FIRED BRICKS (RWANDA)

EVALUATION REPORT - OCTOBER 1992

Prepared for

INTERNATIONAL DEVELOPMENT RESEARCH CENTRE

IDRC FILE 3 - P - 89 - 1007

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INTRODUCTION

Rwanda is a small country with enormous social and economic problems. With a high population density, an increasing population and diminishing arable land, it has a pressing need for low-cost housing and, consequently, for the production of acceptable quality building materials that have the least negative impact on the ecology.

Throughout the countryside one can see a variety of dwellings with building materials ranging from "wattle-and-daub", through adobe brick, to the more durable fired brick, with roofing materials varying from occasional thatch but, generally, either corrugated steel or clay tile. It is clear that, with its considerably greater durabililty, fired brick and tile, if produced economically, is the preferred material for construction for family dwellings. With the exception of a highly automated plant at Kigali, fired brick and tile production lies largely in the hands of small-scale artisans. These artisan plants are scattered among the low-lying "marshlands" where clay suitable for brick and the production lies in a layer 1m - 2m thick close to the surface, covered by a layer of arable top-soil. These producers exploit the land in a haphazard fashion with no thought to the reclamation of arable land, their kilns are fuel-inefficient, the quality of brick highly variable, and the percentage of brick spoilage very high (reportedly in the order of 40% - 50%).

In 1989 the International Development Research Centre (IDRC) in Ottawa approved a proposal for a project having as its overall objective the optimization of artisan fired-brick production in Rwanda. The specific objectives of this comprehensive socio-economic, scientific/technological and ecological study and accompanying training and dissemination of information program are outlined and evaluated under item F, "Achievements", of this report. Participating partners in this research and development are the National University of Rwanda (UNR), Sherbrooke University (US), the Rwandan Ministry of Industry and Labour (MIA), the Rwandan Ministry of Public Works (MTP), the Caisse Hypothecaire of Rwanda (CHR), a national credit union, and, more recently, the Rwandan Ministry of Youth (MJ) becoming involved in the training aspect of the project. Overall responsibility in Rwanda for coordination and implementation lies with UNR, specifically, with Dr. J.-B. Karabarwa, the Director of the Project and Dean of the Faculty of Applied Sciences; and US was charged with the responsibility of providing scientific studies and technical advice, some technician training and post-graduate education.

The project has proceeded through the stages of scientific and technical research to brick production, a pilot plant having been set up at Butare, with parallel socio-economic studies at an early stage.

Now, three years since project approval, an independent evaluation has been commissioned by IDRC, a study that is the subject of the present report. The report is based on:

- a review of the 1989 Project Proposal and files at the IDRC offices in Ottawa in June 1991;
- a review of the May 1991 UNR/US Progress Report to IDRC;
- a review of the September 1991 UNR Progress Report;
- a review of the September 1992 UNR Interim Report, July 1991-July 1992;
- an examination of the US M.Sc. thesis of Augustin Dukuze, based on research conducted on Rwandan clays at US.
- September 1992 visits to artisan brick production plants near Butare;
- September 1992 visits to the Rwanda/Canada Briques Cuites Project at Butare; and
- September 1992 meetings with Dr. J.-B. Karabarwa and his staff at UNR.

This evaluation report follows the general format outlined in the Terms of Reference of the Consultancy Contract (Appendix IV). While all terms are addressed, particular attention is paid to item F that deals with practical accomplishments. A February 1992 Summary Report prepared by the "Fired Brick" Project staff is included as Appendix I, a progress chart from the UNR September 1992 Interim Report forms Appendix II, and photographs relevant to this report are included in Appendix III.

No participant from US was consulted in this evaluation.

A. RESEARCH METHODOLOGY

The scope of this project as a research program is very comprehensive, requiring the coordination of socio-economic, ecological impact, scientific and technical studies that will culminate in improved technology, in the dissemination of information about the improved technology and in the training of artisans.

From the initial identification of a problem, through its preliminary analysis, sampling the various clay deposits, scientific soil classification studies, technical testing, site selection for a pilot plant, kiln improvement, through to the final product - namely, an improved technology and product, the research methodology has been rational.

Documentary evidence of the scientific merit of the project lies in the progress reports, with a proven standard of excellence provided by the work of Mr. Augustin Dukuze, presented as the thesis for his Master's degree in Civil Engineering at Sherbrooke University. Other technical papers are planned. The novel aspect of the research and development lies primarily in the incorporation of rice husk in varying percentages into the clay mix, which itself is a proportioned mix of organic and inorganic clays. As explained in the Summary report of Appendix I, the presence of rice husk in the clay serves many purposes:

i) it acts as a deterrent to shrinkage cracking during air drying;
ii) it provides tensile strength during handling of the green brick;
iii) by burning during firing of the brick it contributes some internal heat to complement that being provided by the fire boxes;
iv) apparently there is a pozzolanic chemical reaction during firing that combines the various calcium, silicates and aluminates, and perhaps other compounds, of the rice husk and clays. The resulting strength reportedly compensates, in part, for strength loss resulting from porosity; and
v) if mixed in sufficient quantity, the incorporation of rice husk leads to a light weight brick with good insulating qualities.

The complete understanding of the role played by rice husk in the mix requires further scientific and technical analysis, but there is sufficient practical understanding for the system to work.

Other novel features of this project include the redesign of the "Igloo" kiln for greater economy and the incorporation of insulating bricks into its construction for energy saving, and in investigating alternative fuels such as peat and/or waste engine oil.

B. CONTRIBUTION TO RWANDAN RESEARCH CAPABILITY

The comprehensive nature of this project provides a number of topics requiring research. To date the principal effort has been directed at scientific and technical research and development and, in this matter, post-graduate and technologist training have clearly provided an expansion of the research capability of UNR. The project itself provides a vehicle for expanding research potential and it is clear that under enthusiastic leadership of Dr. Karabarwa and with continued support the potential will be realized.

