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## 9 The joint project on Vertisols management: Retrospect and prospects

*Mesfin Abebe and S Jutzi*

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### Introduction

To make agriculture and its growth sustainable to fuel economic growth in an essentially agriculture-based society like Ethiopia, is a formidable and multidimensional challenge. Faced with this urgent need to increase agricultural output there is the risk that this will be done at the expense of the productivity and sustainability of the resource base and environment where there is a hierarchy of interlocked subsystems of Vertisol-related resource utilisation. This encompasses diverse components: (1) as the intimate relationship between plants and the soil, or between crops and domestic animals, including energy and nutrient flows among them; (2) relationships between land facets within ecological zones; (3) economic interactions at the farm, and no less important (4) the policy environment within a given political framework. Sustainability at any one level may depend on events occurring at other levels.

Hence, the Joint Vertisol Project which, by its nature and intention has dealt with natural resource research and development; has inherently addressed the complexity of factors and interactions among them. This has led to the two-dimension strategy of choice or prioritisation: 1) issues related to research of the high-rainfall, low temperature and thus highly waterlogged Vertisols of the Ethiopian highlands, thereby providing a common denominator to collaborators for subsequent stages of research and development activities; and 2) high disciplinary priority to soil management related research; waterlogging and soil fertility being the most important constraints for Vertisols use high rainfall areas. Interinstitutional effort was therefore designed involving those in charge of training, research, development and extension. This would ensure more or less simultaneous design of both Vertisol-related management technologies and effective validation and transfer mechanisms commensurate with the constraints and opportunities of target farming systems. Seven years after its initiation, the Joint Vertisol Project had acquired a wealth of experiences which provide important lessons for future direction of its own programme and for similar activities elsewhere.

### The scenario

It can safely be generalised that the cereal-based segment of Ethiopian subsistence agriculture where cereals occupy about 80% of the total cultivated area each year is concentrated in the highlands above 1500 m asl. The highlands constitute about 44% of the country but the concentration of both population and cereal production is found here. Not surprisingly, severe ecological destruction resulted in consequence of the high misuse of resources. It has even been argued that any deviation from the normal farming condition, could easily disable about 60% of the rural population from meeting its basic food

requirements. Yet, it is here that more than 13 million hectares of the dark clay, the Vertisols, are found. These soils with their characteristic shrink-swell properties pose soil-management-related production constraints of waterlogging and fertility. It then follows that potentials have not been fully exploited to maximise productivity leading to a generally stagnant cereal production hence low productivity of land and labour in Ethiopia.

No less important is the fact that contrary to popular belief, fertile land not put under productive use within the means available to the rural farming community is not that much. Equally, the available base-line information on the soils of Ethiopia as well as the concomitant fertiliser use must dispel the myth and illusion that Ethiopia is a very fertile country. The highlands might have offered a habitable environment but not the required land productivity. In contrast, surrounding the highlands are large semi-arid valleys with considerable Vertisols and soils with vertic properties which enjoy the luxury of major rivers that are virtually untapped and/or underutilised. These offer ample potentials for highly productive and sustainable agricultural development.

Pertaining to the need for increased agricultural productivity, a major production breakthrough in cereal self-sufficiency is possible through increased production per unit area followed by increased land under cultivation. Among other things, intensification of production through double cropping, supplementary irrigation from divertable streams could lead to considerable achievement. This would have enormous cumulative effects through the effective utilisation of such resources as land, water, fertiliser, fodder etc which, by necessity, must be augmented by improved varieties, agronomic and/or cultural practices etc with provision to avoid postharvest losses.

On the other end of the spectrum is the stark prospect of the country becoming ever more import-dependent and the inability of increasing food availability to the level of 2000 calories per day. This stark prospect could be a reality if the current rate of population increase is not balanced by major breakthroughs which permit intensification and diversification through the use of appropriate R & D technologies. This could be the overriding concern of the peoples and Government of Ethiopia. Thus, unless massive investments are made that call for further research and development the productivity of the underutilised Vertisols will not be raised.

