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May 17, 2004
Original: English

CONSULT ON RURAL AGRO-MACHINERY DESIGN AND ENGINEERING METHODOLOGY

NC/GHA/02/016/11-02

Ghana

Technical report: Design and engineering methodology for sustainable rural agro-machinery in Ghana

Prepared for the United Nations Industrial Development Organization

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United Nations Industrial Development Organization
Vienna

List of Abbreviations

AMIS	Agricultural Machinery Industrial System
ASCo	Ayensu Starch Company
PSI	President Special Initiative
GC	General Conference
JD	Job Description
UNIDO	United Nations Industrial Development Organisation

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I. INTRODUCTION

The assignment for consult on 'rural agro-machinery design and engineering methodology' has been carried out from 1 November 2003 until 31 January 2004 with Accra (Ghana) as duty station. During this time, the

Ghana office of UNIDO performed a case study to develop a Cassava Harvester within the Agricultural Machinery Industrial System (AMIS) project, which has been set up by UNIDO under the President's Special Initiative (PSI).
Main duty of the assignment, as described in the Job Description (JD) in Annex 1, is to structure and present the redesign process of the Cassava Harvester and of future design processes in AMIS. In this introduction the programmes and projects mentioned will be explained further.

PSI

Ghana has a predominantly agricultural economy and the government stimulates income generation to reduce rural poverty. Important approaches are reflected in the Ghana Poverty Reduction Strategy (GPRS) 2002 – 2004 and in the President's Special Initiatives (PSI) on cassava starch and oil palm, which are sector development programmes to boost production and export.
Income generation depends often on equipment, mostly for agro-processing and rural transport.
Unfortunately, available equipment is often of poor quality, limited affordability, and it regularly hampers or even blocks the rural income generation programmes due to frequent breakdowns.
To assist the government of Ghana in stimulating income generation to reduce rural poverty, UNIDO has initiated to develop the Agricultural Machinery Industrial System.

AMIS

The AMIS project of UNIDO supports the national equipment manufacturing industry, the local blacksmiths, and their respective associations through upgrading support institutions with capacities to introduce sets of equipment that are semi-standardized, economically feasible and are contributing to the national objectives for agro produce.

UNIDO promotes the introduction of an integral product development process, which considers all stakeholders in the value chain. As a result, each of the stakeholders will see their situation improved by the introduction and exploitation of newly developed equipment.

The [AMIS] approach has been explored and defined further by performing a case study in which a new Cassava Harvester has been developed for the Cassava farmers in Ghana. This case was selected as to-date Ghanaian farmers are unable to harvest enough cassava in the right time to meet the market demands, in particular the demands of the largest Cassava processor, the Ayensu Starch Company (ASCo).

Case study "Cassava Harvester"

To obtain a new design for a Cassava Harvester with added value in the chain and to ensure the integral development approach, stakeholders meetings were incorporated in the case study.
To perform the development activities in this case study, UNIDO has composed a special project team, consisting of a project manager, technical expert(s) and international consultants.

UNIDO Project team Case study "development of a Cassava Harvester"		
Function	Name	Duty station
International Project Manager	Mr. Evert Kok	Vienna
UNIDO representative	Mr. Akmel Akpa	Accra
National Programme Co-ordinator	Mr. Solomon Boateng	Accra
National Project Manager	Mr. Daniel Baffour-Awuah	Accra
National Consultant	Mr.Alexander Twum	Accra
International Consultant	Mr.S.Vasantha Kumar	Accra
International Consultant	Ms. Carmen van der Vecht	Accra

This project team worked in close co-operation with especially the PSI, the Ayensu Starch Company, the KUMASI University and GRATIS Foundation.

Based on harvester constructions used in other Cassava countries and found at technical institutes in Ghana, the project team has developed the following three different equipment types:

- The Vertical Pole type, which fixes the Cassava stick by an iron angular feet gripper;
- The Rope type, which locks the Cassava stick by an iron gripper and chain;
- The Chain type, which squeezes the Cassava stick by a rope noose.

These three types have been constructed further into prototypes by the GRATIS institute. Tests with these prototypes on the farms have proven that all the three types reduce the harvest time and drudgery. Especially the 'Vertical Pole' type and the 'Rope' type, which can generate up to 20% more productivity.
Parallel with the technical study, the project team explored a construction in which the farmers can rent or lease tools from an intermediate organization.
Before selecting the most appropriate solution to increase the harvest efficiency, the project team is now preparing another field test to determine the performances under tougher conditions.

EVALUATION OF THE DESIGN AND DEVELOPMENT PROCESS IN THE CASE STUDY

The case study had to be performed in a relatively limited space of time, in which the project team has explored many existing (technical) solutions for Cassava harvesting in Ghana and in other Cassava countries. This analysis prevents reinventing the 'wheel'. Besides, as some of these solutions are commonly used in countries which are in an up coming economical position, like Ghana, the potential of the equipment being economically feasible is high.

During the case study the explored basic solutions have been tested frequently by the farmers and adjusted by GRATIS to improve the sustainability and suitability for mass production of the equipment. Yet with the technical improvements, the costs of the equipment increased and the question raises whether the economical and organisational effects of the new developed constructions will be still that optimal for the Ghanaian Cassava chain. During the assignment, the project team explored these effects, but the emphasis has been put on the technical and ergonomic aspects of the new equipment.

The case study has been limited to exploring existing solutions. The design environment and thus the specifications of the Ghanaian Cassava harvester are likely to differ from that in other Cassava countries. Therefore future studies can benefit from including also the exploration of new solutions, based on regional knowledge of local experts, and include solutions that match the local system conditions. As a result the new developed system or set of equipment will achieve a maximal added value in the chain.

For future development processes, the integrated approach can be enhanced by following a more structured process, in which:

- a detailed analysis of the current chain and the specifications for the new situation form the basics to achieve and select the most optimal end result,
- new/adapted solutions can be explored next to existing solutions and
- the economical and organisational aspects will have a stronger and continuous attention.

Such an integrated methodology can assist a project team who has to fulfil all wishes from the chain by a new or redesigned set of equipment, but who has to start with an empty sheet.

CONTENTS OF THIS REPORT

In this report, after a summery of the assignment activities, an integrated design methodology will be presented and explained using the case study for a new Cassava Harvester. The report ends with recommendations for future (re) design processes in AMIS.

II. ASSIGNMENT ACTIVITIES

This chapter describes the assignment's job description (see also Annex 1) and the activities performed in Ghana, from 1 November 2003 until 1 December 2003.

II.A. Job Description

The broad duties will be to specifically assess the situation in relation to the farmer's manual harvesting of cassava in large quantities and acreage, specifically, identify the drudgery associated with manual cassava harvesting in the rural areas with emphasis on those producing in the framework of the President's Special Initiative (PSI) program. A cassava harvester will be recommended that is affordable in investment and exploitation terms for the farmers, easily accessible and can be manufactured and maintained by the local artisans within the farming communities. Equally the cassava harvester development process will be presented as a development model for other types of equipments. Further the development approach will be presented in a wider framework of engineering sector support, incorporating concepts as value chain building, and supporting de-facto standardization, and conclusions will be drawn for further use in a project concept for phase II of the project. In this assignment the following activities need to be performed:

1. Structure the redesign process of a cassava harvester as a general model,
2. Present the influence and relevance of commercial viability of all elements of the value chain.
3. Advice on the intervention logic and concepts of the follow-up phase of the project.
4. Co-ordinate the presentation of AMIS and the cases study for UNIDO's GC.
5. Assess the capabilities of GRATIS and advise on capacity upgrading of GRATIS if required.
6. Assess implications for mass production of the harvester with private sector entities.
7. Prepare a final report.

II.B. Performed activities

At the start of the assignment in Accra, on the 1sth of November 2003, the UNIDO project team based in Accra, was facing a short time span to present AMIS and the case study at the General Conference (GC) in Vienna during the first week of December 2003.
In the time prior to the assignment, the project team had explored several solutions for Manual Cassava harvesting in Ghana and other Cassava countries. From these solutions, three were selected by the farmers and constructed into prototypes by GRATIS. The coming activities were a representative field-test, select the most appropriate solution and manufacture a prototype, which can be presented at the GC.

Because of the deadlines, the project team in Ghana wanted the assignment to be focussed on task 4; 'the co-ordination of the needed promotional items (brochure, poster, video and prototype) to present at the GC. From these items, special attention was asked for developing a promotional brochure of AMIS and the Case Study. Therefore activity 4 was rescheduled and performed in parallel with activities 1 and 2. The other activities have been mainly performed in The Netherlands subsequently. From the work period in Accra an overview of the meetings are placed in Annex 3.

A summery of the performed activities in Ghana is described underneath:

1. Structure the redesign process of a cassava harvester
The redesign process has been analysed and has yielded with some of the following recommendations:

Formulation: Many different names were used for the retrieved solutions, which causes confusion and made it difficult for externals to get efficiently involved in the project. Therefore adjusted names have been introduced, which were typical for the construction and which were from there on used consistent and in the same sequence.

Testing and selecting conditions: The work plan for the field test with the three constructions was not completely covering an outcome on the basis of which the best solution could be selected. As the test parameters need to be linked with the requirements for the new set of equipment, first a list of these requirements has been made. After this, test parameters have been added, for instance the measurement of the number of tubers left in the ground, the amount of damaged tubers after harvesting and the performance of the current harvesting tools.

Selection: To select the most appropriate solution after the field tests, a selection procedure has been introduced to the project team. The performances of the tested solutions (including the current harvest actions) have been valued and judged on the main restrictions. This in close co-operation with the test consultants and GRATIS.

Optimization: During and after the field test, questions raised on some construction details of the three harvester types, for instance regarding the functionality of the iron platforms and the material use for the pole. Therefore an additional short test has been organised without the iron platform for the 'rope type', which had shown positive results.

Value Chain: the effects of the current and new harvesting situation in the chain is described in paragraph IV.A.5 and IV.C.5.

General model redesign processes: See the next chapter of this report.

4. Co-ordinate the presentation of AMIS and the cases study for UNIDO's GC

This activity has been performed in close co-operation with Mr. Ebenezer Ampaabeng and his team, which included a graphic designer, a photographer and a video shooter. This team was very useful, especially for making the video. Yet as time was very short from the start of the assignment until the GC, it seemed to be more time effective to design the lay-out of the brochure and posters directly while working on the promotion text.

Promotion text: To write the text, first the past activities and available information of AMIS and the case study had to be analysed and structured. After this, lacking information in the development process needed to be retrieved, such as the comparison of the current and the new harvest situation within the cassava chain (task 1). As the text for the brochure had to be suitable for all internal and external parties involved, it has been checked critically by the UNIDO project team, the PSI and ASCo.

Layout: Because of the limited time available, the layout and text of the brochure and posters have been developed simultaneously. The layout is based on the UNIDO house style by using the same main colours (yellow and green) and size of the continuous bar at the bottom side. Besides using significant pictures of the chain and clear schemes, the AMIS abbreviation has been given more attention by placing it in rectangular brackets: [AMIS].

Printing: To print 500 brochures at such short notice in Accra is difficult. Some un- and expected occurred, such as a machinery break down at the proposed printing company. After exploring the availability at other printing companies, it was decided to shift to a more expensive digital print company "Graphic Color".

The resulting brochure and the poster of AMIS and the Case Study are presented in Annex 4.

III. PROPOSED DESIGN METHODOLOGY

To design and develop a set of equipment within [AMIS], a methodology is proposed which is based on customary sustainable design methods (see Annex 9) and adjusted for development projects in upcoming markets, where organisational structures are of influence on the continuity and where the availability of materials and production machinery, and therefore standardization, can be limited.

An integrated sustainable design method gives structure to the design process and fulfils the various preferences for the new set of equipment of all the actors in the chain. This method is used to achieve a new set of equipment with maximum added value in the chain, a sustainable continuity and with a minimum of impact on the environment.