C. PARTICIPATING RESEARCH INSTITUTIONS

The participants in this project are UNR, MIA, MTP CHR and, more recently, MJ, in Rwanda, and US in Canada. To this point, the Faculty of Applied Sciences at UNR has been the principal participant and is clearly providing the appropriate support. I am assured that the other Rwandan agencies in the partnership will provide their support at the appropriate points. Satisfaction with the support from Sherbrooke University has been clearly expressed.

D. COLLABORATION

As a follow-up on item C, and from the project progress chart in Appendix II, which shows the project proceeding on schedule, or ahead of schedule, collaboration to this point has been excellent. As indicated in item E below, future collaboration among the Rwandan institutions promises to be equally good.

E. TRAINING ACTIVITIES

Training activities are off to a good start. The decision regarding a location for setting up a pilot brick production plant was assisted by the offer of the use of land by the Centre for the Training of Youth (CFJ). This organization is under the control of the Ministry of Youth (MJ). The site of the pilot plant borders directly on "marshland" typical of that used by the rural artisan brick plants. Students from CFJ visit the plant to receive training there, and it seems likely that at some time in the future the plant will revert to CFJ as part of its training facility. The workers at the plant are receiving training and two masons have received specialized training in the construction of the brick dome for the "Igloo" kiln.

A document entitled "Different Steps in the Manufacture of a Brick" has been prepared; neighbouring countries have already enquired about technology transfer and training; and I have little doubt that the various different institutions and government agencies will soon become more involved in training activities and in the appropriate dissemination of information. For example, youth attending CFJ are drawn from cooperatives from all over Rwanda, and will be returning to their home communities. Also, I understand that CHR will become closely involved in the dissemination of information.

F. ACHIEVEMENTS

With the overall objective of optimizing rural artisans fired brick production, the specific objectives as listed on p4 of the Project Proposal are:

i) an economic study of the market for the various types and quality of brick;
ii) an analysis of the importance of the industry to artisan employment and wages;
iii) a study of the structure of the wood and charcoal market and the impact of the brick industry on deforestation and reforestation;
iv) analysis of the ecological impact of use of clay from the marshlands;
v) justification of the use of clay;
vi) improvement of the properties of brick;
vii) optimization of firing;
viii) optimization of work force organization; and
ix) technician and artisan training.

As the project enters its third year of operation most of the objectives are on schedule or ahead of schedule, as shown in the project progress chart in Appendix II. Technical studies are well in hand, a pilot production plant has been built with two "Igloo" kilns, the second being a local development and significant improvement of the first, and a labour-intensive but well-organized work sequence has been developed. Bricks of acceptable quality, including low density insulating bricks, and roofing tiles are being produced. The quality of brick is consistent, and a vast improvement over that normally available from other artisan plants. Dimensions are also consistent and spoilage low (in the order of 5% compared with 40% - 50% for other plants).

I understand that the thrust of the project will be towards socio-economic and ecological impact studies in the third year. This will involve academic staff and students from the Faculties of Sociology and Geography. Technical studies into "fine-tuning" the mix proportions for the best quality product will continue. MJ will become increasingly involved in coordinating the training programs, MIA is expected to

provide appropriate political support for promoting brick construction and, in the final year of the project, CHR is expected to lend its considerable support to the dissemination of information. It is likely at some later date, Dr. Karabarwa, a member of APROMETEC, a national standards association for fired clay products, will be instrumental in establishing national standards for brick production.

At the moment, on the scientific and technical side, Dr. Karabarwa (who must also see to the administration of his Faculty) is the only person on the project with post-graduate qualifications, although this will change with the return of Mr. Augustin Dukuze from his post-graduate studies in Canada. Mr. Innocent Dusengmana, who currently appears to head up the detailed technical work, does an excellent job but has no post-graduate training. I strongly recommended that he have the opportunity to further his studies.

G. IMPACT ON DEVELOPMENT

The pressing need for low-cost building material, to stem rural-to-urban exodus, and to reduce the negative ecological impact of present rural brick production practices are all addressed in this project.

Present rural brick production practices haphazardly exploit the "marshlands", for the most part spoiling their agricultural potential; fuel-inefficent wood-burning kilns are used, exacerbating a serious deforestation problem, and produce bricks of variable dimensions and quality with a very high percentage of spoilage.

This project very effectively has developed a new technology that retains the important features of present artisan brick production practice, such as its labour-intensity, and addresses all of the problems noted in the preceding paragraph; and a pilot plant has been built at Butare that demonstrates the effectivenss of the new technology. While the labour-intensive nature of the industry has been maintained, the kilns that have been developed are more fuel-efficient and the use of alternative fuels; such as used engine oil, is being investigated; higher quality clay products,

and a wider variety, are being produced; the work force is efficiently managed; and the clay is being harvested in a manner that will permit the reclamation of potential agricultural land.

This project is a remarkably good example of "appropriate technology", and if the accomplishments to this point can be used as a guide, it promises to accomplish all of its objectives. With an effective program of training and dissemination of information, there is no question about the very significant impact the project will have on development.

CONCLUDING COMMENTS

One cannot fail to be highly impressed by the accomplishments of this project, and with Dr. Karabarwa's enthusiasm for the project, it is difficult not to feel personally involved. Under his direction there is no doubt that this project will become a model of appropriate technology and development that others could well emulate.

I highly recommend continued support for this project and further support for the Faculty of Applied Sciences at UNR.

ACKNOWLEDGEMENTS

I am very grateful to Dr. Karabarwa, and to his technical assistant Mr. Dusengmana, for their time and complete cooperation.

