Table 3. From the table, it can be seen how the water consumption in paddy fields is complicated.

The values of water requirement in depth for respective soil types in Japan are shown in Table 4. The average value of Japan as a whole ranges from 15 to 25 mm/day because of many slopes and sandy soil areas in Japan. In the flatland of Asia, it is usually about 10 mm/day close to evapotranspiration because of little percolation.

When paddy fields are reclaimed from badlands and upland fields, it often occurs that in the beginning, the plowsole is not formed and that the water requirement in depth is large due to large percolation, but if paddy farming, puddling, etc. are repeated several years, the water requirement in depth tends to be gradually smaller as shown in Table 5.

VI. Paddy field reclamation

The reclamation of new paddy fields from badlands and upland fields must take the following procedure.

1. Land preparation and leveling

A paddy field, unlike an upland field, must hold water, and the ground must be flat. Therefore, the land is at first prepared and leveled using a bulldozer, animal, etc. In this case, large stones, tree roots, etc., if any, should be removed.

2. Levee building

To hold water, a paddy field must be surrounded by levees which are built by collecting surrounding earth. If the levees should leak water, it can be effectively prevented by compaction or covering with PVC cloth.

3. Inlet and outlet

To supply water into a field lot and remove excessive water from it, an inlet and an outlet must be formed in any levee. In the case of a paddy field subject to flowing irrigation, the outlet of a field lot acts also as an inlet of the field lot immediately below it.

4. Irrigation canals and drainage canals

It is desirable that each field lot contacts an irrigation canal and a drainage canal. However, in the case of flowing irrigation, an irrigation canal provided at the most upstream end and a drainage canal provided at the most downstream end are enough. The respective canals should be decided to be either unlined or lined with concrete, considering the water flow and subsequent maintenance. An unlined canal is low in construction cost but requires a wider canal site and may face a higher cost of maintenance for preventing slope breaking and weed growth. So careful examination is required.

5. Intake works and drainage works

If a river is intended to be used as a water source, a weir, gate, channel, etc. must be constructed for intake, and for drainage, a drainage canal to a river, drainage gate, etc. are required. If a natural head cannot be used as on flatland, a pump may be used, but it requires energy such as electricity or oil, to raise the maintenance cost. So, it is desirable to plan irrigation and drainage using the gravity of a natural head as far as possible.

VII. Application to the Mongu area

The description made so far introduces the development process of paddy field consolidation in Japan, and the outline of techniques based on it. For development of paddy field agriculture in the Mongu area, it is desirable to positively introduce advanced techniques in reference to the experience and findings accumulated in Japan as far as possible, after sufficiently examining the natural conditions such as regional weather, topographical features, soil, and irrigation and drainage, and socioeconomic condutions such as farmer managememnt, population to be supported, land owned, technical experience and investble funds.

The following are matters to be considered for the agricultural land consolidation, and irrigation and drainage required for securing stable rice production in the development of paddy fields in the Mongu area.

<1> The idea of a paddy field that "a paddy field is a field which has flat ground and levees, to be filled with water" should be clarified, and

consolidation efforts should be made to satisfy the minimum conditions for the field.

<2> The direction for convertion from the conventional agriculture relying on rain to the agriculture based on artificial irrigation and drainage should be clarified, and consolidation efforts should be made to satisfy the minimum conditions for irrigation and drainage.

<3> While considering the compatibility among the present regional socioeconomic situations, the management and land ownership of farmers, the prospect for mechanization of agricultural works, reasonable investment, etc., consolidation efforts should be made at first to satisfy the minimum conditions, and then to enhance the consolidated level stepwise.

<4> Concurrently with the consolidation efforts to satisfy the conditions of fields and irrigation and drainage, efforts should be made to investigate and analyze regional natural conditions such as weather, hydrological features, topographical features, geological features, soil, and irrigation and drainage, and to educationally transfer and disseminate techniques concerning the paddy field agriculture, and also to grow a farmers' organization suitable for a new farming style.