The proposed methodology divides the development activities in different phases. The new set of equipment is developed step-by-step, starting with the analysis of the current chain and preferences for the new situation and ending with the implementation of the solution. The following 5 phases are summerized in the next figure and described further in more detail:

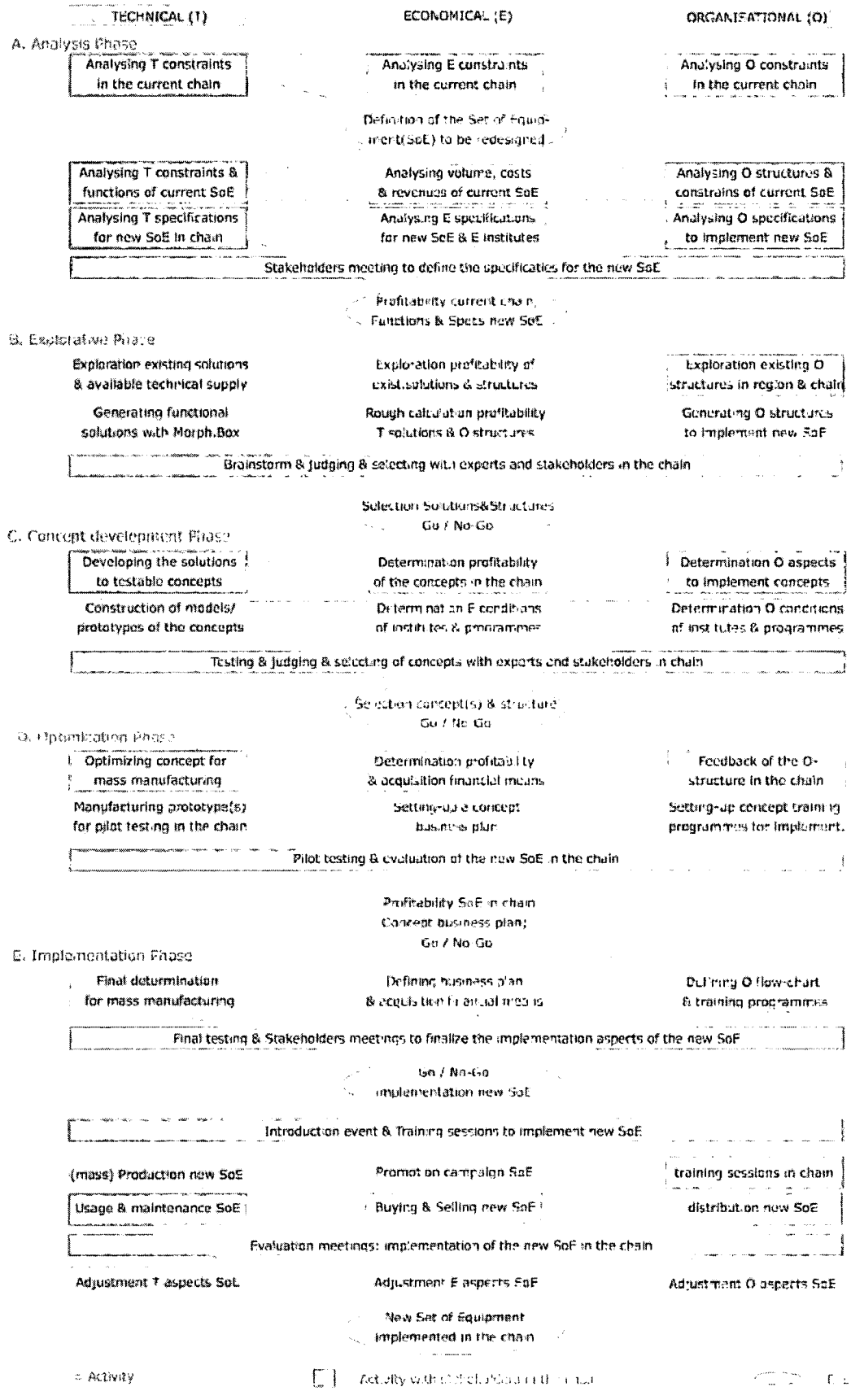
Phase A: Analysis Phase: analysis of the current situation and the preferred new situation;
Phase B: Explorative Phase: exploration of existing and new solutions;
Phase C: Concept Development Phase: development and testing of the selected solutions;
Phase D: Optimization Phase: optimization of the selected solution for production;
Phase E: Implementation Phase: implementation of the new set of equipment in the chain.

Every phase gives attention to technical, economical and organisational aspects and to the stakeholder's opinions. The phases start with diverging actions, for instance generating many ideas, and end with converging actions, such as selecting the most appropriate solution. With a go/no-go decision after every phase, the project will be most effective in time and cost.

Paragraph III.A to III.E give a description of the above phases. Paragraph III.F describes the recommended framework for the (engineering sector) support during the different phases.

Legend used in the tables of the development activities and results.

	Stakeholder's opinion
T	Task
R	Result



Scheme of the integrated development methodology

III.A. Analysis Phase

In the Analysis phase, the current chain is determined on its technical, economical and organisational aspects to define the current problems, the design goal and specifications for the new set of equipment.

T	Tasks Analysis Phase		
	a. Technical Analysis	b. Economical Analysis	c. Organisational Analysis
1	Analysing the technical constraints of the current chain, focused on production, distribution, usage,maintenance and impact on environment.	Analysing the economical constraints of the current chain, focused on production, distribution, usage and maintenance.	Analysing the organisational constraints in the current chain, focused on distribution (import), usage and maintenance.
	Definition of the set of equipment to be (re)designed		
	Analysing the constraints and functions of the current set of equipment, focused on materials, production, distribution,usage, maintenance and environment.	Analysing the volume, costs and revenues of the current set of equipment, focused on production, distribution, usage and maintenance.	Analysing the organisational structures and constrains of the current set of equipment focused on distribution (import), usage and maintenance.
2	Analysing the technical specifications for the new set of equipment in the chain, focused on optimal production, distribution, usage,maintenance and environmental impact & regulations.	Analysing the economical specifications for the new set of equipment in the chain and of the regulations by (financial) institutes.	Analysing the specifications and preferences in the chain and region for the organisational structures and (import) regulations to implement the new set of equipment.
3	Stakeholders/Expert meeting: Feed back on: the constraints of the current chain, the defined 'set of equipment' and the specifications for the new set of equipment on technical, economical and organisational aspects.		
4	Formulation technical goal for the new set of equipment.	Formulation economical goal for the new set of equipment.	Formulation organisational goal for the new set of equipment.
5	Formulation of judgeable[1] technical specifications and functions for the new set of equipment in the chain.	Formulation of judgeable[2] economical specifications for the new set of equipment in the chain.	Formulation of judgeable[2] organisational specifications for the new set of equipment in the chain.

F	Results Analysis Phase
1	Description (& pictures) of the current chain (and equipment).
2	Problem definition of the current chain (and equipment).
3	Description 'set of equipment' to (re)design.
4	List of stakeholders with contact information & meeting report
5	Overview profitability current value chain.
6	Formulation of design goal for the new equipment.
7	List of specifications, regulations and functions for the new equipment.

III.B. Explorative Phase

After the integral Analysis phase, a fresh start can be made to explore a wide range of solutions. This can be done by a research study to existing solutions in other countries and in other markets and by a functional design method with the use of a morphological box to explore new solutions.

T	Tasks Explorative Phase		
	a. Technical Exploration	b. Economical Exploration	c. Organisational Exploration

[1] The specifications need to be judgeable as they will be used to determine the performances of the generated solutions and to select the most appropriate solution.

1	Exploration of existing solutions with similar functions in other markets and in other countries.	Exploration of the volume, costs and revenues of the explored existing solutions	Exploration of existing organisational structures in the relevant region of the chain by organising workshops in the region.
	Exploration of available materials, parts, standards, production methods and suppliers.	Exploration of existing and relevant financial structures in region and by financial institutes.	Exploration of existing organisational structures for similar sets of equipment in other markets.
2	Generation of functional solutions for the new equipment with the use of a morphological box[2]	Rough calculation of the costs and the revenues of the generated technical and organisational solutions.	Generation of possible new or adjusted organisational structures to implement a new set of equipment.
3	Brainstorm with experts and/or stakeholders in the chain: Generate and discuss technical and organisational solutions with other experts and/or stakeholders.		
4	Global judging of the solutions on the main technical specifications.	Global judging of the solutions on the main economical specifications.	Global judging of the solutions on the main organisational specifications.
5	Selection of the most appropriate solutions and structures (±3) Go/ No-go decision for further development of a new set of equipment.		

R	Results Explorative Phase
1	Overview (drawing) of existing market solutions.
2	Overview (drawing) of part solutions for each function.
3	Sketches of possible solutions with indicated dimensions, material and costs.
4	Overview (flow chart) of possible organisational and financial structures.
5	Overview of judging[3] of solutions on specifications & selection of ±3 appropriate solutions and organisational structures for the new set of equipment.
6	(no) Go to next development phase

III.C. Concept Development Phase

The selected indicated solutions and structures for the new set of equipment will be developed further on concept level, like by dimensioning and materializing the constructions. In this phase the project team needs to co-operate with experts and/or institutes.

T	Tasks Concept Development Phase		
	a. Technical Development	b. Economical Development	c. Organisational Development
1	Developing the selected technical solutions to concept level by defining dimensions, material type and acts for manufacturing, usage and maintenance	Determination of the costs and the revenues (profitability) of the technical concepts in the chain.	Determination of the organisational aspects to implement the technical concepts in the chain (include import aspects).
2	Construction of the concept(s) into prototypes or simplified models.	Determination of the economical conditions of relevant financial & governmental institutes or programmes.	Determination of the organisational conditions of relevant financial & governmental institutes or programmes.
3	Testing[4] of the construction(s) by the users and stakeholders under extreme conditions.	Discussing the profitability and the financial structure of the concept(s) with the stakeholders.	Discussing the organisational aspects of the concept(s) with the stakeholders.

[2] Morphological box: After defining the functions of the new equipment, different solutions can be generated for each function. The solutions can be recorded with a simple sketch or description in a table. To design the total equipment, different combinations can be made from one solution per function. The end combination can be recorded with a 3-D drawing and key words. (see also Annex 6)

[3] The different solutions can be discussed on the basis of the most critical requirements, which are defined in the Analysis phase. For review and presentation to others, it is advisable to record the judgement in a table, like with '+' and '–' indications.

[4] The test parameters need to be representative for judging on the requirements

4	Stakeholders/Expert meeting: Judging of the concepts to the technical, economical and organisational specifications; Selection of the most appropriate set of equipment and financial/organisational structure. Go/ No-go decision for further development of a new set of equipment.

R	Results Concept Development Phase
1	Drawings (3D, Technical) of concepts with dimensions and material specifications.
2	3 D models of the concepts.
3	Overview reactions from the chain, include test report with data & results.
4	Overview (flow chart) of possible organisational and economical structures and specifications (costs & revenues).
5	Overview of the profitability in the new value chain.
6	Overview of judging and selection of the concepts and structures with the specifications.
7	(no) Go to next development phase

III.D. Optimization Phase

The selected concept(s) and organisational structure(s) for the new set of equipment will be optimized on technical and economical aspects for mass production, in close co-operation with suppliers, manufactures, distributors, users and others in the chain.

T	Tasks Optimization Phase		
	a. Technical Optimization	b. Economical Optimization	c. Organisational Optimization
1	Optimizing of the selected concept(s) for mass production: detailed determination of dimensions, material manufacturing, distribution, usage, storage and maintenance.	Determination of the costs and revenues (profitability) of the selected set of equipment in the chain on short (1 year) and long term (5-10 years).; Acquisition to financial means for implementing the selected set of equipment.	Setting-up workshops in the region to discuss the proposed organisational aspects for implementation of the new set of equipment; Discuss (import) regulations for implementations with (governmental) institutes.
2	Production of a certain amount of the designed set of equipment, which can be used for pilot testing.	Setting-up a concept business plan to implement the new set op equipment.	Setting-up concept training programmes for implementation the new set of equipment
3	Pilot testing of the technical, economical and organisational aspects: Introducing a certain amount of the set of equipment in the chain for a representative period.		
4	Stakeholders/Expert meeting: Evaluation of the set of equipment on technical, economical and organisational aspects in the chain; Go/ No-go decision for implementation of the new set of equipment.		

R	Results Optimization Phase
1	Data sheet of the specifications of the set of equipment.
2	Prototype(s) of the set of equipment.
3	Pilot test report with data & results.
4	Overview profitability new value chain.
5	Definite data sheet of the technical and economical specifications of the selected set of equipment.
6	(Conceptual) business and training plan.
7	(no) implementation of the new set of equipment.

III.E. Implementation Phase

After a 'go' decision, the new set of equipment can be make ready for implementation.

T	Tasks Implementation Phase		
	a. Technical Implementation	b. Economical Implementation	c. Organisational Implementation
1	Final determination of the construction details of the new set of equipment for mass production in close co-operation with the chain, like: suppliers, manufactures, distributors, users and black smiths; Selection of appropriate suppliers.	Final determination of a business plan to implement the new set of equipment on short and long term; Acquisition to financial means to implement the new set of equipment.	Setting-up an organisational flow chart of the implementation of the new set of equipment in the chain; Setting-up training programmes for implementation of the new set of equipment in the chain.
2	(if necessary) final testing & Stakeholders meeting to finilize the implementation aspects of the new set of equipment in the chain & Go/no-Go decision for implementation of the new set of equipment.		
3	Introduction event and training sessions for the chain of the new set of equipment.		
4	(Mass) Production of the new set of equipment.	Promotional campaign of the new set of equipment.	Training sessions in the chain for implementing the new equipment.
5	Usage and maintenance of the new set of equipment in the chain.	Buying and selling of the new set of equipment in the chain.	Distribution of the new set of equipment in the chain.
6	Evaluation of the new set of equipment after a certain period on technical, economical and organisational aspects in the chain with the stakeholders;		
7	Any possible adjustments of the technical aspects of the new set of equipment.	Any possible adjustments of the economical aspects of the new set of equipment.	Any possible adjustments of the organisational aspects of the new set of equipment.

R	Results Implementation Phase
1	Data sheet of the specifications of the selected set of equipment.
2	Overview organisational flow chart.
3	Training programmes.
4	Business plan.
5	Promotional campaign.
6	(Mass) amount of the new sets of equipment.

III.F. Framework Engineering sector support

The development activities described in the above mentioned phases can be performed and/or managed by specialized agencies, institutes and (inter)national consultants.

Based on the available network in Ghana, the following selection is made of relevant engineering institutes and of commercial and organisational support for the development of new set of equipments for agricultural machinery in Ghana.

Development Phases	Support		
	Technical	Economical	Organisational
Overall	TechnoServe, KIEM		
		CIKOD, ICA	
A: Analysis	GRATIS		
B: Explorative			
C: Concept Development			
D: Optimization			
E: Implementation	*Manufacturer*		
	EWW, Wienco, FAM		

The above mentioned companies and institutes are described further in the sequence of the mentioned development phases.

III.F.1. Overall Support

TechnoServe

TechnoServe's mission is to help entrepreneurial men and women in poor rural areas of the developing world to build businesses that create income, opportunity and economic growth for their families, their communities and their countries. In Ghana, TechnoServe has experience with the implementation of many agricultural developments, such as 'Farmapine'. Farmapine is a farmers co-operation for the export of pineapples, which structure is based on the Farmer Ownership Model of the World Bank. Since 1999 Farmapine consists of a well-organised logistic system to collect, pack and export Smooth Cayenne pineapples. Besides technical support to establish a packhouse and an office, TechnoServe organised integral workshops and trainings with the farmers. TechnoServe can assist with agro-technical, economical and organisational development activities. (For more information: www.technoserve.org/africa/ghana-overview.html)

KIEM sustainable innovations

KIEM is a leading design-engineering bureau in the Netherlands in the field of sustainable product innovation. KIEM develops market-oriented systems, products and packaging taking into account global environmental issues. Projects have been carried out in India, Pakistan, Senegal and Ghana. In Ghana, KIEM initiated a feasibility study of an improved logistic system for rural areas to increase the farmer's income. This project is performed in co-operation with Dutch suppliers of transport and cooling means and in Ghana with ECASARD, a sustainable network of farmers, and Food Research Institute. Currently pilot projects are defined to implement the proposed processing and transportation means.