APPENDIX I

Project Summary Report

Prepared by

"Brique Cuite" Project Staff

February 1992

PROJET BRIQUE CUITE
UNIVERSITE NATIONALE DU RWANDA
FACULTE DES SCIENCES APPLIQUEES
B.P. 117 BUTARE

RAPPORT RESUME SUR LE PROJET BRIQUES CUITES

INTRODUCTION.

Le Projet "Brique cuite" est un projet conjoint de recherche appliquée entre les Facultés des Sciences Appliquées de l'Université Nationale du Rwanda et de l'Université de Sherbrooke (Canada). Le Projet a été monté durant l'année 1988-1989 et officiellement il a démarré le 1 mai 1990 et doit durer 48 mois.

L'objectif général du Projet est l'amélioration de la production artisanale de la brique cuite au RWanda en optimisant l'organisation du travail des différentes phases de production, en diminuant la consommation énergétique et en favorisant la vulgarisation des résultats de la recherche.

L'intérêt d'un tel projet est en définitive la promotion et la commercialisation des matériaux locaux de construction, la formation des artisans dans la fabrication d'une brique ou d'une tuile améliorée, l'augmentation du revenu des artisans par un métier non agricole et le développement de la technologie de la terre cuite.

LES OBJECTIFS SPECIFIQUES DU PROJET SONT LES SUIVANTS:

a) Etude économique du marché pour les différentes qualités et types de briques.

b) Analyse de l'importance de l'industrie sur l'emploi et revenu des artisans.

c) Etude de la structure du marché du bois et du charbon de bois et l'impact de l'industrie des briques sur le déboisement et reboisement.

d) Analyse de l'impact écologique de l'exploitation de l'argile dans les marais.

e) Rationalisation de l'exploitation de l'argile.

f) Amélioration des propriétés de la brique.

g) Optimisation de la cuisson.

h) Optimisation de l'organisation du travail.

i) Formation des techniciens et des artisans.

ETAT D'AVANCEMENT DU PROJET.

Parmi les études qui devaient être réalisées selon les objectifs du projets, certaines sont en cours d'exécution et les autres seront entamées d'ici quelques jours. Une étude préliminaire sur l'exécution du projet a été menée et a permis le choix du marais de Rwabuye comme site d'essais ainsi que la méthodologie à suivre pour l'amélioration de la productivité de la brique cuite. Une analyse au laboratoire de l'argile de Rwabuye a permis de tirer quelques conclusions:

- Pour fabriquer les briques de dimensions constantes il faut s'assurer de la teneur en eau et en sable constante. Selon les températures de cuisson (950° - 1100°C).

- Le retrait moyen varie de 3 à 5% et augmente avec la température de cuisson.

- Les argiles riches en matières organique se cuisent mieux que les argiles riche en alumine qui n'en contenaient pas. Il faudra cuire les briques à au moin 1100°C. Si l'on veut refermer la porosité des briques.

Pour répondre à ce besoin, on a construit des fours IGLOO dans lesquels on va essayer d'atteindres ces températures.

ESSAIS PILOTE

Pour fabriquer une brique de qualité dans le cadre du projet, nous avons développé une méthode d'incorporation de balles de riz dans l'argile pour donner plus de résistances aux briques, diminuer leur retrait et augmente leur palier de cuisson. Nous avons aussi construit un four"IGLOO" de façon à permettre une cuisson homogène de la pile de briques. Le premier four est opérationnel trois cuissons terminés et le deuxième four est en construction.
Pour une meilleure production d'une brique d'argile cuite améliorée, quelques infrastructures s'avéraient nécessaires.

- Construction du Hangar du Terrain de séchage bien applain pour conserver l'aspect extérieur de la brique.

- Construction d'une cabane de chantier pour le stock du matériel et le bureau de gestion du chantier.

- Bien aménager le site en avancant les eaux de pluie et le clôturer.

- Mise en place d'un système de malaxage de l'argile en y incorporant les balles de riz.

- Faire les essais de cuisson avec les charbons de bois et les tourbes; ceci pour essayer de relever la température et rallonger le palier de cuisson.

LES ETAPES REALISES

a) Rationalisation de l'exploitation de l'argile

Des échantillons d'argile ont été prélevés et soumis aux analyses de laboratoire. Quelques essais sont en cours à l'Université de Sherbrooke.

b) Amélioration des propriétés de la brique

Pour l'amélioration de la brique, quelques dispositions ont été établies:

- Homogénéisation de l'argile dans les bacs appropriés.

- Aménagement du Hall de séchage avec un terrain bien applani pour éviter les déformations des briques lors du séchage et un abri pour éviter les intempéries et le soleil direct sur les briques.

- Construction des bancs de moulage.

- Homogénéiser les dimensions des briques en fonction des besoins du marché et de façon à diminuer l'épaisseur des joints de mortier et des couches d'enduits lors de l'utilisation en contrôlant régulièrement les moules.

- La manutention de briques lors du moulage, du séchage, du chargement et déchargement du four se fait avec des outils manuels et avec attention pour réduire des bris.

- Ajout des balles de riz pendant le malaxage d'argile permet de dégraisser l'argile du marais qui est par ailleurs trop plastique.

- Elle renforce la brique verte, grâce à sa structure allongée qui s'apparente à celle d'une fibre grossière courte et empêche le développement de grosses fissures de retrait plastique lors du séchage, elle permet de faire sécher très vite les briques vertes en les mettant sur leur tranche, elle élimine toute déformation des briques lors de leur empilage dans le four.

c) OPTIMISATION DE LA CUISSON

- Incorporation des balles de riz permet le dégagement d'une certaine quantité de chaleur dans la masse d'argile, ce qui permet une meilleure cuisson à coeur.

Aussi la squelette de silice qui subsiste après combustion de la matière de la balle de riz se combine chimiquement (à relativement faibles températures) avec l'argile, si bien que celle-ci acquiert un son cristallin malgré la porosité de la brique et la faiblesse de la température de cuisson.