Region		Area		Unit yield kg/ha	Yield	
Region name	Number of country	1000 ha	Share %		1000 ton	Share %
World	111	141,051	100.0	3,221	454,320	100.0
Africa	41	5,523	3.9	1,813	10,013	2.2
North central America	15	1,627	1.2	4,949	8,050	1.8
South America	13	7,441	5.3	2,148	15,983	3.5
Asia	26	125,335	88.8	3,310	414,804	91.3
Europe	10	415	0.3	5,286	2,194	0.5
Oceania	5	110	0.1	5,227	575	0.1
U.S.S.R	1	600	0.4	4,500	2,700	0.6

(FAO, Yearbook - Production, 1989)

Table 1 Paddy Field Area and Paddy Rice Yield in the World

Land slope	Drainage condition	Short side length	Long side length	Field lot area
Flat zone (1/500)	Well-drained paddy field	30 - 60 m	100 - 150 m	0.3 - 0.9 ha
	Ill-drained paddy field	30 - 60	100	0.3 - 0.6
Gentle slope zone (1/500-1/50)	Well-drained paddy field	30	100 - 150	0.3 - 0.45
	Ill-drained paddy field	30	100	0.3
Rapid slope zone (1/50)		20 - 30	100	0.2 - 0.3

Table 2 Standard Shape and Area of Field Lot

- Water requirement in depth in the field
  - Evapotranspiration
    - Climatic conditions (Air temperature, Humidity, Solar radiation, Wind direction and velocity etc.)
    - Growing conditions of rice (Variety, Soil, Climate, Field management practices etc.)
  - Vertical percolation
    - Hydraulic conditions (Topography, Water level of drainage canal, Ground water table, Evopo-transpiration of rice plant)
    - Permeability of soil (Structure of soil layers, Cracks, Oxidation and reductions, volatilization of gas, Cultivation operation, Water management, etc.)
  - Percolation from border
    - Hydraulic conditions (Differences in elevation of neighbouring paddy fields and in their water level, Water management
    - Permeability of border (Materials of soil, Moisture content, Management of border, Fauna in soil etc.)

Table 3 Main Reasons of Change in Water Requirement

Sand	27
Sandy loam	23
Loam	17
Clay loam	14
Clay	10

Table 4 Soil and Average Net Water Requirement (mm/day)

Year after reclamation	Normal paddy field percolation rate 1.40 - 1.66 l/ sec./ha	Pervious paddy field percolation rate 2.22 - 2.77 l /sec./ha
1/2	5.0 times	—
1	2.0 times	3.5 - 4.0 times
2	1.7 times	2.0 - 2.5 times
3	1.2 times	1.5 - 1.7 times
4	1.0 times	1.3 - 1.5 times
5	1.0 times	1.2 times
6	1.0 times	1.0 times

Table 5 Change in Percolation Rates

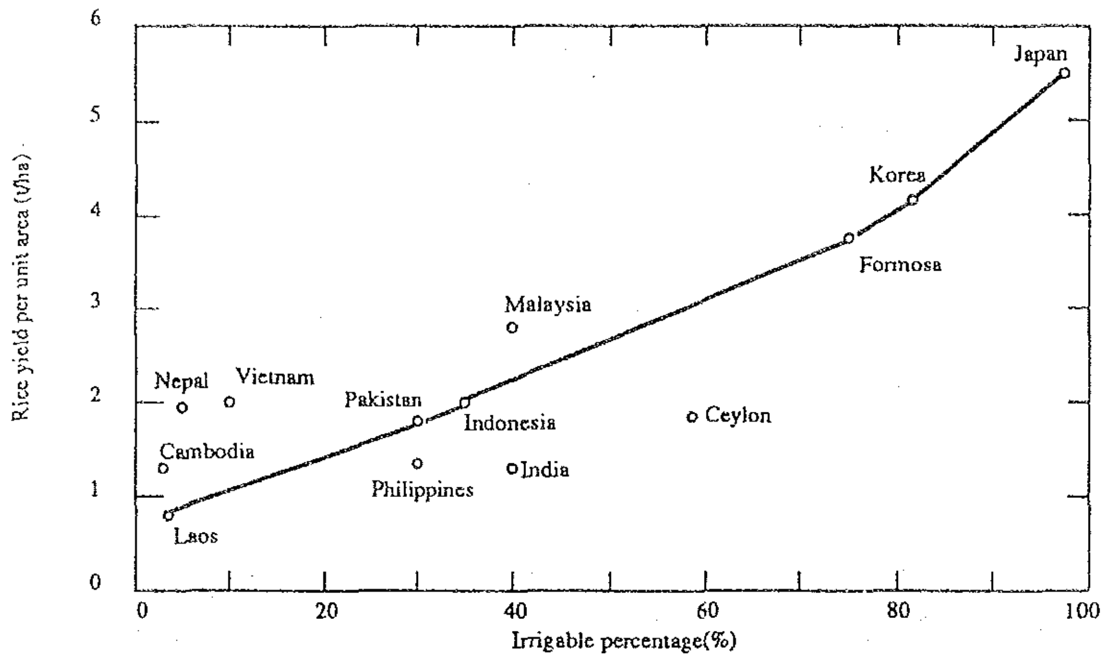


Figure 1 Irrigable Percentage and Rice Yield per Unit Area(ha) in Asian Countries(1976)

