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Diffusion of Rural Innovations: Some Analytical Issues and the Case of Wood-burning Stoves

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Summary. – The literature on the diffusion of rural innovations in Third World countries reveals a spectrum of approaches to the diffusion process. It is argued here that the effectiveness of a particular approach in the diffusion of particular innovations would depend on the technical, the economic and the social characteristics of the innovations. A typology of innovations in terms of these characteristics has been drawn up. This provides the analytical framework within which the instance of wood-burning stoves is concerned. *A priori*, the characteristics of this innovation are seen to be such as to necessitate the close involvement of the users in the design process itself; they point to the likely inappropriateness of the usual 'top-down' approach to diffusion. Available evidence relating to actual experience with promoting wood-burning stoves is seen to bear this out.

1. INTRODUCTION

From the theoretical and empirical literature on the diffusion of innovations[1] in the rural areas of Third World countries, a spectrum of approaches (often varying by academic disciplines) to the diffusion process can be gleaned. Essentially these approaches differ from one another in their degree of concern with, and emphasis on, the relative importance of different factors likely to affect the adoption of an innovation. In this paper, a brief summary of the differences in these approaches is presented, and it is argued that not all approaches would be equally suitable for the diffusion of every innovation. Innovations differ from one another in what could be termed their technical, economic and social characteristics, and the likely effectiveness of a particular approach in the diffusion of a particular innovation would depend on these characteristics. A typology of innovations based on these characteristics has been attempted in the paper.

This provides the analytical framework for considering the instance of improved wood-burning stoves. The promotion of these stoves is being widely sought as an essential component of the strategy for alleviating the 'woodfuel crisis' facing many Third World countries today. However, existing evidence indicates the ineffectiveness of many of these stove diffusion programmes, either in ensuring initial adoption or in bringing about the expected saving of wood, when adopted. It is suggested here that the reasons for this would lie in the characteristics of wood-burning stoves being such as to make their diffusion among a mass of rural users a complex process, requiring a different approach from the usual 'top-down' method typical of most diffusion programmes. In particular, it is noted that the process of innovation (the designing of a stove) needs to be integrally linked to that of diffusion, since the degree to which the user is involved in the design process itself can be significant in determining whether or not the stove is adopted, or continues to be used when

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adopted. However, the acceptance of user-involvement as a necessary condition for diffusion, in turn, is seen to raise the wider question of *how* the needed close and harmonious interaction between scientists/professionals, extension workers and village users (often women of poor peasant households) can be brought about in most Third World countries, where economic and social inequalities are high, and where the ways in which these groups relate with one another are often extremely hierarchical. Existing material, both specific to wood-burning stoves and general relating to other rural innovations and rural development programmes, has been drawn upon in the discussion.

In Section 2 of the paper, which follows, I seek to identify the main approaches to the diffusion process from the literature; in Section 3 a typology of rural innovations, on the basis of broad analytical distinctions between them, is drawn up; in Section 4 the problems relating to the diffusion of wood-burning stoves are discussed; Section 5 contains some concluding comments.

2. APPROACHES TO THE DIFFUSION OF RURAL INNOVATIONS

A review of the literature on the diffusion of rural innovations in Third World countries reveals a wide range of studies covering a variety of innovations: new agricultural practices, High Yielding Variety (HYV) cereals, contraceptive technology, health technology, and so on. Their essential differences, however, may be seen to lie in what are considered to be the main factors constituting bottlenecks to or catalysts in the diffusion process.

Broadly, these factors are seen to concern the following (often interrelated) aspects: the attitudes and personality traits of the individual adopter; the physical attributes of the innovation and the method of its first generation and subsequent development; the economic costs/ benefits associated with it; the supporting rural infrastructure; and finally the socio-economic structure of the community.

In numerical terms, probably the largest number of studies would belong to the approach best characterized by the work of Rogers and his 'school'.[2] This approach takes both the need for the innovation and its attributes as given, and concerns itself primarily with the process of communicating information on the predeveloped innovations to the final users. In so far as the potential users recognize the need for the innovation, the process of diffusion reduces to arranging an information delivery system (mass media, extension agents, demonstration trials and so on).[3] However, for those who do not recognize the need (those lacking in 'venturesomeness', the 'sceptics' etc.), the diffusion process would also require overcoming their 'scepticism' and 'persuading' them to change their 'attitudes'. Here the role of the informal, interpersonal communication channels or 'network' is taken to be primary, as is the role of the 'change agents' and 'opinion leaders' within it.