- L'homogénisation de la température et le rallongement du palier de cuisson dans des fours IGLOO construits à Rwabuye.

- L'essais de cuisson avec les balles de riz, avec du charbon de bois et avec des tourbes.

- Pour l'isolation des fours, on a essayé de mettre au point la fabrication locale de brique isolante à base des balles de riz.

CONTINUATION DU PROJET

1. Etude économique du marché pour différentes qualités et types de briques.

2. Analyse de l'importance de l'Industrie sur l'emploi et revenu des artisans

3. Analyse de l'impact écologique et de l'exploitation de l'argile dans les marais.

   Les contacts ont été faits pour la réalisation de ces études.

4. Exploitation commerciale des projet:
   Un contrat est en cours d'étude pour une exploitation conjointe du projet entre la Faculté des Sciences Appliquées et le Centre de Formation de la Jeunesse de Rwabuye.

5. Formation des techniciens et Artisans

Des séminaires devront être organisés pour permettre la dissémination et la vulgarisation des artisans.

Fait à Butare, le 28 Février 1992

DUSENGIMANA Innocent
Assistant au Projet

APPENDIX II

Project Progress
(from the September 1992
UNR Interim Report)

ETAT D'AVANCEMENT DES ACTIVITES.

Le tableau 1 présente l'état d'avancement des activités par rapport au calendrier fixé initialement.

CALENDRIER DES ACTIVITES

Activité (mois)	0	12	24	36
Etudes socio-économiques		UNR/CHR		
Evaluation et rationalisation exploitation argile	UNR/US			
Analyse propriétés et comportement brique		UNR/US		
Optimisation activités pré-cuisson		UNR/US		
Amélioration fours		UNR/US		
Classification et distribution brique				UNR/US
Normalisation et dissémination			MTP/UNR/US	
Ateliers/rencontres		UNR/MIA		
Déplacement	US UNR	US US US		US
Formation				

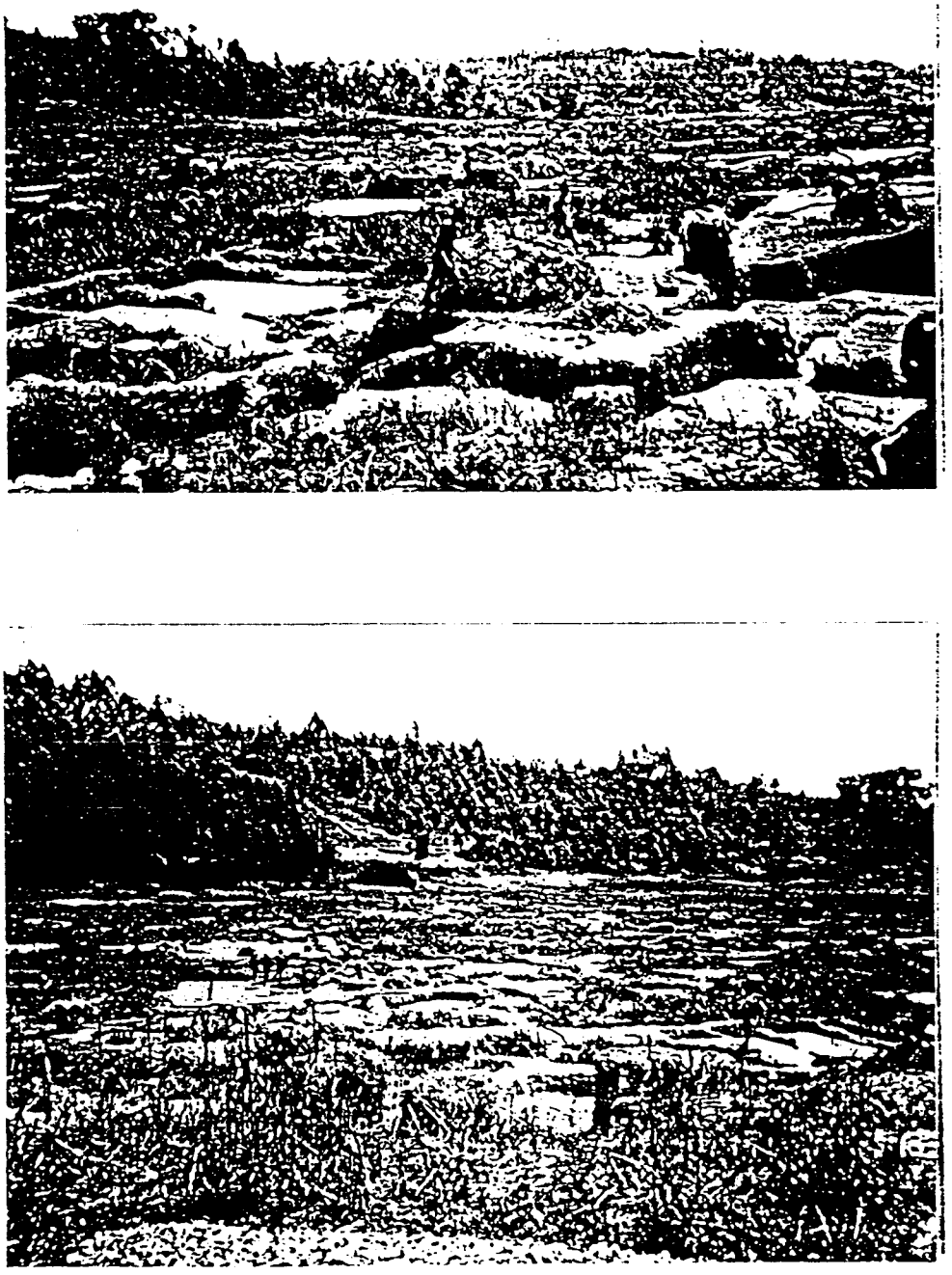
UNR : Université Nationale du Rwanda
US : Université de Sherbrooke
CHR : Caisse hypothécaire du Rwanda
MTP : Ministère des travaux publics
MIA : Ministère de l'industrie et de l'artisanat
_ _ : Etat d'avancement

Tableau 1 : Etat d'avancement des activités par rapport au calendrier initial.