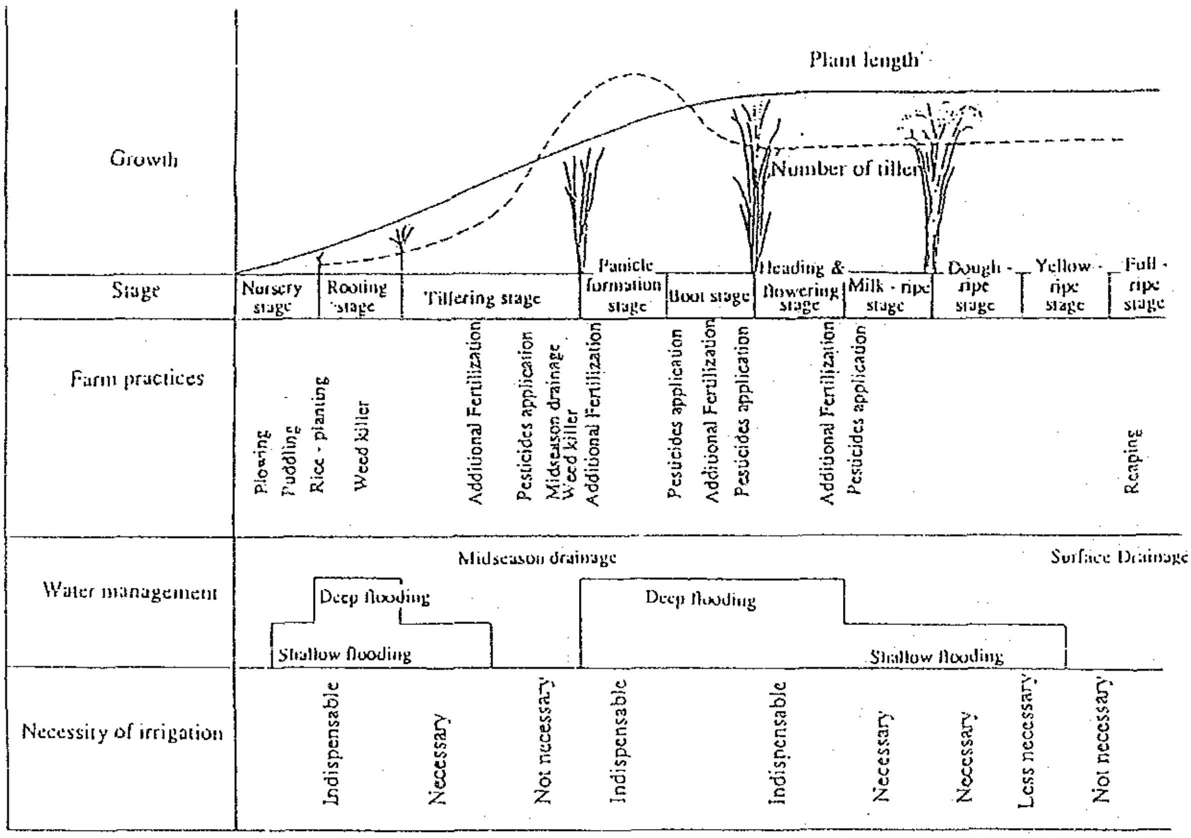
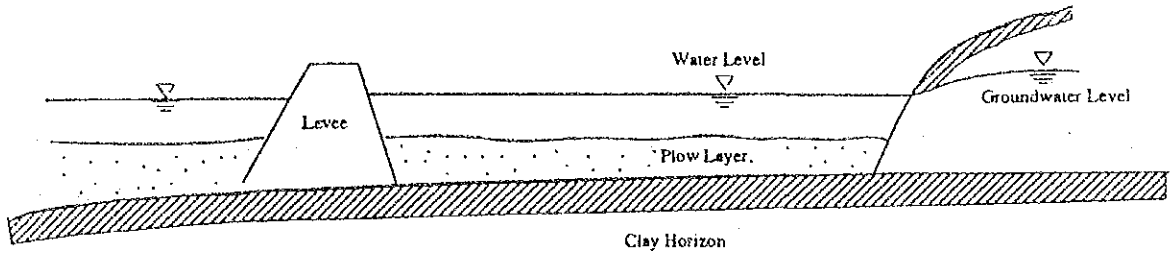
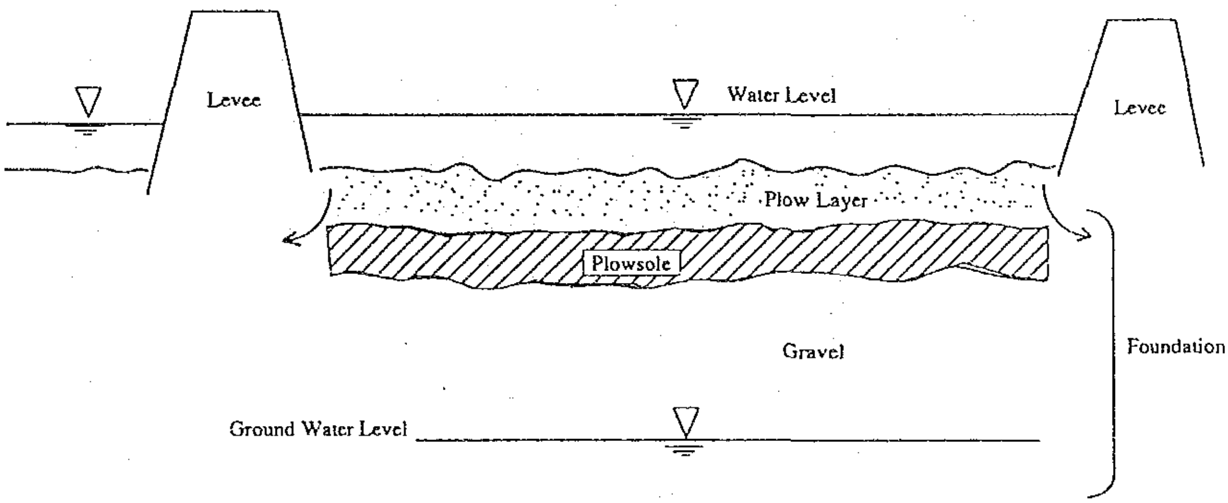