The extent and pace of diffusion (and hence its success or failure) are thus seen to depend on the one hand on the personality characteristics of the potential adopters, and on the other hand, on the efficiency with which the 'network' channels can function. This functioning, in turn, is seen to vary with the degree of 'traditionality' or 'modernity' of the 'social system', the latter being defined as 'a collectivity of units which are functionally differentiated and engaged in *joint* problem solving with respect to a common goal'.[4] Rogers, while allowing for the possibility of social hierarchies within this social system, sees them essentially as influencing the individual's *behaviour* – his/her response to 'communication stimuli' – and not the individual's *ability to adopt*. Interpersonal relationships within the social system are thus seen as being complementary rather than antagonistic in nature.[5]

All in all, by this approach (which could be termed the 'straight transfer' approach), problems of diffusion are basically seen as problems of information-communication and persuasion. Aspects such as the unsuitability of the innovation itself, or difficulties arising from the material conditions (rather than personality traits) of the potential adopter, are little emphasized. Also, the relationship that is implicit in the approach, between those seeking to promote the innovation and the potential adopters, is unequal and hierarchical; the promoters are seen as the ones with superior knowledge and the rural poor as those who do not know what is good for them.

In contrast, a number of other studies recognize that the user's decisions are usually based on rationality, subject to social, economic and cultural specificities. These studies place primary emphasis on the process by which the technique itself is generated and developed, and on the need to ensure its suitability to the user's requirements. They point out that the distinction between innovation generation and diffusion is a false one, and that the innovation

cannot be taken as exogenously given but must be developed/adapted in the field itself. The feature common to most such studies is their emphasis on the desirability of close interaction with, and involvement of, the final user in the innovation process itself. Where they differ is in the degree of involvement envisaged.

In some, the need for user-involvement is admitted essentially in the final stages of the innovation process, that is, a prototype of the innovation would have been developed in the laboratories/research stations and then adapted to the environment (especially physical) of the users. Griliches' study[6] on the diffusion of hybrid corn, although based in the USA, is of interest here, since it presents one of the earliest attempts to incorporate adaptation to varying ecological conditions, as an essential component of the diffusion process. A variant of this approach is implicit too in Rosenberg's following statements:[7] 'Innovation is simply the beginning of the diffusion process' and 'the diffusion process is typically dependent upon a stream of improvements in (the) performance characteristics of an innovation, its progressive modification and adaptation to suit the specialized requirements of various sub-markets'.[8]

Others emphasize that a prototype of the innovation can be obtained from the users themselves and then given sophistication by the scientist in the laboratory. They argue that users often generate innovations or undertake innovative adaptations, which might lack technical sophistication, but which are significant in that they directly manifest user's needs, and embody a store of indigenous knowledge and skills which should be brought into use. This assumption underlay the attempt in Meiji Japan to involve the farmers in the innovative process: 'Intimate knowledge of the best of traditional farming methods was thus the starting point for agricultural research and extension activities'.[9] This again was the idea underlying the promotion in China of the 'three-in-one' innovation teams (a combination of workers, technicians and management personnel) within factories, during the Cultural Revolution, and of a close relationship between peasants and Research and Development (R and D) personnel during the early 1970's.[10] These attempts are in sharp contrast to the one-way flow of information under the 'straight transfer' approach.

Adaptation of innovations whether in consultation with users, or with the help of users, or taking user-innovations and then adapting them, is also seen to have additional advantages, *viz.*:

(a) Preventing indigenous skills and knowledge from dying out: this could happen when outside knowledge legitimized by the superior status of the 'experts' (scientists, planners, extension agents) undermines and destroys the confidence and ability of the local experimentor/innovator,[11] or if indigenous skills fade away through lack of use.[12]

(b) Helping to further develop indigenous skills and knowledge. This, in turn, can enhance the future possibilities of indigenously-generated innovations through the 'learning by doing' effect,[13] or through the release of the 'latent, creative and managerial energy of the farmers'.[14] Additionally, it can enable the users to gain a better technical understanding of the innovations initially generated outside, and this gives them a greater control over and involvement in the process which changes the technical basis of their lives.[15]

(c) Ensuring that the innovation is appropriate to users' needs: this together with the users' increased sense of involvement and understanding of the technical aspects underlying the innovation, could bring about a more ready acceptance and hence successful diffusion of the innovation.