## **The joint Vertisol project**

The main features of Vertisols are highly characteristic. Emanating from the mineralogy of montmorillonite, Vertisols have shrink-swell properties depending on the soil moisture status. Hence, they form hard clods when dry but become sticky and form into puddles when moist. Workability is a major physical problem associated with the agricultural use of Vertisols in high-rainfall as well as in irrigated areas. Low crop yields on these soils are directly or indirectly related to their poor internal drainage, with effects on root penetration, root deformity, aeration, nutrient uptake etc. These are important for both crop and livestock management because they provide opportunities to increase production if properly managed.

About 7.6 million ha of Vertisols are in the highlands above the 1500 m contour in areas of traditional mixed smallholder farming. They are extensively cropped in cereal-based production systems. It is estimated that some two million ha of Vertisols representing as much as one-third of the total national cropland are under arable crop cultivation. In the management of dark clays, both crop and animal production systems should, however, take account of other vertic soils with which they are associated and behave similarly to Vertisols in their management. The total hectareage of vertic soils in Ethiopia is thus increased to 12.2% or 14.4 million ha (Berhanu Debele, 1985).

Despite the fact that the fertility of Ethiopian Vertisols is comparatively above average, with deficiencies of nitrogen and, to a lesser extent, of phosphorus (Berhanu Debele, 1985; Mesfin

Abebe, 1979, 1980, 1981, 1982; Kamara and Haque, 1987), Vertisols are generally regarded as marginal soils for crop and livestock production, mainly due to their physical properties. However, the high waterholding capacity of Vertisols makes them comparatively low-risk soils, in the sense that once recharged they will bridge even prolonged dry spells in the growing season and sustain crop growth and yield. In this context, it has long been realised that waterlogging is severe in the highland Vertisols where high-rainfall and low evaporative demands prevail (Tesfaye Tessema and Dagnachew Yirgou, 1967; Mesfin Abebe, 1981, 1982; Jutzi and Mesfin Abebe, 1987).

Traditional farming, nevertheless, has developed a wide range of practices. One of these concerns Vertisols where the use animal-draught power and low-yielding crop germplasm adapted to poor internal soil drainage or germplasm, perform reasonably well on residual moisture after the main rains. The most widely practiced system since antiquity is using the local plough to construct narrow ridges and furrows at sowing. The crops grow on the ridges and the excess water drains out from the root zone to flow out of the field through the furrows, or to pond in the furrow.

Another system, which is the historic precursor of the new broadbed-and-furrow (BBF) technology (Jutzi and Mesfin Abebe, 1987), consists of drawing shallow drainage furrows with the local plough at varying distances across the contour and thus forming a raised seedbed. In very limited areas, more sophisticated surface drainage structures are utilised. These are broad beds and furrows of about 120 cm wide, and made entirely by hand. The operation entails the participation of the whole family, including women and children.

Soil burning is practiced at high elevations exceeding 2400 m asl, where considerable organic matter (soil) accumulates subsequent to extended fallow period, ranging from 10 to 20 years (Tesfaye Tessema and Dagnachew Yirgou, 1967; Mesfin Abebe, 1981; 1982). Soil burning not only enhances *in situ* drainage through the transformation of micropores into macropores as a consequence of the cementing and aggregation of clay into sand- and gravel-sized particles, but it also contributes to the mineralisation of nutrient elements from organic matter, thereby promoting improved plant nutrition. Soil burning, however, is not only a tedious practice involving women and children, but introduces inefficient land use when considering the extended fallow period before land can be brought into repeated production.

Researchers, however have long recognised (Tesfaye Tessema and Dagnachew Yirgou, 1967; Mesfin Abebe, 1981;1982; Jutzi et al, 1987a; Getachew Asamenew et al, 1989) that with the exception of the hand-made broadbeds and furrows, the traditionally applied surface drainage techniques are inadequate to allow the full realisation of the potential of Vertisols. These considerations were the basis for the establishment of the Joint Vertisol Project on Improved Management and utilisation of Dark Clay Soils in Ethiopia.