APPENDIX III

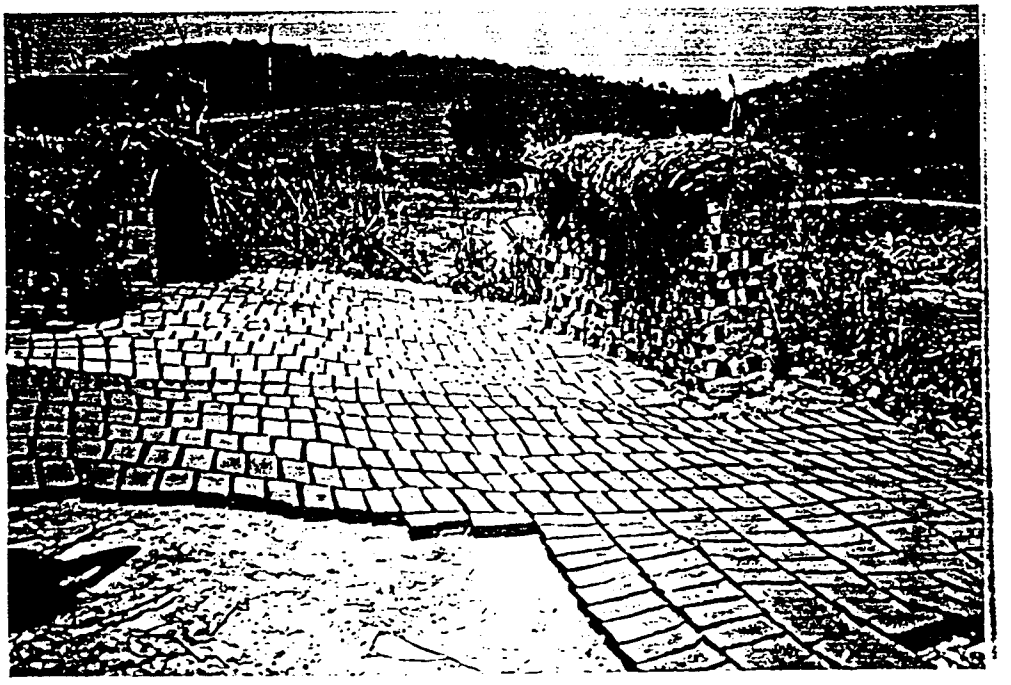
Photographs

Present Practice for Rural Artisanal Brick Producers



Exploitation of arable "marshland" through haphazard clay removal.

Hand moulding of brick.



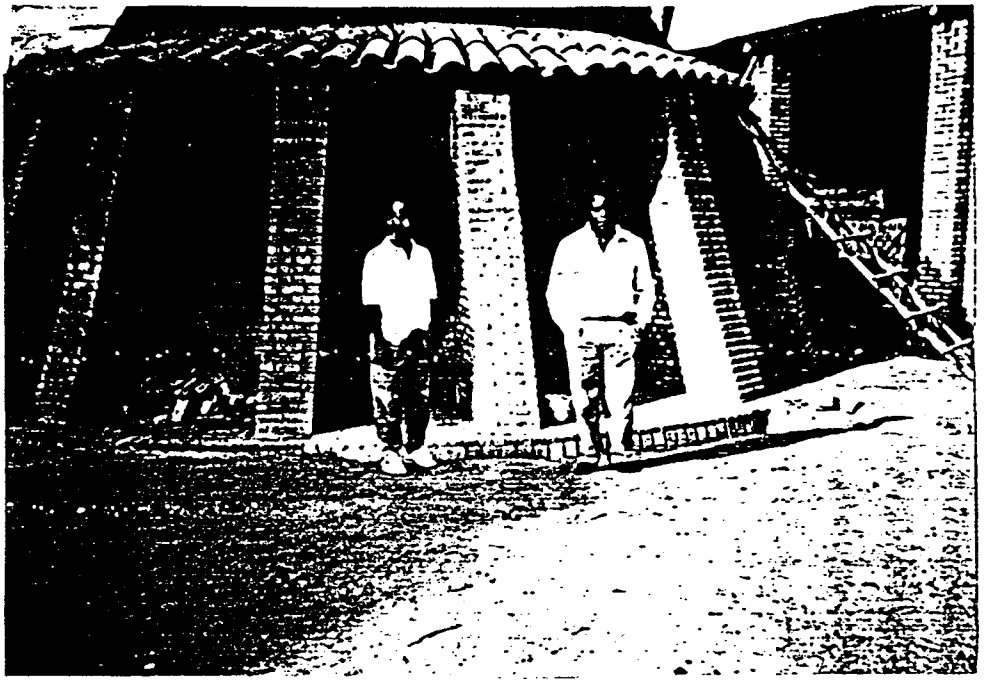
Preliminary air drying on flat (note the uneven surface and dimensional variation) and subsequent stacking for final air drying.

Clamp kilns assembled from raw bricks ready for firing (Note spoilage from previous kilns).

Kilns (centre ground) partly disassembled and bricks sold according to demand.