However, in this context, some studies while emphasizing the need for innovation adaptation, point out that the ability of a country to successfully undertake adaptation would depend on the working of its formalized R and D system. Hayami and Ruttan,[16] for example, attribute the 1960s' lag in the adoption of HYV cereals in Asia to an inadequate development of local R and D facilities.

Other studies, however, which also deal with the diffusion of HYVs give greater importance to the user's ability to gain access to complementary inputs (fertilisers, irrigation), and to credit. They argue, essentially on the basis of the vast volume of literature relating to attempts to popularize the improved crop production technology,[17] that institutions providing information, credit, production inputs, etc. are so dominated by the interests of the few who are economically and socially powerful, as to preclude the majority of the people from access to the innovation. In other words, even if the innovation is technically suited to a users' needs, the user may still not be able to adopt it if he/she belongs to an underprivileged section of society.

The degree of institutional transformation seen as necessary for overcoming these biases again varies between studies. Some merely point to the inadequacies of the extension system, the attitudes of the extension workers,[18] or the constraints (diversity of functions, inadequate training, frequent transfers, low pay scales) that define the work conditions of these people.[19] Others emphasize the rigidity of bureaucratic rules and procedures, the red-tape and the hierarchical structures of bureaucracies.[20] Only a few point to the class basis of society (which might govern both attitudes and institutional working), and question the feasibility (if not relevance) of bringing about piecemeal changes in the working of specific parts of the State apparatus.[21]

To sum up, we note from the above that studies dealing with the diffusion of rural innovations vary widely in what they emphasize as being the main hindrances to or aids in the diffusion process. This variation in emphasis may be seen on the one hand to result from differences in individual judgement, and on the other hand, to relate to the type of technology being promoted. Reserving judgement for the moment, a classification of rural innovations by some analytical categories would be helpful in gaining a better understanding of the likely importance of different factors in the diffusion of particular innovations. In the next section such a classification is attempted.

3. SOME ANALYTICAL DISTINCTIONS BETWEEN RURAL INNOVATIONS

The suitability of a particular approach in the diffusion of a particular innovation may be seen to depend on what could be termed the technical, the economic and the social characteristics of the innovation.

For example, the technical (physical) characteristics become important in determining the extent to which a technology can be generated or adapted in the field rather than in the laboratory (depending, for example, on the material components needed for its development), and by the users themselves rather than by the scientists (depending, for example, on the users' familiarity with the technology or process which forms the basis of the innovation). Thus, the possibility of generating contraceptive technology or vaccines or designing watches, radios, etc. outside the laboratory, clearly would be limited, while that of field adaptation of crop varieties, tree species, and methods of performing agricultural tasks would be considerable.

Again, the kinds of problems likely to be faced with diffusion, and the appropriateness of any specific approach, would be related to the economic and the social characteristics of the innovation. One way of defining the economic characteristics would be in terms of (a) the form – financial or non-financial – in which the costs are incurred and benefits received by the adopter;[22] (b) the level of these costs and benefits; and (c) the quickness with which the benefits can be realized. One way of defining the social characteristics would be in terms of who the potential adopter is – whether it is the individual or the community; and if it is the individual, then of what class and social (e.g. gender, caste) grouping.

The economic and social characteristics together provide a possible way of classifying rural innovations. For purposes of illustration consider the following examples:[23]

(i) those representing a private[24] financial cost and yielding mainly a private financial production benefit: such as HYVs, mechanical agricultural equipment (tractors, threshers, private tube-wells), etc.;

(ii) those representing a private financial cost and providing mainly a private non-financial consumption benefit: such as watches, radios, etc.;

(iii) those representing a private financial and/or non-financial cost and providing mainly a private financial savings benefit: such as family-sized, private bio-gas plants, which would help save on purchased fuel such as kerosene, and on fertilisers through the slurry produced;

(iv) those representing a social/communal cost – financial and/or non-financial – and providing mainly a financial production benefit to the individual: such as irrigation canals, irrigation water reservoirs, etc.;

(v) those representing a social/communal cost – financial and/or non-financial – and providing mainly a non-financial consumption benefit to the individual: such as piped drinking water, public medical services etc.

(vi) those representing a social/communal cost – financial and/or non-financial – and providing mainly a financial and/or non-financial savings benefit to the individual: such as contraceptives which save on the cost of rearing

children both in financial terms (food, education, etc.) and in non-financial terms (work time); and environment conservation projects (soil conservation, flood control, reforestation, etc.).