While research at each level of resource utilisation is necessary, integrative research that links all levels is required for long-term sustainable agricultural resource use. Thus, at the outset research requirements on Vertisol utilisation were recognised to be potentially comprehensive and overwhelming, and a strategy of intelligent choice was considered to be of paramount importance for its successful progress. Conceptually, the integration of development institutions in the Joint Vertisol Project was to safeguard effective research development linkages for technology transfer and feedback generation from the field to research. Nevertheless, there were many instances in important Vertisol areas where local institutional complexity of a multi-institutional research and development project has had both positive and negative aspects. On the one hand, it may provide unique permanent fore for information exchange and decision generation across often tight institutional borders; on the other hand, it may contribute to rather heavy decision processes and little transparent overall project representation. Hence, there was a deliberate attempt to reduce the inherent complexity of resource management research while maintaining a systems approach to problem solving.

The strategy recognised the inter-relationship between economic ecological, social and political parameters in the analysis of land-use issues and in the design of options. Collaboration was thus to be encouraged among the following institutions:

International research institutions such as -

- ILCA (International Livestock Centre for Africa)
- ICRISAT (International Crops Research Institute for the Semi-Arid Tropics)
- IBSRAM (International Board for Soil Research and Management), an international research network sponsoring institution; the national agricultural research systems in Ethiopia, namely
- IAR (Institute of Agricultural Research)
- AUA (Alemaya University of Agriculture)
- AAU (Addis Ababa University);

and the formal agricultural development institutions, namely:

- the Ministry of Agriculture, and
- the Relief and Rehabilitation Commission.

In addition to the above, attempts were made to involve non-governmental development organisations in technology field testing and pilot extension activities.

The Joint Vertisol Project also recognised, where possible, indigenous knowledge as the starting point. To this end, the JVP worked in association with people who had traditional knowledge or with those who regulate the use of resources. Experience so gathered constituted a "store-house" of knowledge. Therefore attempts has been made to replenish the store house or at least keep under control the loss of information and lack of coordination.

The Joint Vertisol Project would, thus, represent an exemplary model of interinstitutional and inter-disciplinary collaboration towards the support and sustenance of agricultural and natural resource development. Here, the classical trinity functions of instruction, research and extension were integrated to play a vital role in the conservation, development, utilisation and monitoring functions of our fragile environment.

The identification of a problem and the search for the solution thereof is a great task, an almost impossible task at times. In this context, the Joint Vertisol Project has made impressive progress and a qualitative leap. JVP's bold initiative in its short life of seven years resulted in creation of critical mass going hand in hand in the inter-play of comparative advantages and complementarities. Some of the advances constitute giant steps while others are a modest contribution but nevertheless encouraging considering the difficulties and obstacle, which constituted pitfalls in the search for direction. Notwithstanding, these same difficulties and obstacles indeed were valuable sources of strength and inspirations in the formulation of the new Joint Vertisol Programme. In retrospect, this becomes more true and can be best appreciated because the Joint Vertisol Project was initiated at a time when the military government intensified its attempts to collectivise agricultural production; where the risk-taking attitudes even among progressive farmers was dampened in a scenario of a *Dergue* policy that was inversely related to participatory developments; and in a setting where a reliable, sufficiently stable agricultural environment which respects established cultural structures as a precondition for vigorous, and sustainable technology adoption did not prevail.

## Achievements lessons learnt

### Achievements

A number of national institutions have been involved in the identification and mitigation of Vertisol-related problems, but in a rather loose collaborative setup. But, emanating from the rationale that the general availability and economic viability of animal power for Vertisol cultivation in the Ethiopian highlands should allow the addition of animal-powered surface drainage construction with concomitant increased productivity of both grain and straw, towards food self-sufficiency in Ethiopia the Joint Vertisol Project was initiated as a research, training, and outreach project aimed at improved management of Vertisols in the Ethiopian highlands. From the outset, national and international institutions joined in the operation, along with their respective interests, mandates, and comparative advantages relevant to the undertaking (Jutzi and Mesfin Abebe, 1987; Jutzi et al, 1988a).