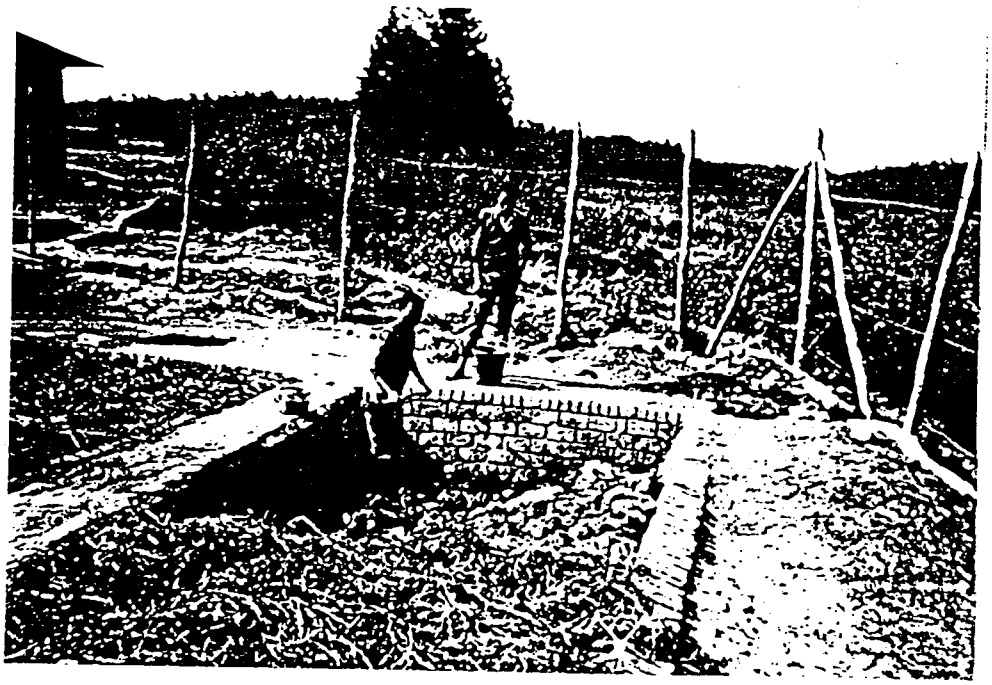
Typical artisanal bricks.
(Note variable colour, quality and dimensions.)

Pilot Brick Production Plant at Butare



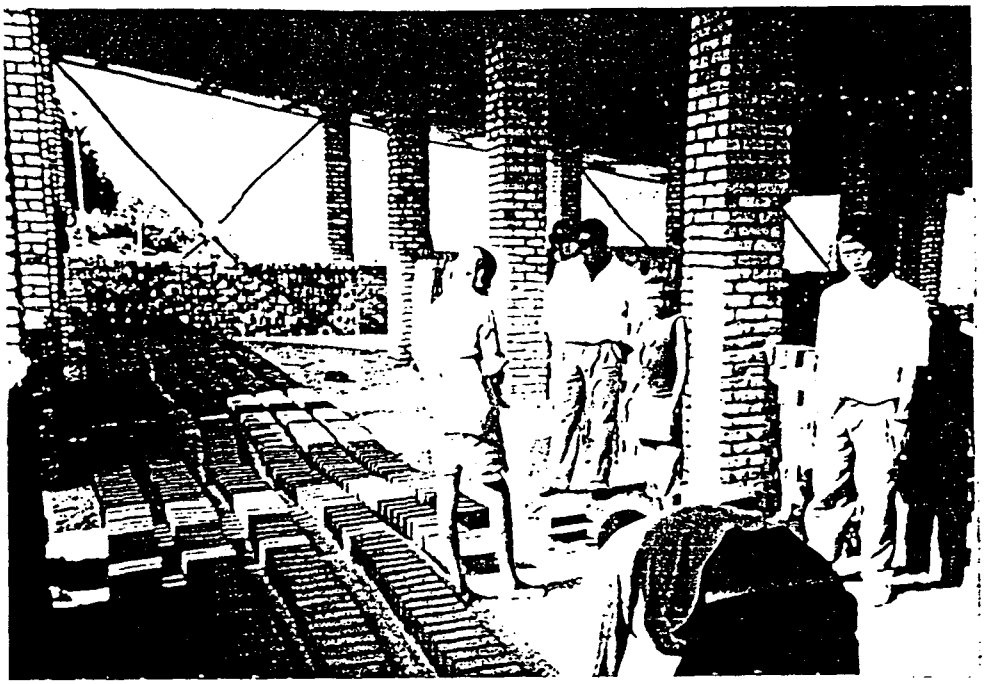
Dr. Karabarwa (right) and technical assistant Mr. Dusengmana at #2 kiln, Butare pilot plant.

Excavation of clay.

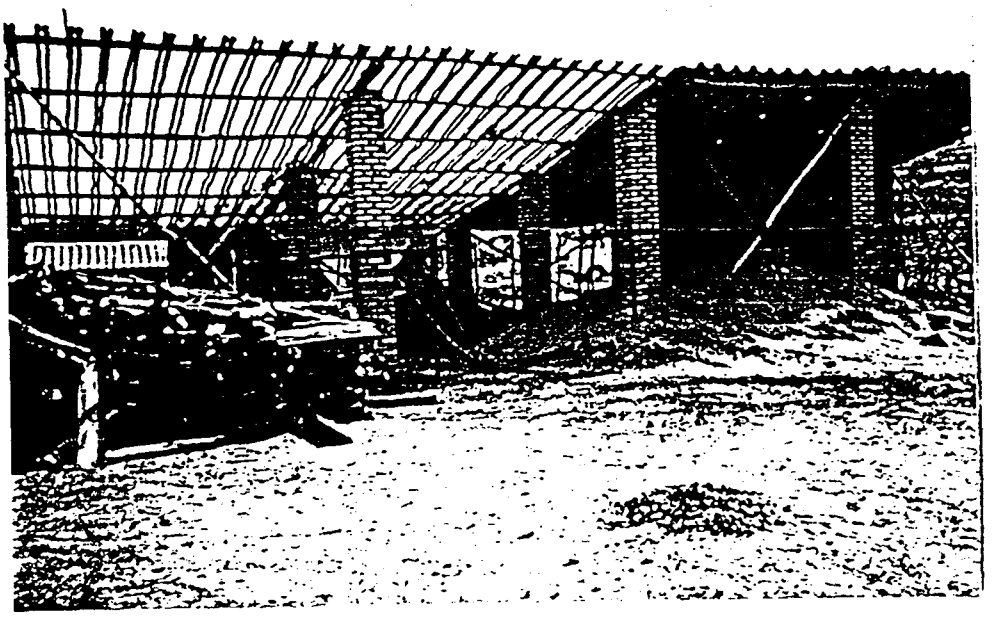


First mixing and storage.