KIEM has expertise with sustainable strategic consulting, system development and industrial product /packaging development. (For more information: www.kiem.nl)

III.F.2. Economical and organisational support

Centre for Indigenous Knowledge and Organisation Development (CIKOD)
CIKOD is a NGO in Ghana, which aims to improve the capacity of development practitioners to work with traditional authorities and indigenous institutions for sustainability in community organizational development. In co-operation with Care (www.careusa.org), CIKOD has initiated the project 'Civil Society Capacity Support for Agriculture & Natural Resources', to improve the capacity of local NGOs to access and use development and facilitation methods which enable community empowerment and civil society strengthening.
CIKOD is, under the flag of Konrad Adenauer Foundation (www.kas.de), specialized in organising workshops in rural Ghana and in implementing new developments within existing rural organisational structures.

The Institute of Cultural Affairs (ICA)
ICA, found in 35 countries as autonomous national organisations, believes that a group's cultural dynamics must be considered in order to build any sustainable pattern of change or development. Their aim is to put human beings at the centre of development by providing training and sustainable development activities in all spheres of Ghanaian society, e.g. agriculture, credit schemes, health and education. In north Ghana ICA has developed and implemented a Grains Credit Scheme for subsistence farmers to reduce poverty by offering guaranteed prices for grains to subsistence farmers and give them training in appropriate management methods.

III.F.3. Technical development support

GRATIS
GRATIS/ITTU comprises of a central unit in Tema and nine intermediate technology training units (ITTUs) distributed over various regions in Ghana. Their aim is to transfer appropriate technologies to small-scale industrialists through training, manufacturing and the supply of tools, plant and equipment. In Tema, GRATIS has a professional engineering department to develop industrial machinery means and a workshop to manufacture prototypes and small series.
The ITTUs support the regions with the maintenance and small scale manufacturing of machinery equipment. Within the case study, GRATIS supported UNIDO with the development of three different Cassava harvesters and the manufacturing of prototypes.
For extra technology and development support, GRATIS gives students from (inter)national universities the opportunity for internship, such as students from the *Delft University of Technology/ Faculty Industrial Design Engineering.*

III.F.4. Implementation & Import support

EnterpriseWorks - Implementation support
EnterpriseWorks Worldwide (EWW) is a non-profit organization that promotes sustainable, enterprise-oriented solutions to economic challenges in the developing world, primarily in Africa and Asia. EWW assists small-scale producers in more than 60 countries, enabling farmers and other entrepreneurs to boost their productivity, tap broader markets, capture higher value of finished products, and improved management of natural resources.
In Ghana, EWW has successfully introduced two new technological developments, a treadle pump for irrigation and a high-efficiency charcoal stove. Both are now produced by small manufacturers in Ghana and used by respectively farmers and consumers/small processors. (See also www.enterpriseworks.org/about_news_GhanaMarketing.asp.)

Wienco Gh. Ltd. – Implementation & Import support
Wienco is a joint venture Ghana-Dutch Company involved in businesses in the agricultural sector. The core business of the company is import and distribution of fertilisers and other agricultural inputs for agricultural improvement in Ghana. Wienco's distribution is done through accredited key wholesalers who in turn sell through their retail networks to the end users, both commercial estates as well as individual farmers.
To guarantee a constant stock of fertilisers, Wienco has also entered warehousing for their import and export activities. Besides this, Wienco introduces organic farming and organic certified products, such as Mango and bananas (Oké).
Wienco can assist with research, training and warehouse activities to implement new set of equipment in the agro industry in Ghana. (For more information: www.wienco.com)

Foundries and Agricultural Machinery (FAM) - Importer
FAM import pumps from India and has five distribution outlets for spares: one in Tema, two in Accra, one in Kumasi and one in Tamale. FAM delivers spare parts, such as for handpumps, to the
the Community Water and Sanitation Agency in Ghana.

Other assistance within the implementation phase can be asked for performing market tests by specialized marketing agencies, such as *Impretec*, and to *Ebenezer Ampaabeng* for taking care of promotional activities.

For the contact information about the above-mentioned organisations, see Annex 5.

IV. CASE STUDY: DEVELOPMENT CASSAVA HARVESTER

The case study of the development of a new Cassava Harvester will be described as an example on the hand of the proposed integral design methodology. As the case study is performed in a very short time span, there are marks made what can be completed or continued further. Besides this, an evaluation of the performed activities related to the proposed methodology can be find in Annex 7.

Notes

Grey-Italic: Special attention
Grey-Marked: Tip for follow-up developments
Yellow-Marked: Main results from a phase

IV.A. Analysis Phase

The project team has analysed the current situation of the Cassava chain in a short but integral way. This by interviewing and visiting the main stakeholders in the Cassava chain, such as: the farmers, processor (Ayensu Starch factory), small-scale manufacturers and technical institutes as GRATIS and the technical University of Kumasi.
The opinion of the stakeholders has also been heard during an expert meeting, yet in this meeting some more attention was put on the [AMIS] project in general.

As the findings from the analysis phase were not noted on a very structural way, it was some unclear what the bounders were for the new design. Especially the formulation of the design specifications could have been more detailed in consultation with the stakeholders.
Besides this, also more attention and structure could have been made to the analysis of the organizational and economical aspects of the current Cassava chain.

IV.A.1. Description of the current Cassava Chain

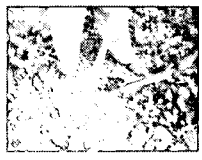
Currently all farmers, of which *45% women*, are harvesting Cassava on small and mixed cropped farms with a conventional *Cutlass* and some also with an *Earth Chisel*.

To harvest the Cassava tubers, the following activities are done manually:

- Clearing the land around the stem with the cutlass;
- Cutting the stem to 1.5 ft to 2 ft from the ground to facilitate lifting the tubers;
- Loosing the tubers in the ground by *hitting* with the Cutlass or Earth Chisel around and under the tubers;
- Lifting the tubers out of the ground by pushing the tubers with the Earth Chisel or just by pulling manually on the stem, *which differs in thickness and shapes.*

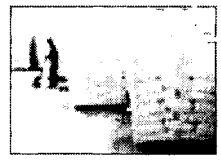
After harvesting, the tubers are carried *by head load* to the side of the road. At the road side the tubers will lay on a staple *in the sun* until transport comes to sell raw at the market or process at the factory, like Ayensu Starch Company (ASCo), a cassava starch producing company for export established under the President's Special Initiatives (PSI).


Black smith


Earth chisel & Cutlass

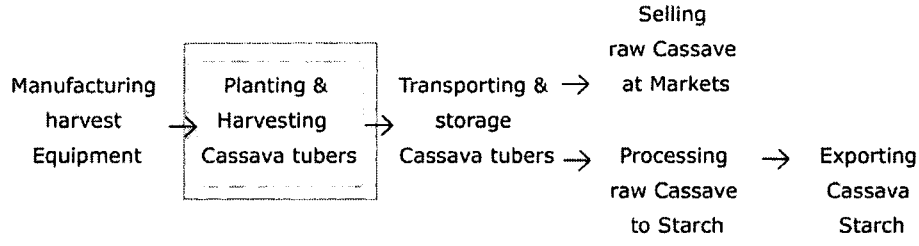

Head load & Storage


Selling at domestic market


Processing & Export

Chain

The most important party in the value chain for the Cassava Harvester are the village communities and or individual farmers at the rural level. The other parties in the value chain being at the end: the Cassava sellers, processors and exporters and at the beginning of the chain the equipment manufacturers and workshops, like village blacksmiths.



Organisational structures

The Ayensu Starch Company (ASCo) has established an innovative farmer-owner scheme, called the Co-operative Village Enterprises (COVE) scheme. Beside small-scale outgrowers farmers, the cassava is produced by company-owned and managed block/nucleus farms.

Tip: In the implementation phase of the cassava harvester, these farmer structures can be analysed and discussed more in detail, like by organising workshops in the regions.

IV.A.2. Problem definition of the current chain

The following bottlenecks have been identified in the current Cassava harvesting chain:

Selling & processing raw Cassava

- *Low harvest quantity*: To-date, the farmers are unable to harvest enough cassava and in the right time to meet the demands under the PSI, in particular of the Ayensu Starch Company (ASCo). The current manual harvest method takes relatively too much time.
- *Low harvest quality*: Currently ±8% of the tubers is spoiled before processing. This is partly due to the rough harvest process with the cutlass and the earth chisel and partly because of the relatively long waiting time in the sun for transport.

Transport & storage raw Cassava tubers

- *Heavy transport load*: Especially the farmer women are carrying the heavy Cassava tubers on their heads from the farm to the transport point.
- *Long storage in the sun*: At the side of the road, the tubers are waiting too long in the hot sun, so that damaged tubers will easily get rotten.

Planting & harvesting Cassava tubers

- *Heavy and difficult work*: To harvest the Cassava tubers out of the ground, the farmers have to bend many times and to apply much force.
- *Low farmer's income*: Because of selling low qualities, partly also at small prices, farmers have a relatively low income and therefore have difficulties to invest in good harvest equipment.

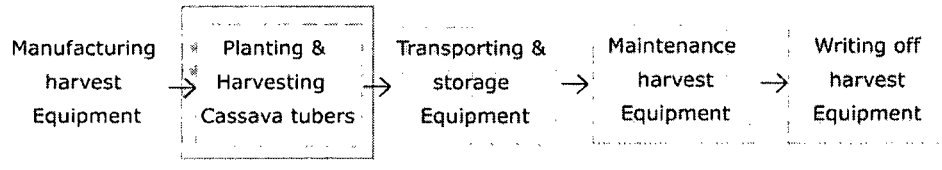
- *Small and non-organized farms*: Most farms are small and planted crowded with mixed crops. This makes it difficult or even impossible on short time to harvest with big machinery's, like with tractors as in other Cassava growing countries.

Manufacturing Cutlass & Earth Chisel

- *Simple technology*: Both the cutlass and the earth chisel are not made by modern production technologies, but by old basic methods with a simple construction and with common materials, even with scrap materials.
- *Low costs*: The prices of the tools are relatively low: the cutlass cost €3 and the Earth Chisel €5.
- *No uniformity*: All tools are different in size and shape, as they are made without standards and by many (small) manufacturers (black smiths).
- *Low quality*: The tools are some times damaged (bend), because they are used for long times and under heavy conditions.
- *Easy maintenance* : Every blacksmith can maintain the current tools easily, for instances sharpening the blade.

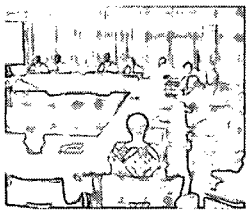
IV.A.3. Selected 'set of equipment' to (re) design

From the above description of the current problems in the Cassava chain, the main concern of the Ghanaian Government's (PSI) is the low quantity and quality of raw Cassava sold to ASCo, which is partly due to the high drudgery and low efficiency of the current manual Cassava harvesting. A new *Cassava Harvester* tool can therefore improve this situation.
Besides the above chain scheme, another chain can be made for only the harvester tool:



IV.A.4. Feed back from stakeholders

The project team has organised a workshop on 29 Oct 2003[5] to receive feed back from the stakeholders on the [AMIS] project and the case study. The invitee list, which is not totally focussed on the Cassava chain, is attached in Annex 8. Tip: a separate list with contact information can be made for the stakeholders purely in relation to the Cassava chain.



In the workshop also feed back was coming on the [AMIS] project. Main conclusions were that there is the need to:

- think about *new innovations*;
- train artisan on *manufacturing skills* through capacity building;
- *strengthen and enforce standards* for manufacturers to follow.

IV.A.5. Profitability current value chain

[5] The workshop was organized after the second field test, see also paragraph IV.C.3

Manufacturing cutlass and earth chisel

+ Tools can be made with simple techniques by every blacksmith;
+ Low material costs;
- Lack of standards results in poor quality.

Blacksmith: *"The cutlass tool is easy to manufacture and the scrap material is easy to get."*

Cassava harvesting with cutlass and earth chisel

+ Cheap handtools (5 euro);
+ Easy maintenance;
- High drudgery to pull the tubers out of the ground;
- Low efficiency, due to crop damages (15%) and low harvest quantity per day.

Farmer woman: *"The harvesting job is difficult. The bending has an effect on my waist. I have back pain."*

Selling Cassava on the domestic market

- Low profit;
- Dependency on traders;
- Low and irregular market prices and income;
- No re-investment in income generating activities.

Market woman: *"I don't know how much cassava I will sell for today"*

IV.A.6. Design goals for the new set of equipment

Overall goal

With the new Cassava Harvester the farmers, especially farmer women, will *improve their harvest efficiency and quality*, while the *drudgery reduces* and their *income increases*.

Technical goals

The new harvester needs to:

- *reduce harvest time* (efficiency), *handling activities and harvest power* (drudgery) for the farmer, especially for farmer women;
- be *produced* and *repaired* for by local *black smiths*;

- be manufactured with semi-standardized parts.

Economical goals

The new harvester needs to assist in:

- *increasing the farmer's income*;
- *increasing the export volume* of Cassava starch;
- *increasing the agricultural productivity*;
- *increasing the employment* of small-scale blacksmiths.