Figure 2 Rice growth, farm practices and water management

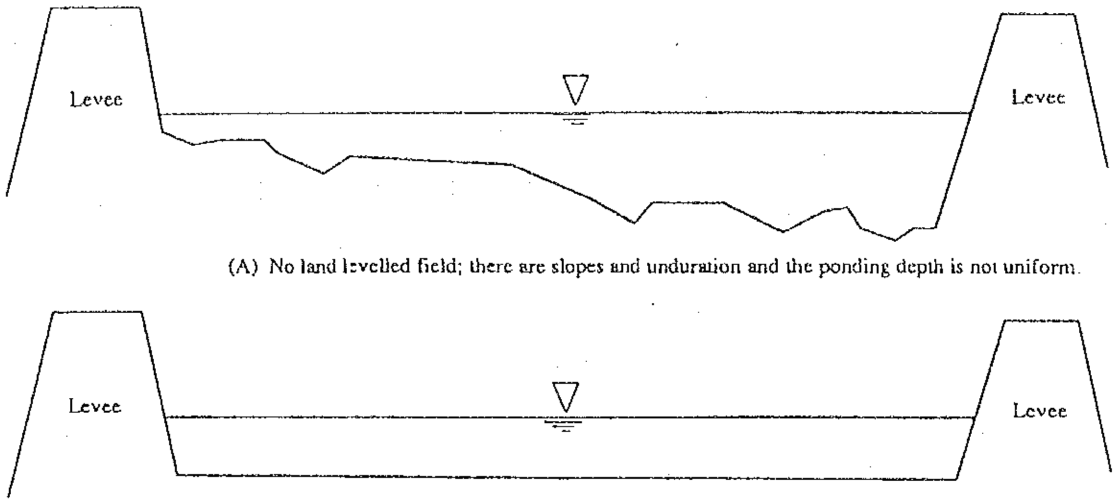


(A) Section of clay Soil Paddy Field Foundation



(B) Profile of Gravel Foundation

Figure 3 Cross Section of Paddy Field



(A) No land levelled field; there are slopes and unduration and the ponding depth is not uniform.

(B) Land levelled field; field surface is horizon and smooth, the ponding depth is uniform.