These represent some broad illustrative categories. Basically, the list could be extended quite easily to cover other, and more complex, combinations of the economic and social characteristics. In practice, some innovations would fit into more than one category, depending on circumstances. For instance, clean piped drinking water in so far as it substitutes for polluted river water or is introduced in water scarce areas, provides essentially a non-financial consumption benefit (as indicated above); but if alternative sources of water are distantly located, it also provides a non-financial savings benefit (the saving of water-fetching time). Further, to the extent that it improves the health and hence the productive capacity of the individual, it could provide an indirect production benefit in the long run. Similarly, whether the costs/benefits of an innovation are mainly financial or non-financial in nature could vary by context. The essential point is that the nature of the characteristics is likely to define the ease or difficulty of diffusion, and an identification of these characteristics within a given context, would provide clues on the appropriate approach for diffusion in that context.

To elaborate, the effects of these characteristics on innovation diffusion would be manifest through: (a) the potential adopter's perception of the advantages of the innovation, and (b) the potential adopter's ability to gain access to its benefits. Consider first the issue of perception. In terms of the economic characteristics it can be suggested that the advantages of innovations such as HYVs and irrigation, which provide a direct, high, financial benefit, and in a relatively short time, are likely to be perceived more readily than those of innovations such as contraceptives or conservation projects whose benefits to the individual would generally be indirect, non-financial and often (for conservation projects) realizable only after a considerable period of time. Again, in terms of the social characteristics of an innovation it can be suggested that the advantages of innovations which men use are likely to be more readily perceived than those used by women, where decisions on cash expenditure are made by men.[25]

Next consider the problem of the potential adopter's ability to gain access to the benefits of the innovation. This again relates both to the economic and the social characteristics of the innovation. For example, innovations which require cash expenditure (the economic characteristic) are likely to be much more difficult to diffuse, particularly where the potential adopters are poor and have little cash at their disposal. Again innovations which require communal cooperation for successful adoption (the social characteristic) are likely to be much more problematic to promote. Here the basic difficulty is that the way individuals act within a group would depend on what assumption each makes regarding how the others will act, and on the degree of assurance that the burdens and benefits of effort will be equitably shared.

These analytical distinctions between innovations give clues about the likely importance of different factors in the diffusion process. For example, identifying the technical characteristics of the innovation would help determine the technical feasibility (if not relevance) of innovation development/adaptation in the field by the user. An identification of the economic and social characteristics would give an idea of whether the innovation can be promoted on a commercial basis like other items which are financially profitable or which provide direct consumption benefits to the individual adopter, or whether it requires a different approach dictated by the communal nature of the innovation, or by its being aimed at a mass of economically and socially underprivileged individuals of households.

A classification of innovations by these characteristics leads further to a number of practical questions as, for instance: if the technical characteristics are such as to permit, and in fact make it desirable, that the users be involved in innovation generation, then how can such an involvement be brought about? Or, where the potential adopter does not have the cash for the innovation which needs financial expenditure, then how can he/she be enabled to acquire the innovation? Or, where the decision to adopt rests with someone who is not the potential user and who therefore does not perceive the need for it, how can this perception be altered? Or, where decisions to adopt need to be communal in nature, how can the consensus of the community members be ensured?

In fact all these questions, in one way or another, link to the issue of social structure. We have noted, for example, that the diffusion of innovations which need communal co-operation, requires an assurance that there will be a fair sharing of the costs and benefits

among the community members. However, one can legitimately question whether such an assurance can exist in societies where the distribution of material resources and political power is highly unequal, and where the distribution of costs and benefits from new schemes may likewise be unequal. Most experiences of the failure of communal projects which involve heterogenous (in economic and social terms) groups of people, indicate that the reluctance of the underprivileged to participate in the programme is not located in 'irrationality' but in their specific material and social circumstances.

In this sense, institutional and structural changes may become important even when the innovation is not communal in nature, but is aimed at a large number of individuals rather than a few. For, the ability of many potential users to adopt the innovation, again would be dependent on the extent to which infrastructural facilities (such as extension, credit, etc.), serve *their* needs rather than being biased in favour of a few.

Similarly, when we consider the issue of benefit-perception by the individual household, as noted, divergent gender interests within the household may serve as a barrier to adoption. In this case, the social 'institution' which would need adaptation is the family which 'reproduces' specific attitudes of men and women towards one another.