Organisational goals

- The new harvester needs to be developed in an integrated manner, considering the *stakeholders' opinions* of the current and the new harvest situation.
- The implementation of the new harvester in the chain needs to be *sustainable* and *accepted* by the existing organisational structures in the chain.

Tip: These goals can be quantified further by mentioning the goal quantities, like in %, which has to be achieved.

IV.A.7. Specifications for the new harvester

Based on the previous results, the criteria for the new design can be analysed. The criteria can be determined best by analysing the chain of the set of equipment on technical, economical and organisational aspects.

After formulating a detailed list of criteria, a short list can be made of the ± 5 most important requirements for the new set of equipment. In the explorative and concept development phase, the created solutions will be judged on these criteria, so that the most appropriate solution(s) can be selected.

Example of a detailed criteria list

Production (distribution and selling) of the Harvester:

- The cost price of the new harvester need to be minimized (max...€).
- The new harvester need to be fabricated with semi-standardized parts and materials, which are available in Ghana.
- The new harvester need to be fabricated with available machinery/technology of local black smiths, such as: welding, cutting..

Harvesting with the Harvester:

- The farmer needs to be able to buy the new harvester, with maximal costs of ...€ per year.
- The harvester needs to increase the harvest productivity to ... ton Cassava per acre per day.
- The harvester needs to pull the tuber out of the ground in maximal ....steps and maximal ... minutes with a minimal needed bending movements of the farmer (women).
- The harvester needs to be used manually.
- The harvester needs to be used in *dry and wet* soil.
- The harvester needs to be used for cassava stem with different sizes and shapes: minimal....mm and maximal ...mm.
- The harvester needs to be used by farmer women, with:
  - Maximal pull force ....N;
  - Maximal standing/pulling height ...cm from the ground;
  - Maximal hand gripping diameter of ...cm
- The harvester needs to reduce the damage on the tubers with ...%.

Transport and storage of the harvester:

- The harvester needs to be easily transported from the farm field to the farmhouse.
- The harvester needs to take minimal storage place in the farmhouse.

Maintenance of the harvester:

- The harvester needs to be maintenanced easily by local black smiths with available materials and parts against affordable costs (...€) per year for the farmer.

Organisational

- The harvester need to be implement smoothly and without complains in the chain.

Main specifications for the new Harvester

- The manufacturing cost need to be minimal;
- The harvest efficiency need to be maximal;
- The crop damages need to be minimal;
- The harvest handling need to be minimal;
- The tool weight needs to be minimal.

Main functions of the Harvester

- Lifting the tubers out of the ground;
- Fixing the stem of the cassava plant;
- (manual) Gripping by the farmer (women);
- Moving by the farmer(women);
- Transporting by the farmer(women).

IV.B. Explorative Phase

In the case study, the explorative phase has been performed parallel with the analysis phase. To explore possible solutions to harvest Cassava manually, the project team has focussed mostly on existing technical solutions in Ghana and in other Cassava countries. This research is done at and by institutes, internet search and a workshop with GRATIS.
In this workshop, the existed solutions were discussed on technical and production details.

In future, such a workshop can be used to explore also new or adapted solutions for in the country itself on a more structural way. This can lead to solutions with a bigger added value in the chain.
Also more registration and uniformity of names could have been made of all the solutions thought by the project team.

IV.B.1. Existing market solutions

The following existing market solutions for mechanical[6] and manual Cassava harvesting are found by internet, visits to and research studies at institutes and manufacturers.

In Ghana

Mechanical harvest equipment:

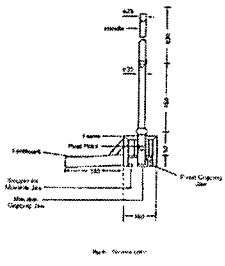
- There are no mechanical harvesters used on Cassava farms in Ghana.
- 2 models of Mechanical harvesters (tractor operated) are being contemplated for further developments in GRATIS and the Agricultural Engineering Department of the Kwame NKrumah University. Yet no tested data is available to confirm the performance of these harvesters. Both the models need redesign to make them lighter.

Manual harvest equipment:
At the GRATIS institute:

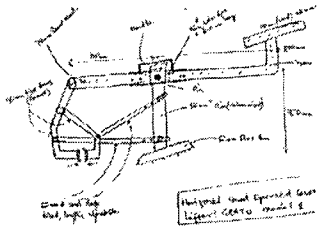
- A drawing of a *vertical pole model* with a gripper foot to harvest Cassava. This construction has been developed by the DAPIT institute, which is now GRATIS;
- A drawing of a *horizontal* hand operated Cassava lifter;
- A prototype of a *wooden pole* with V-notch gripper and a *chain* to wrap and lock the Cassava stem. This equipment is still used in Thailand.

At the ASCo factory:

- A *horizontal* harvest tool, which is used in Rubber Plantations for lifting the rubber stump, named the *GREL Model.*



Vertical pole (DAPIT)



Horizontal lifter

Pole with chain

Grel model (rubber)

Other Cassava countries

Mechanical harvest equipment:

[6] The choice for focussing on manual harvesting is made in the explorative phase.

- In Brazil different machinery is developed for Cassava farms to use for seed germination and for harvesting, both tractor driven. This harvesting machine primarily softens the ground around the cassava tubers and makes uprooting quite easy: *uprooting of the tubers is still done by hand.*

Manual harvest equipment:

- In Thailand Cassava is harvested manually with a *wooden pole with a chain* to grip the Cassava stem (source: Cassava and Starch Technology Research Unit).
- In Malaysia Cassava is harvested manually with a *wooden pole with a rope* to grip the Cassava stem (source: via GRATIS by internet search)

IV.B.2. Functional analysis sub solutions (Morphological Box)

The functions for the new Cassava harvester have been determined in phase A, see A.R6.

Function new Harvester	Sub Solutions			
	a	b	c	d
1.Lifting the tubers out of the ground	Push to you / pull away with a lever principle.	Push down with a pump principle.	Turning mechanic by a jack principle. (-time)	Turning hydraulic by a jack principle. (-costs)
2.Fixing stem with different thickness & shape	Teeth & V-nodge	Chain	Rope	
3.Gripping by the farmer	With the hand	On the waist	By the foot	
4.Moving by the farmer	By arm bending	By walking	By back bending	By knee bending

Results	Dapit type: a1,a2,a3,a4	Rubber type: ? b1,a1,a3,a4	Chain type: a1,b2,a3,a4	Rope type: a1,c2,a3,a4	Jack sample: d1,a2,a3,d4

Tip: More functional solutions and combinations can be added and clarify with simple drawings.

IV.B.3. Technical solutions.

See paragraph IV.C.3 for the technical aspects of the retrieved solutions in this case study.
Tip: Simple sketches of the first solutions with short and rough comments on usage (handling), material, dimensions and costs can be useful for intermediate translation of the development activities to externals involved.

IV.B.4. Organisational & financial structures (schemes)

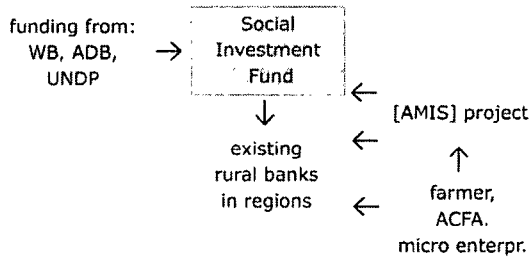
The following organisational and financial structures have been explored:

Model a: Funding via the Social Investment Fund (SIF)

The Farmer /ACFA approaches SIF with a linkage from the [AMIS] project for a loan to invest in the harvesters. SIF can lend money with the following conditions:

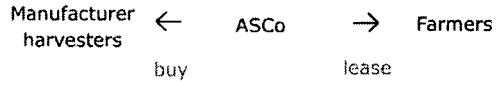
- The SIF can lend up to maximum of 4 million cedis per farmer or micro entrepreneur and 40 million cedis to a group of 10 entrepreneurs (like ACFA). Other groups, that are not supplying to ASCo but to the open market, could be facilitated by AMIS similar to the REDS (Rural enterprises Development Support) project's group networks.
- Interest rate at 36% per annum and repayment period of 1 year.

- Loan could be given to a rural entrepreneur to make the harvesters and to the farmers to buy the harvesters from the rural micro-entrepreneur.



Model b: Funding via ASCo

Since ASCO interest is to feed their starch plant with higher quantities of cassava and so in the use of the Cassava Harvester, a financial structure can be proposed to ASCo, that ASCo buys and leases the harvesters to their farmers.



This model will also be suitable for their out-grower farms, yet it will need further discussion with PSI and ASCo.

IV.B.5. Selection of appropriate solutions

Technical solutions

Farmers, Field test (1): To select the most appropriate solutions to detail further in the next phase, first a small test on 16 September 2003 has been performed on a ASCo farm with the solutions that were available in a working model: the *wooden chain type* and the *horizontal rubber lifter*.

The following results came out of this small test:

- The horizontal rubber lifter takes too much space at the farm ground and the Cassava tubers could not be lifted out of the ground.
- The wooden chain type showed cracks in the wood and the pole dimensions can be shorter and thinner for the Ghanaian farmer (women).

With this outcome and the technical know how of the Ghanaian project team, the following judgement has been made roughly on the main specifications:

Restriction	Mechanic harvester (tractor)	Pole with chain (Thailand)	Pole with rope	Pole with gripper (DAPIT)	Horizontal tool (rubber)	Jack principle
Expected cost	high	low	low	low	low	High (hydraulic)
Expected Harvest time	Long: manual harvesting	short	short	short	long	Long: turn (mechanic)
Others		- Wooden pool was too weak			Wide area around stem	
Selection	-	+	+	+	-	-

With the above judgement a first selection has been made to develop the following technical solutions in the next phase:

- The Vertical pole with a gripping nodge (DAPIT type)
- The Rope type (based on the tool used in Malaysia)
- The Chain type (based on the tool used in Thailand)

Note: As there are many small farms in Ghana, the project team will focus on the development of a manual harvester for on short term. Mechanic harvesters might be of interest only on long term, like 5-8 year, on co-operative farms.

Organisational & financial structures

From the proposed structures, the project team has seen more interest in model a, *funding via a financial institute*.

IV.C. Concept Development Phase

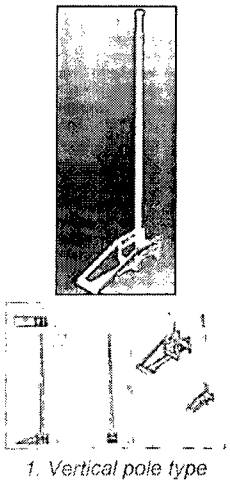
In this phase, the project team has got assistance from the GRATIS institute to develop the 3 harvester types further and to make prototypes for testing activities. The adaptations that are made on the constructions were based on the results from tests with farmers and on the know-how from the institute itself.

For the main field tests in November 2003, the project team (and test consultants) could have received more support from GRATIS to set up the test parameters and to explain the working of the Harvester types to the farmers.
During the test, it seemed that the test conditions were not sufficient, constructions were still over-dimensioned and that the function of some parts was not completely clear. Directly after the test, the optimization of the constructions has only taken place for the Vertical pole type, before any selection took place yet.

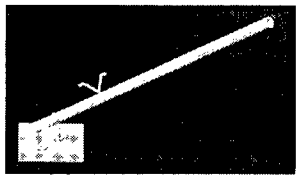
In the concept development phase more attention has been given to the technical aspects then to the organisational and financial aspects.

IV.C.1. Technical development of the selected solutions

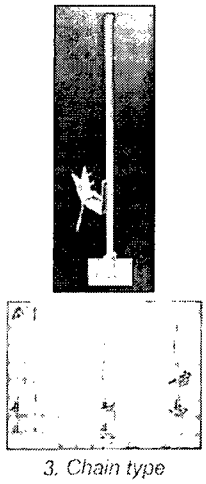
The 3 selected technical solutions -vertical pole, rope pole and chain pole- have been constructed further by GRATIS on dimensions, material use and production, see the following computer drawings:



1. Vertical pole type



2. Rope type



3. Chain type

Tip: A clear overview of the technical aspects of the developed concepts will be useful to present and evaluate the differences with others involved on aspects such as: material type, main dimensions, manufacturing plan, usage (drawing) and maintenance. See the underneath example for a table format.

Technical aspects	Vertical pole type	Rope type	Chain type
Dimensions			
Weight			
Material type			
(spare) parts (import)			
Manufacture actions			

Usage actions			
Maintenance			

Material & Spare parts: All concepts will be fabricated basically out of *steel*, whereof the poles and the other used construction parts are all standard available in Ghana.

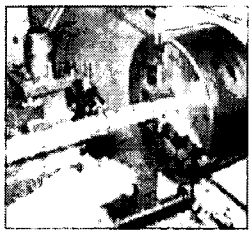
Manufacture actions: The manufacturing actions can be specified / indicated with the needed production time. This information is also needed to make calculations of the production costs. In general the three concepts can be manufactured with machinery techniques as well as with the common mechanical techniques of the black smiths. Tip: Both these manufacturing processes (by machinery and by black smith) can be specified more in detail in the follow-up.

Usage actions: With simple drawings and/or comments the usage actions can be presented in the sequence of the harvesting process. Like carrying the harvester from the house to the field, fixing the harvester around the cassava stem, pulling the tuber out of the ground, removing the harvester from the stem, carrying the harvester back to the house and storage of the harvester.
To carry the harvester, the vertical pole type is the most heaviest tool of the three types. Yet for fixing and remove the 'rope'type and the 'chain'type from the stem, the farmer still has to bend. These handling aspects are taken into account in the field tests.