Figure 4 Case of (A) : No Land Levelled Field and (B) : Land Levelled Field

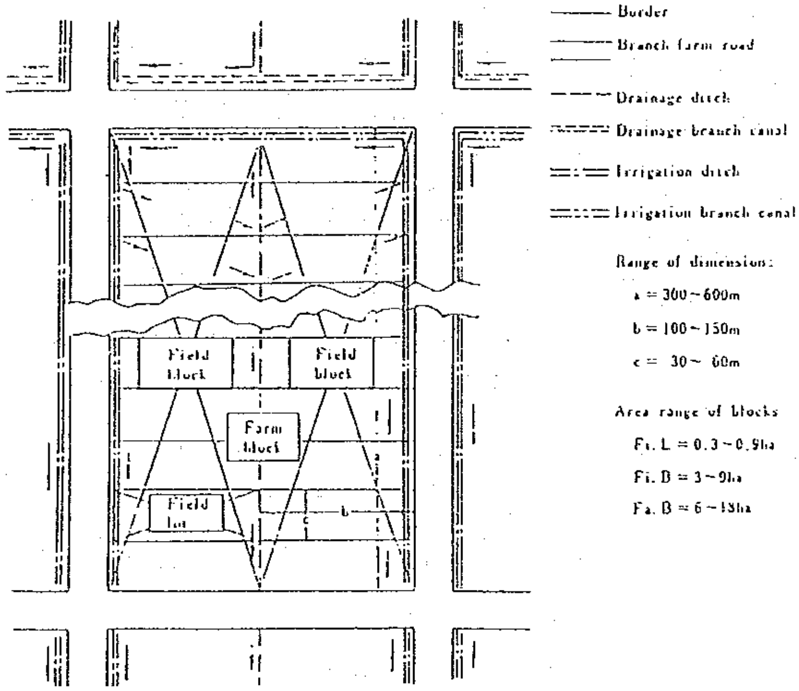


Figure 5 Definition of Farmland Blocks in Paddy Field

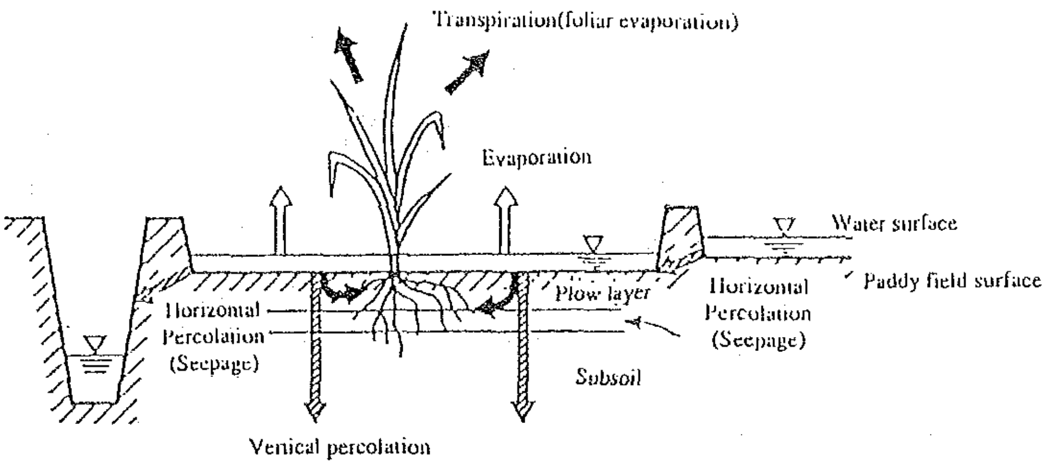


Figure 6 Water Consumption Mechanism in the Paddy Field

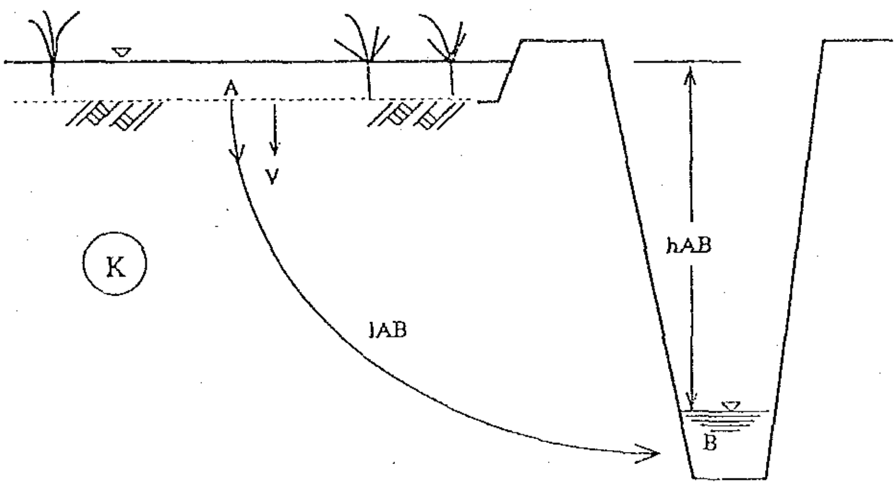


Figure 7 A Diagram of Paddy Field Percolation

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