It could likewise be argued that user-involvement too may need structural/institutional changes, since the success of this approach to diffusion is dependent on the degree to which a *dialogue* is possible between the scientists/professionals and poor peasants, or between male extension workers and female innovation-users, and dialogue usually requires equality (in attitudes, material conditions) between those conversing.

In short, the existence of divergent, often antagonistic interests defined by economic (class) and social (gender, caste, etc.) hierarchies is likely to constitute circumstances where the diffusion process cannot be treated merely as being a question of a 'straight transfer' or even solely as one of innovation adaptation, but as one where structural transformation (redistribution of material wealth, change in attitudes) might need to be a significant component of the diffusion process.

4. FACTORS AFFECTING THE DIFFUSION OF IMPROVED WOOD-BURNING STOVES

In applying the issues raised in the above section to improved wood-burning stoves (henceforth called wood-stoves), it is useful first to consider the context within which they are being promoted, that is, the purpose they are meant to serve, and the people they are meant to cater to. Subsequently the factors observed to (or considered likely to) affect their adoption will be discussed.

Recent interest in the promotion of wood-stoves stems from the growing recognition in many Third World countries of an energy crisis that relates not to the widely publicized scarcity of fossil fuels, but to the rapid depletion of a potentially renewable resource – wood – and to the implications of resultant shortages.

Currently wood is the single most important source of inanimate energy in large parts of the Third World: firewood and charcoal are estimated to provide two-thirds of all inanimate energy in Africa, one-third in Asia and one-fifth in Latin America.[26] In many countries such as Nepal, Tanzania, Uganda, Upper Volta and Chad, the figure is estimated to be 90% of total inanimate energy used, and for the majority of other countries in Asia and Africa, it is estimated as being well over 50%.[27]

The bulk of energy from wood is used for domestic purposes, especially cooking. Although no precise macro-estimates exist of the percentage of wood consumed directly as firewood relative to charcoal, micro-studies indicate that charcoal is used mainly as an urban fuel. In the rural areas, wood is generally burnt directly in most households,[28] and for a large proportion of such households (especially those in Asia and Africa) firewood would constitute the main and for some the sole source of inanimate energy. Given that 75% or more of the populations of most of these countries are rural based, this would account for a significant dependence by their people on this one source.

In most regions, firewood has been and still largely continues to be a non-monetized item,[29] so that people usually have to depend on what they can themselves gather. Rural households with land can obtain firewood from trees located on their own plots, supplemented by crop residues etc. The landless, however, have to depend on wood from common land or, where allowed to do so, gather it from other people's land, often in return for labour services. The collection of firewood is done mainly by women and children – a task which is both time-consuming and strenuous. For example, in the African Sahel, women are noted to walk up to 10 km, taking 3 hours per day for this purpose.[30] In the Niger, village

women are found to spend 4 hours per day,[31] while in Gambia it is usually seen to take from midday to nightfall, to gather an evening's supply. Although wood is a potentially renewable resource, deforestation due to a variety of causes (of which foraging of wood for fuel would be but one)[32] has led to an increasing scarcity of firewood in many areas, and the problem is likely to intensify over the years. The implications of these shortages are likely to be particularly severe for the poor (especially landless) households, who have been compelled in some parts of the world to shift, as a result, from cooking two to one meal a day.[33] Within the household, it is the women who are most affected, as it is *their* work burden which increases disproportionately as a result of the scarcity. Digerness[34] notes how 10 years ago, in Bara (Sudan) firewood was available after a 15–20 minute walk from the village, whereas now women have to walk for at least 1–2 hours. Eckholm[35] makes a similar observation for Nepal.

It is in this context that improved wood-stoves, by saving on the amount of wood needed by the household for cooking, are seen as one way of alleviating the problem. Clearly, however, the degree to which this goal is achieved would depend on the extent to which the stoves do in fact save wood in practice (and not merely in laboratory tests), and the degree to which they are acceptable by the mass of rural users, especially by the women of poor households who (as noted) experience the problem most acutely.

Applying the analytical framework outlined in Section 3 to this context, we can say *a priori* that the characteristics of this innovation are such as to make its diffusion a complex process. For example, its primary use is in cooking, an activity whose requirements vary by cultural norms and the specific needs of users; this would make it unsuited to mass production in the laboratory, and would require field adaptation to users' needs. Again the non-financial, indirect form of its benefits – essentially a reduction in women's work burden and labour time (which may have little or no opportunity cost in monetary terms[36]) in the collection of what is customarily considered a 'free' item (firewood) – would make it a low priority item, especially where the decision on adoption rests on men.