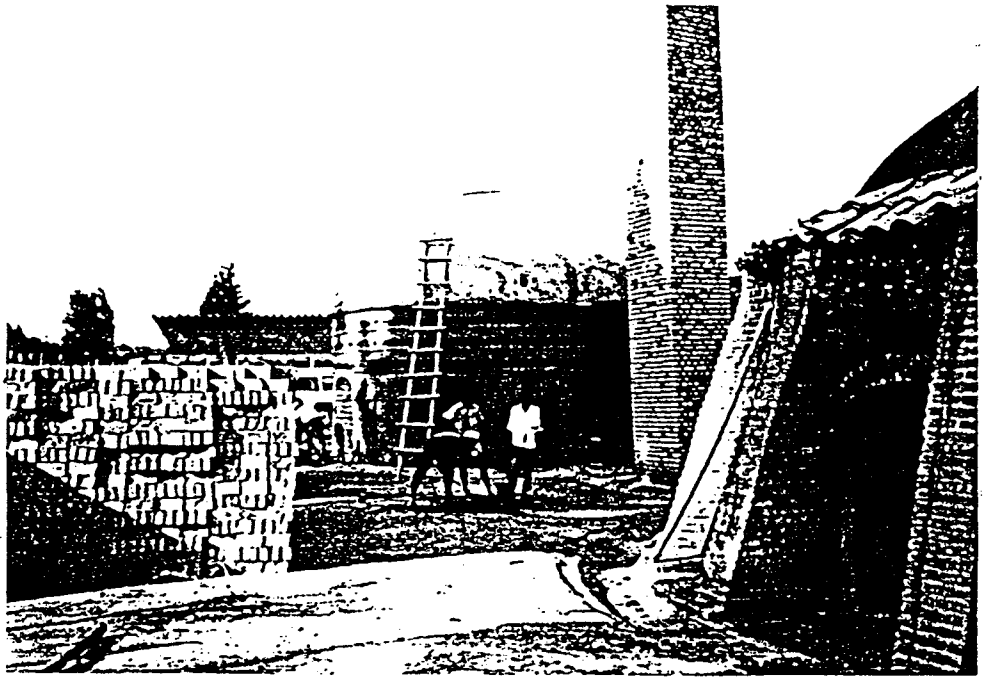
Hand moulding of bricks.



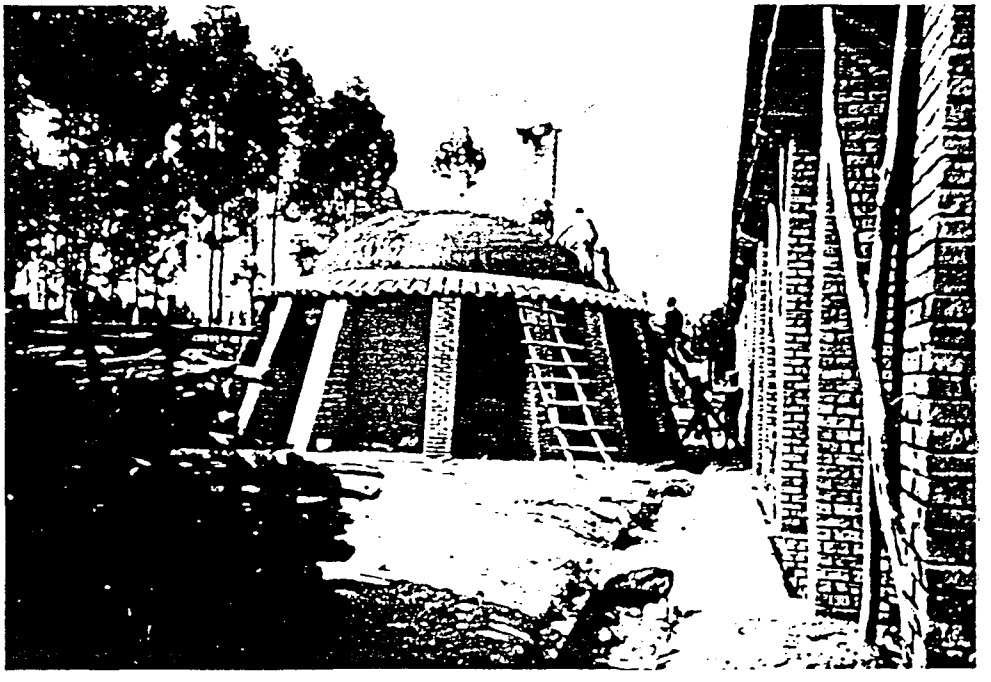
Primary drying on level ground (Note stacked bricks - background and right for final air drying).