The constitution of the advisory and technical committees, and the general agreement on institutional coordination, constituted the basis for a considerable degree of research and development integration. While the extent to which this can be implemented is a function of time, project success, and the commitment of each participating institution, it was planned to address the development of the Joint Vertisol Project in three stages:

- a) consolidation of Vertisol-related activity planning and implementation in participating institutions with necessary support organization across institutional borders;
- b) organisation of comprehensive programmes for research and development with the aim of implementing the projects' internal procedures for the formulation of priorities, strategies, and the execution and reporting routines for collaborative projects across institutional borders; and
- c) acquisition of funds and major strategic inputs, including those necessary for the training of qualified manpower for national institutions in order to remove operational constraints (Jutzi et al, 1988).

### Consolidation and activity planning

The initial phase focussed on the coordination of research activities and establishing the basic research groupings and information-exchange mechanisms required for inter-institutional agreements on this coordination. Within the framework of the project, considerable research protocols were established which included soil-water management, tillage, cropping systems and nutrient management. When designing options there was no attempt to assemble a comprehensive technological package, but rather stand-alone technological elements which could be introduced and combined as per the opportunities of a target-farming community. This project strategy to ease the process of management-technology adoption was the result of an early involvement of farmers in technology development.

### Programme development and implementation

The animal-powered conventional tine-plough broadbed maker (BBM) as developed by ILCA which is an implement within the technical and economic reach of small farmers thus offer an option for reducing drastically the drudgery of seedbed preparation as in the soil-burning practice or in hand-made broadbeds and furrows. Through the use of the BBM for implementing effective surface drainage, participating institutions designed and executed a number of trials on the effects of improved drainage on crop germplasm and cropping systems, and on soil fertility management in improved cropping systems.

In this process, ILCA provided to all national partner institutions extensive training opportunities in the manufacture of the animal-drawn surface drainage implement, and in handler and oxen-training. Through its core funds, a number of short-term training opportunities were offered to Ethiopians at both ILCA and ICRISAT. Logistical support was provided to the Ethiopian NARS during the initial phase of the Project.

In the second year of the Joint Project (1987), ILCA in collaboration with the NARS, organised an international conference on the management of Vertisols in sub-Saharan Africa, in Addis Ababa, Ethiopia. The proceedings of the conference have since been published (Jutzi et al, 1988).

ICRISAT not only provided specific training in economics, agro-ecology, and soil and water management to Ethiopian scientists, but was also consistently represented at the regular meetings of the Technical Committee. In addition, ICRISAT seconded a senior ICRISAT scientist to the Ethiopian Vertisol Project particularly for research work on watershed management.

The concerted efforts made in the Joint Vertisol Project were further enhanced by the creation of Vertisol research teams at IAR and AUA with a mandate to carry out research on tasks agreed upon within the Joint Vertisol Project. Therefore, a growing appreciation emerged to define more sharply the responsibility domain of partner institutions within the overall programme. With the regular exchange of experiences, the buildup of mutual trust, the confidence in the Joint Vertisol Project and hence greater commitment by participating institutions, more understanding on research task-sharing within the Joint Vertisol Project was achieved in 1988. This implies the delegation of "intellectual leadership" for comprehensive coverage of the research areas assigned to each institution. Even with the institutionalisation of the "intellectual-leadership" approach, it is recognised that substantial flexibility is indicated to safeguard institutional autonomy.

### **Acquisition of funds**

Research on natural resource management in the comprehensive sense requires, as stated above, the concerted action of several institutions for the research agenda to be adequately treated.

The Joint Vertisol Project successfully integrated international and national research institutions around a broad agenda of interest such as agricultural research and manpower development where the AUA and the IAR jointly represent the major elements of the Ethiopian NARS while the MOA represents the extension arm.

Funding was sought in order to strengthen and enlarge the national network of research, training and extension activities of the NARS, the MOA and others with a supplementary budget from the Ethiopian Government. The objective was the establishment of an inter-institutional understanding of the problems and their possible solutions set on priority basis. While research tasks were shared among participating agencies along institutional mandates and individual scientists' priorities, commitment of the institutions during the project life was naturally variable.