Maintenance actions: While developing the constructions, an analysis need to be made of the weak points during the expected usage actions by the farmer. The expected weak points can be clarified and discussed further during the field tests. Like during the field test, the pole of the 'chain'type was bending around the chain construction. If this type will be selected, this expected damage need to be solved with the design engineers and black smiths. Further, all types can be manufactured and therefore also maintenanced by the local black smiths. Especially the most complex constructions, the 'vertical pole' type and the 'chain' type have been discussed with them. They can assemble the tools, yet they foresee difficulties with pre-advance payment to buy the relatively expensive parts.

IV.C.2. Manufacturing models of concepts

After the technical drawings, GRATIS had manufactured 36 new tools to use for testing activities, as the project team planned to test the 3 types in 12 different regions.



IV.C.3. Feed back from the Chain

See also the comments of the chain in paragraph IV.C.5

Farmers: Field test (2)

On 24 September 2003 (*rain season*), a small test has been performed on an ASCo farm with a model of each of the 3 construction types: the Vertical pole type, the Chain Type and the Rope type. During this test, also the press was present to promote these development activities under the PSI.

The farmers were positive of the results from all 3 harvesters, there are all better to handle than the current manual activities. Yet the Vertical pole type could be smaller in dimensions and the gripper needs to be stronger.

Stakeholders workshop

During the stakeholders workshop on 29 Oct 2003, the models were presented and shortly discussed. Some recommendations were made on the dimensions, such as to reduce the length and the thickness of the poles. These recommendations are taken into account during the production of the prototypes.

Farmers: Field test (3)

During November 2003 (*rain season*), the 12 sets of the manufactured prototypes were tested on different farms, which are related to ASCo. The project team had asked assistance from 2 technical test consultants.

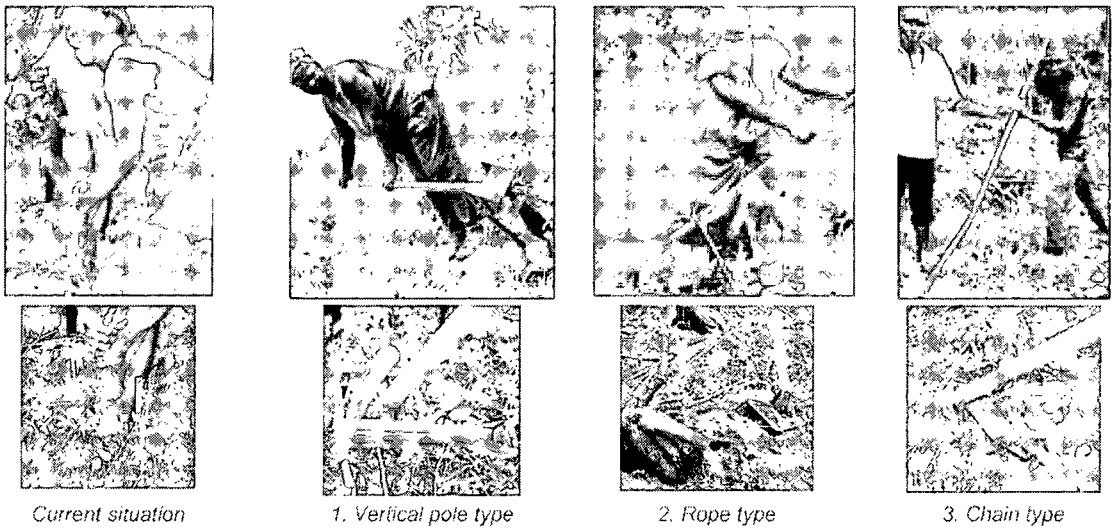
At each of the 12 selected farms, the new and current harvest tools were used several times for *15 minutes* by *farmer men*, as well as by *farmer women*.

The following parameters were measured for each of the 3 new tools, as well as for the harvesting with the current tools:

- Harvesting time;
- Losses: the tubers that are still kept in the ground;
- Damages on tuber after pulling out of the ground.

Besides this the test persons were interviewed afterwards to receive their comments on:

- How they will store the new tools;
- How many acres the farm has;
- How many hours per day they harvest in general.



Current situation *1. Vertical pole type* *2. Rope type* *3. Chain type*

Test results

In general the tests have proven that with a new harvester tool, the farmer can produce 20% more in the same working hours under less strenuous conditions.

From the 3 types, the Chain type was less favourable, as the handling time takes long to lock the chain around the stem. Besides the gripper glide easy away from the stem.

The feet *platform*, fixed on the Rope type as well as the Chain type, seemed to have less functionality. The farmers were confused about the rotating and position of the platform to the stem and were not standing on the platform during the pushing activity.
During the test at 2 area's, the platform was therefore removed from the Rope type to determine the working of it. Yet in the dry season, the Rope type could still function without platform.

See the test reports of the test consultants for the quantified results.

Test results	Vertical pole type	Rope type	Chain type	Current tools
Harvest time	%	%	%	%
Losses (ground)	%	%	%	%
Damaged tubers	%	%	%	%
Comments				

Test recommendations

- As all the test were performed in the *rain season* with soft ground, it will be necessary to test all 3 types again around March in the *dry season* with more tough ground.
- The 15 minutes testing time per each model was not representative for one day harvesting time in the normal situation. The test time need to be increased, if possible to 4 –to 8 hours.
- The training and introduction time with the new tools in one day is not representative to compare with the traditional daily use with the current harvesting tools.

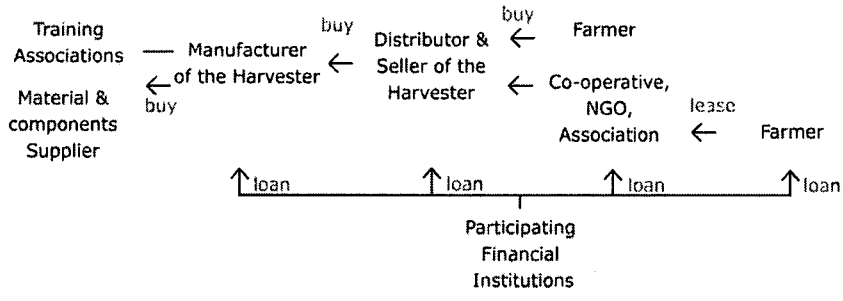
IV.C.4. Economical and Organisational structures

In general, the new harvesters will help to increase the farmer's income by an increase of the harvest efficiency up to 20%, as shown by the first tests results. Yet the production costs of the new harvester types will be more expensive as the current tool:

Costs	Vertical pole type	Rope type	Chain type	Current tools
Production cost	13 euro	11 euro	12 euro	5 euro

Although it is expected that the extra revenues in the same harvest time will level these extra costs, the pre-payment of the more expensive tools by the farmer and/or local seller/black smith need to be made possible by the economical and organisational structures.

The explored model to finance the harvesters by financial institutes, as described in B.R4, is further finalised with the project team to the following scheme:



With this construction the farmers can lease the harvester tools from an intermediate organization, thus substantially reducing their financial risks, specially where micro credit schemes are less available.

IV.C.5. Profitability value chain with a new Harvester

Manufacturing newly developed harvest tools

+ Increase of product quality;
+ Economics of scale by standardization of the newly developed harvester;
+ Increase of profit margin;
- Increase of material costs.

Blacksmith: *"I could make the harvester, but I will also need training and capital to buy the material"*

Harvesting with the new tool

+ Less drudgery;
+ Increase of harvest and income with approx.20%;
+ Crop damage reduction with one third;
+ More savings and re-investment potential;
+ Decreased operating / exploitation cost;
- Increase of the investment costs to 12 euro;
+ Harvester can be leased.

Farmer woman: *"Now it is so easy to uproot the cassava out of the ground. I can do more and better work with the harvester."*

Processing & Export Cassava starch (ASCo)

+ Guarantee of a stable market for the farmers;
+ Increase supply and quality of raw Cassava from the farms;
+ Expected Increase of capacity utilization and export value with an estimated 20%.

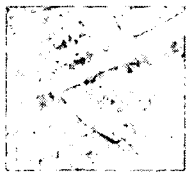
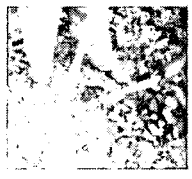
ASCo: *"The harvester helps to bring in more cassava, so the plant can run and export more. This helps reducing poverty in our area."*

Tip: If even more specified economical data can be retrieved of the current and new situation, the comparison will be more valuable.

IV.C.6. Selection most appropriate solution(s)

Together with GRATIS and the test consultants, the project team has discussed the performances of the 3 Harvester types compared with the current tools on the main specifications.

In the next overview the + mark indicates a positive judgement, and the – mark a negative judgement.

Judgement aspects	Concept 1 'Vertical pole' type	Concept 2 'Rope' type	Concept 3 'Chain' type	Current Tool 'Earth Chisel'
					
Manufacturing costs	- - - 13 euro	- 11 euro	- - 12 euro	+ 5 euro
Harvest efficiency	+++ 2 ton /4hr	++ 1,9 ton /4hr	+ 1,6 ton /4hr	- 1,5 ton /4hr
Crop damages	++ 13 %	+++ 10 %	+ 14 %	- 15 %
Harvest handling	+++ no bending	+ part bending	+ part bending	- bending
Tool weight	- 7 > 4 kg	- - 5 kg	- - - 8 kg	+ 3 kg
Farmer judgement	++ Nov '03	+++ Nov '03	+ Nov '03	- Nov '03
Total judgement	**+ 6**	**+ 6**	**- 1**	**- 2**
Comments	*Continue testing in dry season (March) & optimalization Vertical pole and Rope type*			

In the optimization phase the *Vertical pole type* and the *Rope type* need to be optimized and tested further, before the final selection can be made for the most appropriate solution.

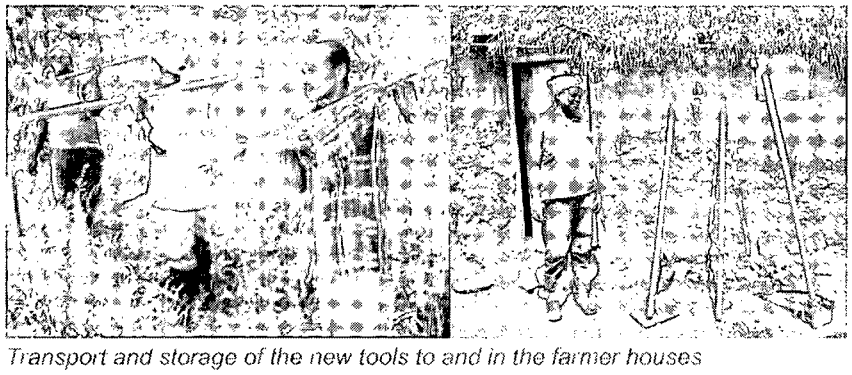
And beside the technical feasibility, the *economical* and *organisational effects* of the different harvester types in the chain need to be researched and discussed further before the selection can take place.

IV.D. Optimization Phase

Technical aspects

To make the new cassava harvester easily accessible for the farmer and can be manufactured and maintained by the local artisans, the following recommendations can be taken into consideration:

- The dimensions of the pole can be reduced in length and thickness to improve handling activities during harvest and for the storage of the tools in the farmer house;
- The tool weight needs to be reduced to improve handling activities during harvest and transport of the tool to the farmer houses.
- The material of the pole can be perhaps replaced by wood;
- The foot platform of the Rope type can be reduced in dimensions or even deleted. Besides, the turning facility can be perhaps removed, as it is confusing for the functionality and position of the tool to the Cassava stem.
- The construction of the fixing foot platform of the 'vertical' pole type need to be reduced in complexity and material use.
- The performances of the adjusted constructions need to be tested in the dry season with tougher soil conditions and for a longer usage period.



Transport and storage of the new tools to and in the farmer houses

Financial & organizational aspects

To make the new cassava harvester affordable in investment and exploitation terms for the farmer, the following recommendations can be taken into consideration in this phase:

- The relatively high costs for both the 'vertical pole' type as well as the 'rope' type need to be reduced as much as possible by adjustment of the constructions and material use, like mentioned above in the technical recommendations.
- More discussion and research can be taken place with the chain and existed farmergroups to develop the organisational and financial structure to implement a new harvester tool.
- Also a more detailed cost and revenue analysis can be made of the 3 different types based on the results from the next test.
- In this phase, after selecting the most appropriate harvester tool to the specifications, attention can be placed to set-up a concept business plan and training programmes to implement the new equipment in the chain. Besides acquisitions steps can be taken to explore the possibilities for financial support.

IV.E. Implementing Phase

To implement the new cassava harvester in the chain the following development activities are proposed, see also paragraph III.B.:

Final determination activities

- Final determination of the construction details of the selected harvester type for mass production in close co-operation with the chain, like: suppliers, manufactures, distributors, users and black smiths.
- Selection of the most appropriate manufacturer and supplier of parts for the new harvester;
- Final determination of a business plan to implement the new harvester on short and long term and acquisition to financial means to implement the new harvester in the chain.
- Setting-up an organisational flow chart and training programmes for the implementation of the new set of equipment in the chain;
- (if necessary) final testing of the optimized construction.
- Organisation of a stakeholders meeting to finalize the implementation aspects of the new harvester in the chain
- Go/no-Go decision for implementation of the new harvester.

Implementation of the harvester in the chain

- Organisation of an introduction event and training sessions for the chain to implement the new cassava harvester;
- (Mass) Production of the new set harvester by the selected manufacturer and the supply of needed parts by the selected suppliers.
- Promotional campaign to introduce the new harvester to the farmers in the regions and elsewhere in Ghana.
- Training sessions can be held in the chain and region/communities for the specific implementation aspects per actor.
- The new harvester will be sold, distributed, used and maintenanced in the chain.

Adjustments of the new harvester

- Evaluation with the stakeholders of the performances of the new harvester in the chain after a certain period on technical, economical and organisational aspects;
- If needed, possible adjustments of the technical, economical and organisational aspects of the new harvester can take place.