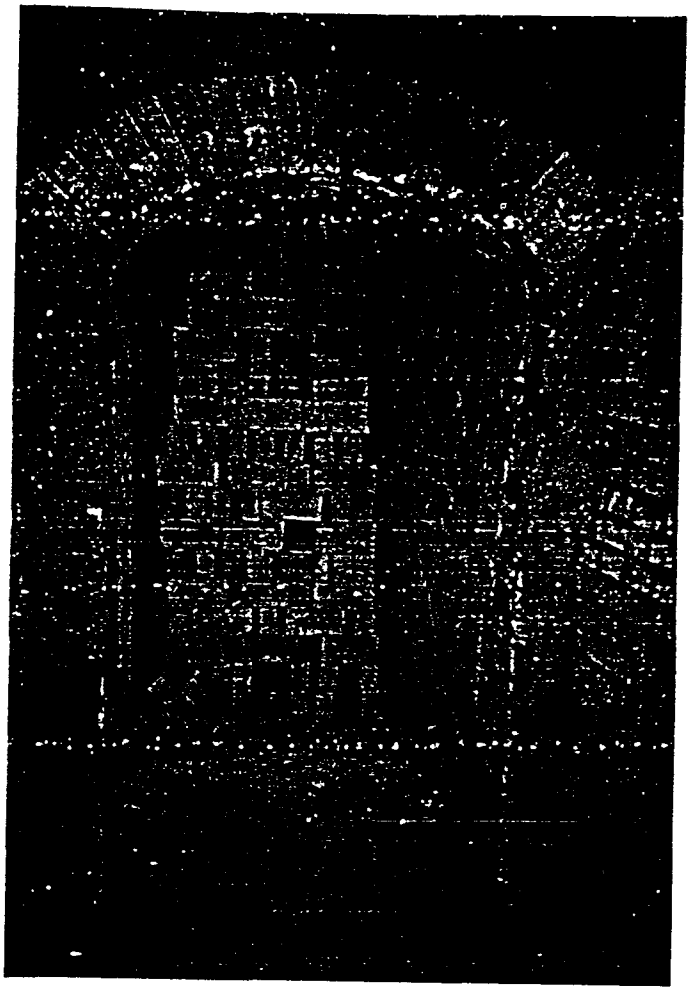
Stockpiles of wood (left), peat (centre) and rice husk (right).



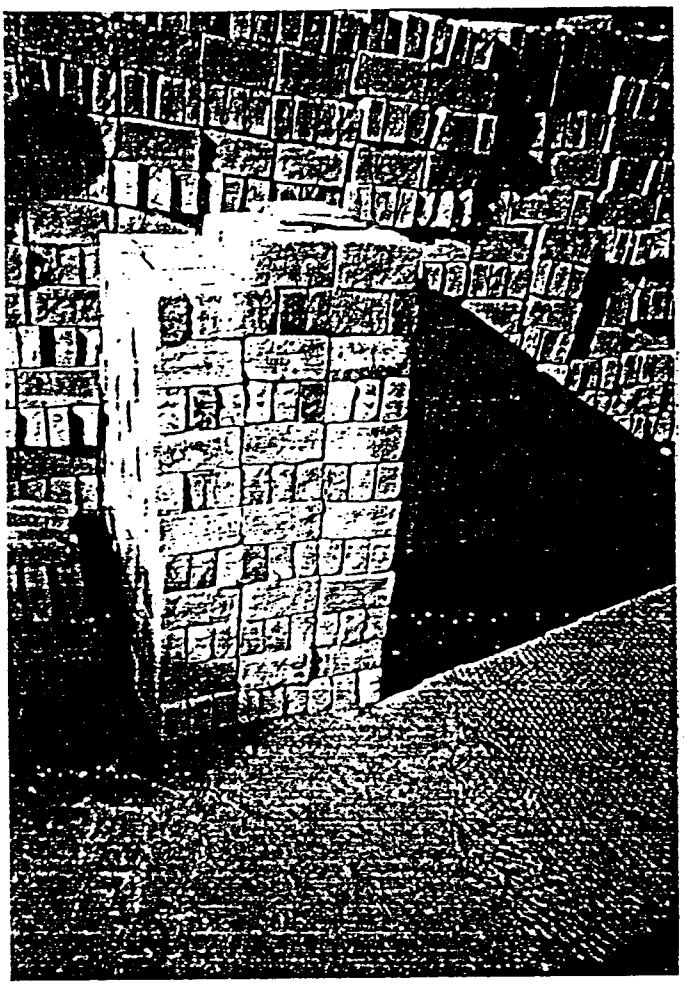
"Igloo"kiln #1.
(Note kiln #2, right, and stack of fired bricks, left).



Kiln #2 - incorporating significant improvements over kiln #1.



Kiln ready for unloading after firing and cooling.



Final product stockpiled ready for sale.
(Note relative uniformity of colour, and therefore of quality, and of dimensions).

APPENDIX IV

Terms of Reference

1. Terms of Reference

Under this contract, the services required of you are as follows:

a) an evaluation of the research methodology: scientific/technical merit; novel approach being pursued in terms of brick development. In particular, how do the novel aspects of the research differ from what is done by other researchers in the field, and how do they differ from similar research funded by IDRC and/or by other research funding agencies? How will the proposed research, in its essence and in terms of objectives and methodology, bring the known technology one step ahead of its previous knowledge level? Stated briefly, what is the essence of the novelty, innovation, or what are the special features of the research work undertaken which should, if successful, bring scientific and/or technical knowledge one step ahead?

b) an evaluation of the project contribution in building up the research capacity and capability of the recipient institution in the countries concerned;

c) an evaluation of the research institutions and research participation. Have they supported the project(s) in an adequate way?

d) a review of the quality of the face to face collaborative aspects of the projects; the technical assistance content versus the collaborative aspect; the relationship between partners; their mode of collaboration and contribution to the overall execution and results of the projects;

e) an evaluation of training activities for the utilization of the technical research results through dissemination, popularization and other means;

f) an evaluation of the achievements of each project vis-a-vis their objectives;

g) the impact of these projects on development;

h) as well as the project by project evaluation described above, EES requires an overall evaluation of the approach to shelter problems via brick technology development. Is the approach chosen correct and appropriate in the case of each of the projects and in general? If so, why? If not, why not and how could it be made more appropriate?