Experience has shown that formal support of the shared research agenda by the chief executive of an institution is required for that institution's contribution to be commensurate with expectations.

Effort was made to acquire hard currency funding for all active partners; and detailed research portfolios were elaborated for activity-based budget submissions to the donors.

In view of the rather precarious recurrent funding situation of the national research system,

incremental, particularly hard currency capital and supply funding is required at this level for safeguarding working conditions at least technically comparable with international project partners. The Joint Vertisol Project has, in cooperation with the main project donor, the Swiss Development Cooperation Agency (SDC) and through mediation by ILCA, elaborated a mode of fund acquisition and handling which is one viable example of complex resource management research activities likely to become more frequent in the future, particularly in the context of the ecoregional research approach within the CGIAR (Consultative Group on international Agricultural Research).

Features of this funding operation are (1) an agreed research agenda based on comparative institutional advantages, (2) activity-based budgets, (3) equal material cost standards for all partners and (4) presence of an honest broker or mediator institution for fund handling. In the experience of the Joint Vertisol Project the latter role may preferably be with an international agricultural research centre which by mandate and strategy is required to look for effective research alliances with national agricultural research systems. Such research alliances are indeed likely to be very effective tools for the generation of technologies. Their balanced and equitable funding, however, requires adequate attention for them to be sustainable.

## **Lessons learnt and the prospects**

Convincing evidence for the strong impact of Vertisol surface drainage on crop production has motivated a number of international and national agencies to direct increased attention to the agricultural utilisation of these soils. A formal agreement on the coordination of these efforts has been adopted and quite detailed procedures for the implementation of inter-institutional research and development initiatives have emerged from this agreement. It has now been confirmed that improved Vertisol management technologies are the result of multi-disciplinary efforts. These efforts have dealt with agroecological and socio-economic resource assessment of Vertisol areas. Improved soil and water management, new cropping systems for drained Vertisols, improved land management techniques, and on-farm technology verification were also included.

The initial phase has focused on the coordinating research activities and establishing the basic information exchange mechanisms required for inter institutional agreements on this coordination. The research emphasis has been on the use of an animal-drawn implement, the broadbed-and-furrow maker, that enhances surface drainage, thus reducing waterlogging.

During the intermediate term, the emphasis was on crop germplasm, cropping systems, and soil fertility research on Vertisols with improved drainage. The aim was to offer improved agricultural Vertisol utilisation technologies to generate maximum returns from scarce available resources. To achieve these aims, there was a need to further integrate the research and development of participating institutions so as to generate and transfer technology more rapidly primarily in smallholder mixed crop-livestock farming systems for very substantial returns in terms of grain and crop residue production. Given the large acreage of Vertisols in high-rainfall, high-potential highland areas of Ethiopia, and given the large gap between actual and potential production from these soils, these returns may have a significant bearing on the national thrust towards food self-sufficiency.

Despite the conceptual clarity and the symphonic working relations of partner institutions in the JVP, funding for development, and especially for research activities, tended to be chronically deficient. The coordination of effort is therefore crucial for the judicious use of scarce available resources in order to maximise the returns from the respective investments.

It is generally understood that each participating agency will, in principle, independently fund its own Vertisol-related activities. The CGIAR centres involved also pledged to provide strategic inputs into national research and development institutions and to be instrumental in

catalysing incremental funding for national partner institutes to implement agreed activities. Such executive commitments to the Joint Project were made by AUA, IAR, IBSRAM, ICRISAT and ILCA. In the experience of the Project, the formal inclusion of institutions without such high-level commitment was probably somewhat inconsiderate in that it tended to create an erroneous impression of programme strength and did lead to a dangerous gap between expectations and performance.

Institutional complexity of a multi-institutional research and development project has both positive and negative aspects. On the one hand, it may provide unique permanent fora for information exchange and decision generation across often rather tight institutional borders; on the other hand, it may contribute to rather heavy decision processes and little transparent overall project representation. This latter aspect is a particular problem in programme funding. There is therefore, much justification for careful preparation, discussion and application of exigent criteria by which formal membership in the multi-institutional project may be awarded or withdrawn. Formal executive commitment to the joint programme is also prerequisite since internal and external fund allocation to the activities agreed are within the programme.