V. CONCLUSIONS DESIGN METHODOLOGY CASE STUDY

After the description of the proposed integral design and development methodology and the development activities in the case study for a Cassava Harvester, the following conclusions can be drawn related to the design process of the case study:

+ The process is performed on an integral way, taking the opinion of the stake holders in consideration during the different development phases.
+ The project team has explored in a short time span, a wide range of harvesting solutions (mechanic and manual) in Ghana and other Cassava growing countries.
+ All the three developed and tested Harvester types proved improvements on the harvest efficiency while the drudgery for the farmer (women) reduced.
+ During the project promotional activities enlarged the awareness in Ghana how the current Cassava harvest can be improved with (new) developed equipment.
+ The GRATIS institute supplied the project with good technical skills to develop and manufacture harvest equipment with good quality.

- The design goals and specifications could be analysed and reported more clearly in the analysis phase. If in a later phase other goals or specifications come along, the design might be not optimal anymore and the process needs to be done again.
- The development activities and results could be reported more clear to assist other persons involved in the process and to evaluate the project in a later phase.
- The project terms and the concept names for the developed equipment and (financial /organisational) structures were not used consistent. This leads to confusion.
- The preferences and adjustments of the harvester concepts by GRATIS could be influenced by their interest to produce the designed equipment themselves.
- Most focus is put to the technical feasibility of the solutions. As the economical and organisational feasibility for the implementation of a new harvester is not clear yet, solutions and structures might need to be optimized or developed again.

VI. RECOMMENDATIONS FOR FUTURE DESIGN PROCESSES IN [AMIS]

To design and develop a new set of equipment in the future within [AMIS], the following recommendations can be taken into consideration:

- Design goals and specifications should be formulated in close consultation with relevant stakeholders in the first project phase.
- Clear registration of the development activities and (intermediate) results for new persons involved and for the evaluation of the project results.
- Consistent use of project terms and concept names for the developed equipment and financial/organisational structures.
- Integrate and discuss the economical and organisational influence of the technical solutions in every process phase with stakeholders and experts.
- Assistance of an independent organisation or person to co-ordinate the design and development process for the technical, as well the organisational and economical issues.
- Training of the development methodology by an expertised organisation to the organisations involved with (the co-ordination of the) follow-up development activities in [AMIS].
- Besides the availability of the technology and manufacture skills in GRATIS, the institute can eventually be upgraded with development methodology skills to design a sustainable new set of equipment with added value the chain.
- Involvement of the (traditional) organisational structures in the selected chain, regions and communities for sustainable implementation of the new set of equipment.
- Besides the development of a Cassava harvester, [AMIS] can put attention to other aspects in the Cassava chain, like the improvement of the transportation and the intermediate storage of the Cassava from the farms to the factory or domestic markets.

ANNEXES WITH THE REPORT:

CONSULT ON RURAL AGRO-MACHINERY DESIGN AND ENGINEERING METHODOLOGY

NC/GHA/02/016/11-02

Ghana

TABLE OF CONTENTS

ANNEX 1: JOB DESCRIPTION

NC/GHA/02/016/11-02

Post title:	International Consultant on rural agro-machinery design and engineering methodology.
Expected start:	01 November 2003
Duration:	0.8 w/m (over period of three months)
Duty station:	Accra Ghana

Purpose of the project:
The current project is the first explorative and definition phase of an effort focused on supporting the national equipment manufacturing industry and the local welders and blacksmiths through upgrading support institutions, based on introduction of a specific series of semi-standardized economically feasible sets of equipment that should contribute to the national objectives and President's Special Initiatives for agro produce. The approach of the final project is a systemic one following the UNIDO model on Agricultural Machinery Industrial Systems, which analyses all actors relevant to agricultural productivity improvement through mechanization.

Duties:
The broad duties will be for the Consultant to specifically assess the situation in relation to the farmer's manual harvesting of cassava in large quantities and acreage, specifically, identify the drudgery associated with manual cassava harvesting in the rural areas with emphasis on those producing in the framework of the President's Special Initiative (PSI) program. The consultant will recommend a cassava harvester that is affordable in investment and exploitation terms for the farmers, easily accessible and can be manufactured and maintained by the local artisans within the farming communities.
Equally the consultant will present the cassava harvester development process as a development model for other types of equipments. Further he/she will present the development approach in a wider framework of engineering sector support, incorporating concepts as value chain building, and supporting de-facto standardization, and he/she will draw conclusions for further use in a project concept for phase II of the project.

The consultant is expected to carry out the duties in close collaboration with the international and national consultants and counterpart staff, as well as national and local authorities, and in close co-ordination with the staff of the UNIDO office in Accra and other relevant UN organizations, under the general guidance of UNIDO HQ staff. The activities in this assignment will include but not be limited to:

1. Based on available information, structure the redesign process of a cassava harvester, as a general model for approaching redesign processes of PSI related equipment for local production, repair and maintenance. Specifically highlight in the model the relevance of the different actors in the value chain in which the harvester is placed. Assure that due attention is given to a baseline study of current practices, with adequate analysis of product development information from different actors point of view. Record improvements from stake holder's point of view after redesign and prototyping.
2. Specifically present the influence and relevance of commercial viability of all elements of the value chain. Make recommendations in case special governmental policies will be required to facilitate such, for instance in the field of raw material imports or credit/leasing schemes.
3. Advice on the intervention logic and concepts of the follow-up phase of the project that would include redevelopment of other equipments, and capacity building for design and industry support.

4. Co-ordinate the presentation of the project methodology, its logic and its linkages with the value chain building, for UNIDO's GC and in for Ghana represented donor entities. This would cover leaflets, prototypes, photo's, reports, and if feasible video presentation.
5. Assess the capabilities of GRATIS to act as prototype developer and equipment manufacturing trainer, and advise on capacity upgrading of GRATIS if required.
6. Assess implications for mass production of harvester with private sector entities including SUAME in Kumasi.
7. Prepare a final Report.

ANNEX 2: PEOPLE INVOLVED IN THE PROJECT

FUNCTION	NAME	ORGANISATION	CONTACT details
International Project Manager Agro-Industries and Sectorial Support Branch	Mr. Evert Kok	UNIDO, Vienna	e.kok@unido.org +43 1 26026 4570
Assistant to Evert Kok	Ms. Isabella Gindler	UNIDO, Vienna	i.gindler@unido.org
UNIDO representative (UR)	Mr. Akmel Akpa	UNIDO, Ghana	a.akpa@unido.org +233 21 782537
National Programme Coordinator	Mr. Solomon Boateng	UNIDO, Ghana	Unidoopso@ghana.com +233 21 785034
National Project Manager	Mr. Daniel Baffour-Awuah	UNIDO, Ghana	danbaff@hotmail.com +233 20 2013000
UR assistant	Ms. Lydia Gyasi-Denteh	UNIDO, Ghana	lydia.gyasi-denteh@undp.org +233 21 782537/38
International Consultant / buli 11-01	Mr.S.Vasantha Kumar	UNIDO	Svkumar1@vsnl.com +91 080 6622405
International Consultant/ buli 11-02	Ms. Carmen van der Vecht	KIEM *Sustainable Innovations*	c.vandervecht@kiem.nl +31 20 6385678
National Consultant/ buli17/02	Mr.Alexander Twum		
Co-ordinator starch project	Mr. Osei Owusu-Agyeman	PSI	psighana@africaonline.com.gh +233 20 2012005
Managing director	Mr. Andrew E. Quayson	Ayensu Starch Co	+233 21767907
Production Manager	Mr. Silva Lumor	Ayensu Starch Co	+233 218159238
Co-ordinator Farming	Mr. Boateng	Ayensu Starch Co	+233 218159238
Executive Director	Mr. Sheini Abu-Bakar	GRATIS Foundation	Gratis@ghana.com +233 22 204243 +233 22 8118233
Project Manager	Mr. Seth.K Dotse	GRATIS Foundation	+233 22 207610
Test Consultant	Mr. Daniel Kwame Numo Ms. Lian		+233 24712181 +233 24321892
PR Co-ordinator -Video -Photographer -Sound -Graphics	Mr. Ebenezer Ampaabeng -John; -Eugene; - Dominique; -Ruben		+233 27 7415306 +233 24 950430
Printing brochure		Graphic Color ltd	near Airside Hotel
Printing posters	Fouad w. nassar	Ro-Marong grafix	+233 21 778477

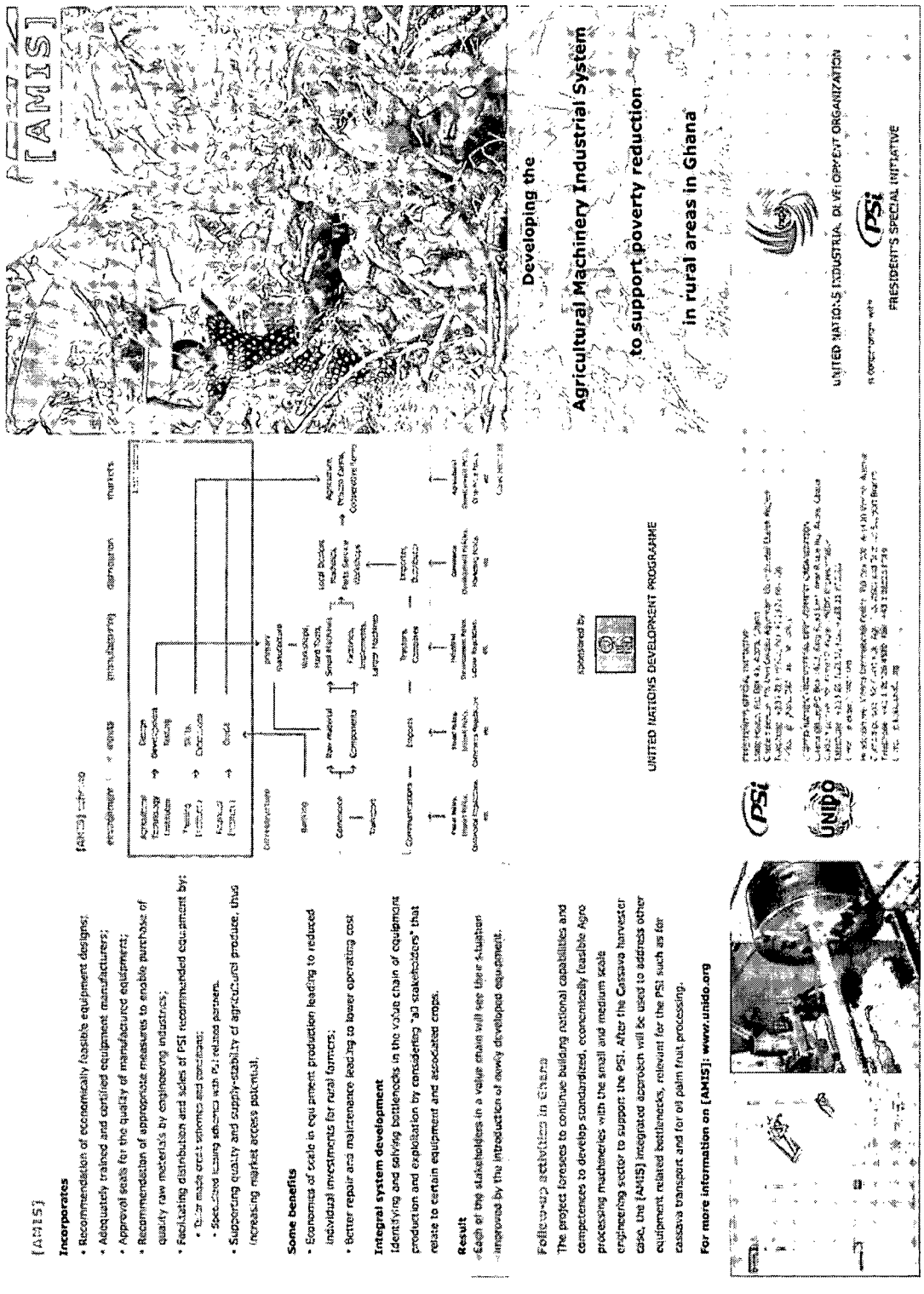
ANNEX 3: MEETINGS

DATE	PLACE	PARTICIPANTS	TOPIC
3 Nov 2003	UNIDO office, Accra	Mr. Daniel Baffour-Awuah, UNIDO Mr.S.Vasantha Kumar, UNIDO	Job Description & Coming activities
4 Nov 2003	Ayensu Starch Company	Mr. Daniel Baffour-Awuah, UNIDO Mr.S.Vasantha Kumar, UNIDO Mr. Boateng, ASCo Mr. Silva Lumor, ASCo	Introduction processing & farming activities; Discussion Test parameters; Field trip current situation
5 Nov 2003	Ayensu Starch Company	Mr. Boateng, ASCo	Field trip and first Testing with the 3 harvester types
6 Nov 2003	UNIDO office, Accra	Mr. Akmel Akpa, UNIDO Mr. Daniel Baffour-Awuah, UNIDO Mr.S.Vasantha Kumar, UNIDO Mr. Ebenezer Ampaabeng	Discussion Activities General Conference, Economical and Organisational structures
7 Nov 2003	GRATIS	Mr. Daniel Baffour-Awuah, UNIDO Mr.S.Vasantha Kumar, UNIDO Mr. Ebenezer Ampaabeng & film crew	Introduction Designs Discussion Designs Shooting of video & pictures
9 Nov 2003	GRATIS	Mr. Daniel Baffour-Awuah, UNIDO Mr.S.Vasantha Kumar, UNIDO Mr. Sheini Abu-Bakar, GRATIS Mr. Seth.K Dotse, GRATIS	Judging and selection of the developed and tested harvester designs
10 Nov 2003	Ayensu Starch Company	Mr. Daniel Baffour-Awuah, UNIDO Mr.S.Vasantha Kumar, UNIDO Mr. Boateng, ASCo Mr. Silva Lumor, ASCo Mr. Ebenezer Ampaabeng & film crew	Processing & export effects with new harvester designs; Discussions with Black Smiths new designs; Shooting of video & pictures
12 Nov 2003	UNIDO office, Accra	Mr. Akmel Akpa, UNIDO Mr. Solomon Boateng, UNIDO Mr. Daniel Baffour-Awuah, UNIDO Mr.S.Vasantha Kumar, UNIDO	Design discussions; Activities General Conference;
13 Nov 2003	Ayensu Starch Company	Mr. Daniel Baffour-Awuah, UNIDO Mr.S.Vasantha Kumar, UNIDO Mr. Ebenezer Ampaabeng & film crew	Discussion Test & constructions Discussions with Black Smiths Shooting of video & pictures
17 Nov 2003	UNIDO office, Accra	Mr. Akmel Akpa, UNIDO Mr. Daniel Baffour-Awuah, UNIDO	Discussions Brochure & GC; Econ & org. structures
17 Nov 2003	PSI	Mr. Osei Owusu-Agyeman, PSI Mr. Ebenezer Ampaabeng & film crew	Information PSI Shooting of video & pictures
19 Nov 2003	UNIDO office	Mr. Daniel Baffour-Awuah, UNIDO Mr.S.Vasantha Kumar, UNIDO Mr. Daniel Kwame Numo, Testconsultant	Test evaluation, Shooting of video & pictures
23 Nov 2003	Film studio	Mr. Ebenezer Ampaabeng	Discussion Video montage
24 Nov 2003	UNIDO office, Various printing locations	Mr. Akmel Akpa, UNIDO Mr. Daniel Baffour-Awuah, UNIDO Mr.S.Vasantha Kumar, UNIDO Mr. Ebenezer Ampaabeng	Discussion printing of the brochure and posters; Activities for presentation at Industrial day (Trade Fair) Printing preparation brochure
25 Nov 2003	UNIDO office, Accra Printing locations	Mr. Daniel Baffour-Awuah, UNIDO Mr.S.Vasantha Kumar, UNIDO	Activities for presentation at Industrial day (Trade Fair) & Printing preparation brochures
26 Nov 2003	UNIDO office, Accra	Mr. Daniel Baffour-Awuah, UNIDO Mr.S.Vasantha Kumar, UNIDO	Activities for presentation at Industrial day (Trade Fair)

27 Nov 2003	Trade fair, Accra	Project team UNIDO, GRATIS, ASCo	Presentation AMIS, Case study and harvester types
28 Nov 2003	Various printing locations, Hotel Chez Lien, Osu	Mr.S.Vasantha Kumar, UNIDO	Printing brochures, posters, Folding brochures
9 Jan 2004	UNIDO office, Accra	Ms. Lydia Gyasi-Denteh, UNIDO	Pass on assignment information & Contacts

ANNEX 4: BROCHURE & POSTERS

Brochure - outside



Poverty reduction in Ghana

In Ghana, which has a predominantly agricultural economy, the government stimulates income generation to reduce rural poverty. Important approaches are reflected in the Ghana Poverty Reduction Strategy (GPRS) 2002 – 2004 and the President's Special Initiatives (PSI) on cassava starch and oil palm, which are sector development programmes to boost production and export.

Income generation depends often on equipment, mostly for agro-processing and rural transport. Unfortunately in general, available equipment is of poor quality, limited affordability, and it regularly hampers or even blocks the rural income generation programmes due to frequent breakdowns. To improve the situation, the government of Ghana approached UNIDO for assistance.

Developing the
Agricultural Mechanization Initiative Systems (AMIS)

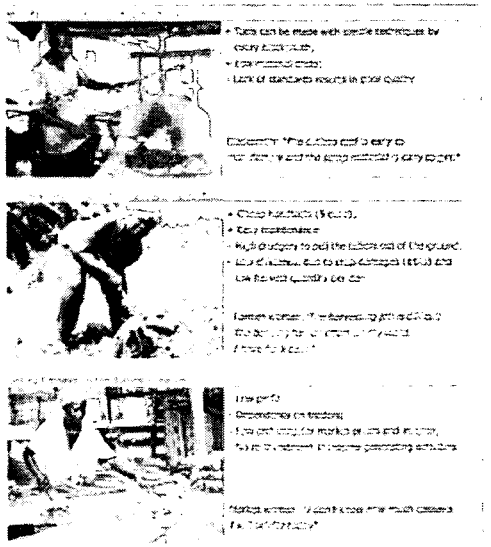
The [AMIS] project supports the national equipment manufacturing industry, the local blacksmiths, and their respective associations through upgrading support institutions with capacities to introduce sets of equipment that are semi-standardized, economically feasible and are contributing to the national objectives for agro produce. [AMIS] suggests a set of integrated measures to be taken in coordination with the PSI to achieve economies of scale in manufacturing, thus reducing investment costs to farmers and supporting de-facto equipment standardization.

A precondition for investment in equipment by the rural population is the existence of effective linkages of farmers with their markets. The PSI provides these linkages, specifically with the export market. Consequently, rural farmers become a sustainable market for better quality equipment from manufacturing industry and local blacksmiths. [AMIS] connects all stakeholders in a value chain. As a result, each of the stakeholders will see their business improved by the introduction and exploitation of newly developed equipment.

Case study: Development of a Cassava Harvester

UNIDO has performed a case study of cassava harvesting in Ghana. To-date, farmers, of which 45% women, are unable to harvest enough cassava and in the right time to meet the demands under the PSI, in particular of the Avensu Starch Company (ASCo), a cassava starch producing company for export.
To reduce harvest time and drudgery, especially for farmer women, a new manual harvester is developed in an integrated manner, considering the stakeholders' opinions of the current and the new harvest situation.

Current Cassava chain

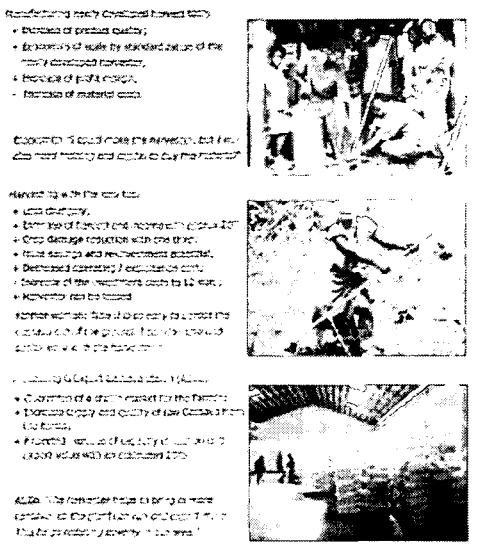


Development of 3 Cassava harvester types

Improvements through a new Cassava harvesting tool

Tests have indicated that with a new harvester tool, the farmer can produce an estimated 20% more in the same working hours under less strenuous conditions.The new harvester will help to increase the farmer's income, especially that of women, which are foreseen to constitute 50% of the PSI participating farmers in 2005.
Together with equipment cost reduction, the project also explores financial constructions in which the farmers can lease tools from an intermediate organization, thus substantially reducing their financial risks, especially where micro credit schemes are less applicable.

New value chain by harvester end (export) market



Financial structure

Poster [AMIS]

Developing the Agricultural Machinery Industrial System to support poverty reduction in rural areas

[AMIS]

Poverty reduction in Ghana

Ghana has a predominantly agricultural economy and the government stimulates income generation to reduce rural poverty. Important approaches are reflected in the *"Ghana Poverty Reduction Strategy"* (GPRS) and the *"President's Special Initiatives"* (PSI) on Cassava Starch and Oil Palm; programmes that are designed to boost production and export.

Income generation depends often on equipment, mostly for agro-processing and rural transport. Unfortunately, available equipment is mostly of poor quality, limited affordability and can hamper the programmes. UNIDO assists the government to improve this situation.

The [AMIS] project

- Supports the manufacturing industry, the local blacksmiths and their associations through upgrading support institutions to introduce sets of equipment that are: *Standardized, economically feasible and contributing to the national objectives;*
- Achieves economies of scale: *Reducing cost and supporting de-facto equipment standardization;*
- Facilitates investments in equipment by the rural population by providing linkages with their markets: *Rural farmers become a sustainable market for better quality equipment.*

Incorporates

- Recommendation of economically feasible equipment designs;
- Adequately trained and certified equipment manufacturers;
- Approval seals for the quality of manufactured equipment;
- Recommendation of appropriate measures to enable purchase of quality raw materials by engineering industries;
- Facilitating distribution and sales of PSI recommended equipment by:
  - Tailor made credit schemes or leasing;
  - Specialized trading schemes with PSI farmers primary;
- Supporting quality and supply stability of agricultural produce, thus increasing market access potential.

Some benefits

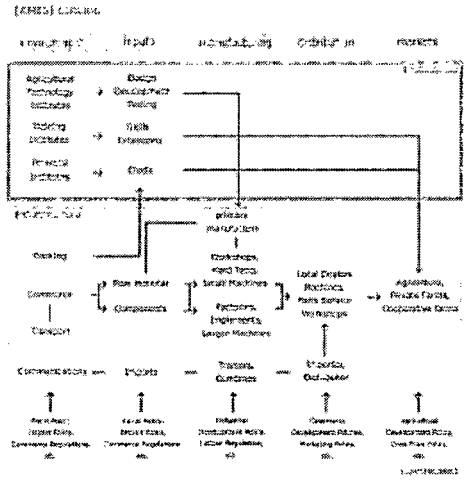
- Economies of scale in equipment production leading to reduced individual investments for rural farmers;
- Better repair and maintenance leading to lower operating cost.

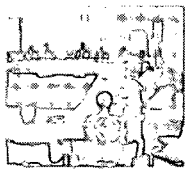
Integral system development

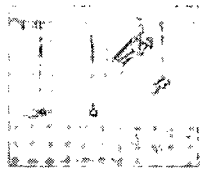
Identifying and solving bottlenecks in the value chain of equipment production and exploitation by considering "all stakeholders" that relate to certain equipment and associated crops

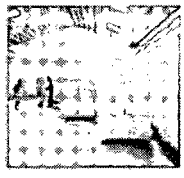
Result

Each of the stakeholder in a value chain will see their situation improved by the introduction of newly developed equipment.









For more information on [AMIS]: www.unido.org

Poster Case study Cassava Harvester

CASE STUDY

Development of a Cassava Harvester in Ghana

To-date, farmers, of which 45% women, are unable to harvest enough cassava and in the right time to meet the demands under the PSI, in particular of the Ayensu Starch Company (ASCo), a cassava starch producing company for export.

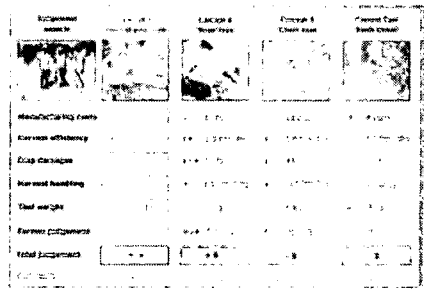
Integrated Development Process

To reduce harvest time and drudgery, especially for farmer women, a new manual harvester is developed in an integrated manner, considering the stakeholders' opinions of the current and new situation.

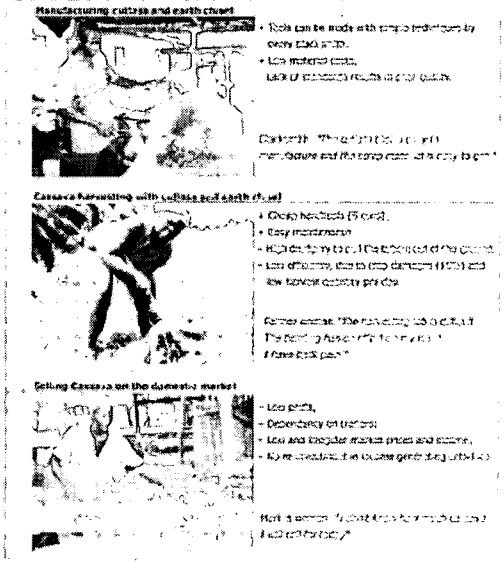
Improvements through a new Cassava harvesting tool

Tests have indicated that with a new harvester tool, the farmer can produce an estimated 20% more in the same working hours under less strenuous conditions.The new harvester will help to increase the farmer's income. Together with equipment cost reduction, constructions are explored in which the farmers can lease tools from an intermediate organization.

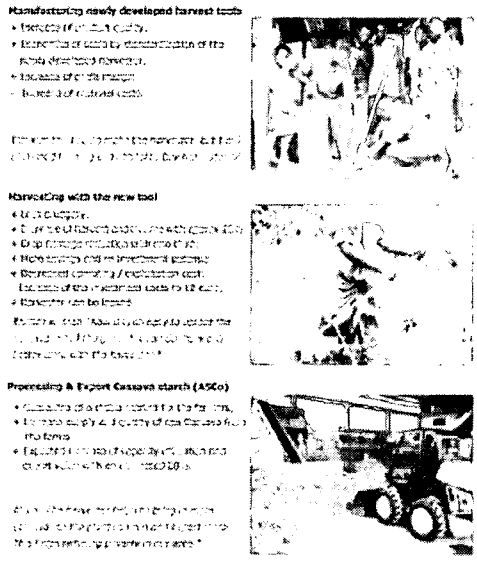
Comparison
3 developed harvesters with the current tool



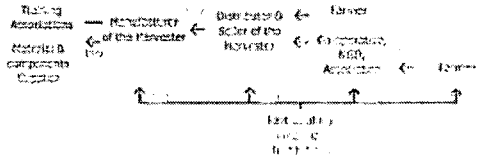
Current Cassava chain



New value chain by harvester and (export) market



Financial analysis



Future activities

After the Cassava harvester case, the [AMIS] integrated approach will be used to address other equipment related bottlenecks, relevant for the PSI such as for cassava transport and for oil palm fruit processing.