We now note that agricultural research centres such as those within the CGIAR system have an important innovative potential given the considerable human and material resources allocated to them. However, these centers can only fully exploit this potential for the benefit of their mandate areas if they are all properly linked with national research and extension systems where such a diversity of activities requires a large degree of intra- and inter-institutional coordination. The work of individual institutes therefore, can be substantially upgraded if directly or indirectly assisted by collaborators of partner institutes working along similar lines. The assembling of a critical mass of information is thus more likely to be achieved from more areas of work and in less time. This becomes more obvious during the implementation stage thus further underlining the fact that many institutions have conducted research on soils which are essentially similar, but which require somewhat different management according to rainfall amount, and distribution differences.

Conceptually, the integration of development institutions in the Joint Vertisol Project was to safeguard effective research-development linkages for technology transfer and feedback generation from the field to research. Therefore, improved surface drainage technologies, once validated on-farm, should be brought into the extension phase as soon as possible. This will involve the extension services of the Ministry of Agriculture, as well as institutes mandated with research. In the experience of the JVP there were many instances in important Vertisol areas where local and regional Ministry of Agriculture officials agreed to embark on Vertisol management technology extension at the pilot or even on a larger scale. There was, however, no decision at the executive Ministry level for such activity to be within its central mandate. The institutional integration of research and development was therefore not as successful as anticipated.

JVP must conclude from this experience that it should abstain from formally integrating the research and development sectors and rather address research and extension agendas in separate, though interlinked institutional set-ups. The aims of the collaborative research were to study Vertisols management in a range of wet to semi-arid environments, and, by exchanging experience between similar areas, to evolve locally adapted management techniques and cropping systems.

Agreed priorities for Vertisol management research include soil water management and tillage problems. The aim has been to develop techniques for using as much as possible of the water received while also providing surface drainage to avoid waterlogging. Man-made microrelief patterns to improve surface drainage include cambered beds, ridges, narrow beds and furrows, and broadbeds and furrows. In very dry areas, water harvesting techniques involve planting crops in the furrows rather than on the beds and ridges. These aspects have also



been tried. Some M.Sc. and Ph.D thesis have also been undertaken (Ali Yimer, 1992; Selamyihun Kidanu, 1992; Tamrat Tsegaye, 1992).

All told, research must be linked with development. Hence there is a need for pilot extension projects to be an integral part of the Joint Vertisol Project with the Ministry of Agriculture to prepare the implementation of a general Vertisol management line and its increased responsibility in setting a logical framework for activity planning and programme direction in the Joint Vertisol Project.

In some quarters it has become fashionable to refer to "women's role" and 'participatory development'. Such euphemism does not apply to the Ethiopian woman because the role of women in improving the Ethiopian subsistence agriculture is high. This is important in Vertisols where it is estimated that, depending on localities, women contribute from 50 and 91 per cent of the labour input. Corrective measures that remove the household chores and the back-breaking drudgery of making hand-made BBF would unleash a formidable working force. Thus, appropriate projects need to be designed to gain the meaningful participation of women in future development programmes.

With the advent of appropriate research and development and the ushering of decentralisation, the prospect of making traditional agriculture responsive to the changed situation, and hence increased productivity, looms large. This is because of the prospects of favourable government policy and its implementation being streamlined. Hence, the motivation and popular participation of the rural communities needs to go hand in hand with agricultural extension programme. Thus, the cooperative initiation and implementation of the activities will seek a high degree of coordination between NARS, international communities and finally the government. Unlike the top-down approach of the past, the current democratic situation allows provision for a genuine participation with the community. Hence, there is a need to guarantee the formulation and adoption of participatory extension service" for promoting sustained agricultural development. As a consequence, cognisance must be taken of social dynamics in the conceptualisation, designing, and implementation of projects that would involve popular participation on Vertisols towards their sustainable utilisation.

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