For more information on [AMIS]: www.unido.org

ANNEX 5: ENGINEERING SUPPORT [AMIS] DEVELOPMENT S

SUPPORT ORGANISATION	Scope	NAME	FUNCTION	CONTACT details
Ampaabeng	Promotional activities	Mr. Ebenezer Ampaabeng	Manager	+233 27 7415306 +233 24 950430
CIKOD	Consult on rural economical & organisational developments	Mr. Bernard Guri	Director	cikod2000@yahoo.co.uk
Delft University of Technology	Study for sustainable innovations	Mr. Jan Carel Diehl	Advisor/ Co-ordinator	j.c.diehl@io.tudelft.nl +31 20 6385678
Enterprise Works Worldwide	NGO for sustainable, enterprise-oriented solutions	Mr. Alan Brewis	Country Director	brewisa@africaonline.com.gh www.enterpriseworks.org
FAM- Foundries & agricultural Machinery ltd	Importer of spare parts (from India) in the agricultural sector	Mr. Shewak Ram Mirpuri	Managing Director	famcp@ghana.com +233 22 304113
GRATIS Foundation	Engineering & Industrial Design; Prototype & Manufacturing	Mr. Sheini Abu-Bakar	Executive Director	gratis@ighmail.com P.O.Box CO 151, Tema,Gh. +233 22 204243
ICA	Consult on rural economical & organisational developments	Mr. Lambert Okrah	Executive Director	Icagh@ghana.com +233 21 224167
Impretec	Market studies			Ringway Crescent +233 226090
KIEM	Consult and development of sustainable innovations	Mr. Carmen van der Vecht	Partner	c.vandervecht@kiem.nl +31 20 6385678 www.kiem.nl
TechnoServe	Business solutions to rural poverty	Mr. Nick Railston-Brown; Mr. Takyi Sraha	Country Director; Business Advisor	tns@tnsgh.org +233 21 763675 www.technoserve.org
FAM- Foundries & agricultural Machinery ltd	Importer of spare parts (from India) in the agricultural sector	Mr. Shewak Ram Mirpuri Mr. Kamal Ram Mirpuri		famcp@ghana.com +233 22 304113
Wienco Gh. Ltd.	Trading ; Plantation agriculture; Warehousing	Mr. H.J.M. Wientjes	Managing Director	+233 21 773458 www.wienco.com

ANNEX 6: MORPHOLOGICAL BOX

By Bob King
http://www.goalqpc.com/pastezines/January03.pdf.

One of the most powerful and advanced creativity tools is the Morphological Box. By looking at the key parameters (essential characteristics) of a solution and linking together the most likely options, the Morphological Box creates thousands of practical solutions to a problem.

To construct a Morphological Box

- Define the problem.
- Assemble a team of experts. This tool requires the use of people who thoroughly understand the parameters of the solution and the most likely options.
- Define the parameters for all possible solutions and arrange them in the first column of the Morphological Box in order of importance, with the most important parameter listed at the top of the column. Each parameter represents part of the solution. All the parameters together represent the solution to the problem.
- List all the possible options for each parameter in the other cells of the box. Consider a balance between what is reasonable and what may generate new ideas.
- Build alternative solutions by selecting an option for each parameter, marking the option with a dot, and connecting the dots to create a solution. Use different colors and different style lines (i.e., dotted, wavy, etc.) to help keep the options separate.
- Analyze the solutions and select the best one.

A sample of a Morphological Box

Murder Mystery Plots

Parameters	Options				
Victim	Butler	Wall Street broker	Parrot	Doctor	Lawyer
Cause of death	Suffocation	Poisoning	Gun shot	Bomb	Fire
Scene of the crime	Restaurant	Home	Conference	Pool	Mall
Murderer	Chamber maid	Investor	Game hunter	Patient	Prince
Motive	Greed	Revenge	Jealousy	Insanity	Love
Hero	Senator	Computer technician	Gardener	Detective	Psychic
Solving method	Laboratory results	Logical reasoning	Photograph	Confession	Vote

What is most interesting about the Morphological Box is the number of possibilities it generates. In our example, the number of possible murder mystery plots is the product of multiplying the number of items in each line. The Morphological Box helps generate many ideas that would not be possible without this creativity tool.

ANNEX 7: EVALUATION DEVELOPMENT PROCESS OF THE CASE STUDY

Code:

	Activity is done
	Activity is partly done
	Activity is not done
	Activity is still to come

A. Analysis Phase

T	Tasks Analysis Phase		
	a. Technical Analysis	b. Economical Analysis	c. Organisational Analysis
1	Analysing the technical constraints of the current chain, focused on production, distribution, usage,maintenance and impact on environment (x).	Analysing the economical constraints of the current chain, focused on production, distribution, usage and maintenance.	Analysing the organisational constraints in the current chain, focused on distribution (import), usage and maintenance.
	Definition of the set of equipment to be (re)designed.		
	Analysing the constraints and functions of the current set of equipment, focused on production, distribution,usage, maintenance and environment.	nalysing the volume, costs and revenues of the current set of equipment, focused on production, distribution, usage and maintenance.	Analysing the organisational structures and constrains of the current set of equipment focused on distribution (import), usage and maintenance.
2	Analysing the technical specifications for the new set of equipment in the chain, focused on optimal production, distribution, usage,maintenance and environmental impact & regulations.	Analysing the economical specifications for the new set of equipment in the chain and of the regulations by (financial) institutes.	Analysing the specifications and preferences in the chain and region for the organisational structures and (import) regulations to implement the new set of equipment.
3	Stakeholders/Expert meeting: Feed back on: the constrains of the current chain, the defined 'set of equipment' and the specifications for the new set of equipment on technical, economical and organisational aspects.		
4	Formulation technical goal for the new set of equipment.	Formulation economical goal for the new set of equipment.	Formulation organisational goal for the new set of equipment.
5	Formulation of judgeable technical specifications and functions for the new set of equipment in the chain;	Formulation of judgeable economical specifications for the new set of equipment in the chain.	Formulation of judgeable organisational specifications for the new set of equipment in the chain.

P	Results Analysis Phase
1	Description (& pictures) of the current chain (and equipment).
2	Problem definition of the current chain (and equipment).
3	Description 'set of equipment' to (re)design.
4	List of stakeholders with contact information & meeting report
5	Overview profitability current value chain.
6	Formulation of design goal for the new equipment.
7	List of specifications, regulations and functions for the new equipment.

B. Explorative Phase

T	Tasks Explorative Phase		
	a. Technical Exploration	b. Economical Exploration	c. Organisational Exploration
1	Exploration of existing solutions with similar functions in other markets and in other countries; Exploration of available materials, parts, standards, production	Exploration of the volume, costs and revenues of the explored existing solutions; Exploration of existing and relevant financial structures in	Exploration of existing organisational structures in the relevant region of the chain by organising workshops in the region; Exploration of existing organisational

	methods and suppliers.	region and by financial institutes.	structures for similar sets of equipment in other markets.
2	Generation of functional solutions for the new equipment with the use of a morphological box.	Rough calculation of the costs and the revenues of the technical and organisational solutions.	Generation of possible organisational structures to implement the new set of equipment.
3	Brainstorm with experts and/or stakeholders in the chain: Generate and discuss technical and organisational solutions with other experts and/or stakeholders.		
4	Global judging of the solutions on the main technical specifications.	Global judging of the solutions on the main economical specifications.	Global judging of the solutions on the main organisational specifications.
5	Selection of the most appropriate solutions and structures (±3) Go/ No-go decision for further development of a new set of equipment.		

R	Results Explorative Phase
1	Overview (drawing) of existing market solutions.
2	Overview (drawing) of part solutions for each function.
3	Sketches of possible solutions with indicated dimensions, material and costs.
4	Overview (flow chart) of possible organisational and financial structures.
5	Overview of judging of solutions on specifications & selection of ±3 appropriate solutions and organisational structures for the new set of equipment.
6	(no) Go to next development phase

C. Concept Development Phase

T	Tasks Concept Development Phase		
	a. Technical Development	b. Economical Development	c. Organisational Development
1	Developing the selected technical solutions to concept level by defining dimensions, material type and acts for manufacturing, usage and maintenance	Determination of the costs and the revenues (profitability) of the technical concepts in the chain.	Determination of the organisational aspects to implement the technical concepts in the chain (include import aspects).
2	Construction of the concept(s) into prototypes or simplified models.	Determination of the economical conditions of relevant financial & governmental institutes or programmes.	Determination of the organisational conditions of relevant financial & governmental institutes or programmes.
3	Testing of the construction(s) by the users and stakeholders under extreme conditions.	Discussing the profitability and the financial structure of the concept(s) with the stakeholders.	Discussing the organisational aspects of the concept(s) with the stakeholders.
4	Stakeholders/Expert meeting: Judging of the concepts to the technical, economical and organisational specifications; Selection of the most appropriate set of equipment. Go/ No-go decision for further development of a new set of equipment.		

R	Results Concept Development Phase
1	Drawings (3D, Technical) of concepts with dimensions and material specifications.
2	3 D models of the concepts.
3	Overview reactions from the chain, include test report with data & results.
4	Overview (flow chart) of possible organisational and economical structures and specifications (costs & revenues).
5	Overview of the profitability in the new value chain.
6	Overview of judging and selection of the concepts and structures.
7	(no) Go to next development phase

D. Optimization Phase

All tasks and results in this phase are still to come

E. Implementation Phase

All tasks and results in this phase are still to come

ANNEX 8: INVITEE LIST STAKEHOLDERS WORKSHOP (29 OCT 2003)

ORGANISATION	NAME	CONTACT ADDRESS
AGI, EMADOM LTD	Dr. Dominic Quainoo	P.O. Box CT 385 Cantonment, Accra
	David Wiredu	P.O. Box 8624 Accra-North
A.M.S.M.I	E.V.O Opare	c/o Suame ITTU/TCC KNUST, Kumasi
	G.K. Workey	
ARB Apex Bank	Theophilus P. Obeng	P.O. Box GP 20321, Accra
ASSI Kumasi	D.Y. Frimpong	P.O. Box AH, 8756 Kumasi Tel 024-763906
Ayensu Starch	A.E Quayson	P.O. Box 113, Bawjiase
	J.J Afuakwa (Dr.)	
	Silva Lumor	Tel.020-8183725
FATECOWD, CTED	Robert Woode	P.O. Box 899, Accra Tel.502914/502547/024383858
FP Quansar Resources	Felix Quansar	P.O. Box CT5810 Accra/Tel. 021-781874
Ghana Standards Board	P.K Fleku	P.O. Box MB 245, Accra
	M. A. Pappoe	
GRATIS Foundation	K. Dankyi Darfoor	P.O. Box CO 151, Tema 022-207609
	Sheini Abu-Bakar	Tel.020-8118233
	S.K Dotse	Tel.022-207610
IT Ghana Denco Foundry	Daniel Numo	P.O. Box BT 508 C2, Tema
KNUST		KNUST Kumasi:051-60233/60242
- General	Alexander Twum	
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- Chemical Engineering	Dr. M. Y. Woode	
- TCC	G.Y Obeng	
	Dr. Peggy Oti-Boateng	Tel.051-60296/7
- Mechanical Engineering	E.E.K Agbeko	
	E.S.D Afrifa	
MoFA-AESD	Sam Adu Somuah	P.O. Box M82 , Accra
	Sylvester Owusu	024-628305
	J.K. Boamah	Tel. 021-7010262/777789 (87)
MoTI/PSI	Robert B. Tandor	P.O. Box M47 Accra
NBSSI	Albert Boachie Amofa	P.O. Box M85 Accra
	Emmanuel Lamptey	021-661396
NIB	P.T. Kwapong	P.O. Box 3726 Accra/Tel.661703
UNIDO	Daniel Baffour-Awuah	P.O. Box 1423, Accra
	Mr.S.Vasantha Kumar	
	Elaine Asafo-Adjaye	
UNIDO/REDS	George Dake	UNIDO/REDS P.O. Box Hp958 Ho

Tip: this list can be categorized also on the chain: manufactures, farmers, processor, financing institutes etc.

ANNEX 9: REFERENCES

Brezet H, T. van der Horst T,G. Duijf, S. Haffmans, H.Böttcher, A. Zweers, H. Verkooyen, *'PROMISE, Handleiding voor milieugerichte productontwikkeling' (PROMISE, Tool for sustainable product development),* SDU Uitgeverij, 's-Gravenhage 1994.

Brezet H, Hemel, C, *'ECODESIGN, a promosing approach to sustainable production and consumption,* UNEP, United Nations Publication, 1997 (ISBN 92-807-1631-X).

Eekels,J., Poelman W.A, *'Industriële Productontwikkeling, deel 2 methodologie' (Industrial product development, part 2 methodology)*, LEMMA, Utrecht 1995 (ISBN 90.5198.435.X)

Roozenburg, N.F.M., Eekels, J., *'Productontwerpen, structuur en methoden' (product design, structure and methods)*, LEMMA, Utrecht 1995 (ISBN 90.5189.067.2)

Twum, A, *'Developing the agricultural machinery industrial system (AMIS) to support poverty reduction in rural areas, Agricultural Equipment feasibility'*, UNIDO NC/GHA/02/016/17-02, Ghana / Austria, 2003.

Vamantha Kumar, S., *'Developing the agricultural machinery industrial system (AMIS) to support poverty reduction in rural areas'*, UNIDO NC/GHA/02/016/11-01, Austria/Ghana, 2003

Van den Kroonenberg, H.H., Diers F.J., *'Methodisch ontwerpen' (methodological design)* , Educaboek, Culemborg 1992

Van der Vecht, C., de Pauw I, *'Feasibility of a logistic system to improve the market value of fruit & vegetables in Ghana'*, KIEM sustainable innovations, Amsterdam 2002.