How these and other economic and social characteristics of wood-stoves tend to affect their diffusion in practice is the focus of the discussion that follows. It must however be stated here that evaluation studies on programmes for diffusing wood-stoves are extremely few, although those that exist are sufficiently detailed to provide rich illustrative material and useful pointers. Where relevant, literature relating to the diffusion experience of other rural innovations has been drawn upon, to illustrate particular points, and to support *a priori* reasoning *vis-à-vis* wood-stoves.

Broadly covering the aspects highlighted in Section 2, we could divide the factors likely to affect the diffusion of improved wood-stoves into five (often inter-related) categories: (a) technical aspects – the method of wood-stove designing and development; (b) economic aspects; (c) infrastructural aspects (extension, credit etc.); (d) cultural aspects (attitudes to change etc.); and finally what could be seen as the connecting link, *viz.* (e) social structure. Let us consider each in turn.

(a) *Technical aspects: method of wood-stove designing and development*

Available evidence strongly points to the unsuitability of a 'top-down' and 'straight transfer' approach for the diffusion of wood-stoves, and the importance of field adaptation involving the local users, local materials and local artisans. Consider two case studies. Prominent among these is Shaller's[37] research on the diffusion of the Lorena stove in the severely deforested highlands of Guatemala. This study is based on 36 in-depth interviews with stove owners, plus an intensive observation of the cooking practices of six families. The stove was developed in 1976 at the Estacion Experimental Choqui (ICADA), a small appropriate technology centre near Quezaltenango, and is meant to replace the open fire. Formed from a monolithic block of sand and clay (locally available materials) it is designed to conserve firewood (the promoters estimate a saving of 50%) and decrease smoke build-up in the kitchen.[38]

Shaller does not indicate what the level of initial adoption has been, that is, what proportion of those exposed to the stove have in fact adopted it. He notes an overall high level of acceptance of the stove in that most of those who have adopted it are using it daily, in lieu of the open fire. However, the effectiveness of the diffusion programme *vis-à-vis* one of its primary purposes, namely saving firewood, has been limited. This is because the users, while perceiving that the stove has a number of advantages (indicated below), also see in it several disadvantages which they have sought

to overcome by 'adapting' the stove to their particular needs, thereby reducing its efficiency[39] in terms of the wood-saving potential inherent in the original design.

As perceived by most users, the main advantages of the stove over the open fire are decreased smoke (although some households see this as a negative feature – this is where the house-roofs are of straw which the smoke-soot helps to seal and make water-tight, or where the smoke serves to eliminate pests from ears of corn hung from the rafters); cleaner and more comfortable working conditions (cooking can be done standing up); less effort needed in cooking (with the open fire, the pots are often in a precarious position and need constant watching); some saving of firewood (although no precise estimates of this were made, and only two families claimed saving half of the wood used previously, while four reported using the same amount as before).

The main disadvantages perceived by the users are that the stove provides no space heating; the cooking surface is inflexible in that the pot holes provided in the body of the stove limit the number and size of pots which can be used; the pots often do not fit the holes (causing smoke and heat to escape), and the stove needs more careful maintenance.

Attempts by the users to 'adapt' the stoves to suit their needs include removing the firebox door to provide some space heating, making almost exclusive use of the firebox to cook individual foods quickly, rather than using all the pot holes for slow simultaneous cooking of different foods as had been intended in the stove design, the removal of the flue dampers due to an inadequate understanding of their functions in controlling and directing heat flows inside the stove, the use of the firebox as an oven (a use for which it had not been intended), and so on. In other words, the women have attempted to keep to the cooking techniques that they had been using with the open fire. Not all the adaptations have been in the nature of adaptations-in-use. In some, the owners have attempted ingenious improvements of the stove design, but adaptations-in-use have been more common.

The need for the users to make the noted 'adaptations', point to specific lacunae in the programme (as apparent at the time of Shaller's study). First, the specificity of users' needs has not been taken into account adequately in the design. If the local methods of cooking had been better understood, appropriate modifications could have been made without a loss of technical efficiency[40]. Second, the stove has been promoted as a piece of equipment rather than as a new process of cooking.[41] Yet subsumed in the design is a somewhat different process of cooking than that possible with the open fire. To enable the user to successfully adapt to the design, however, requires making the user more familiar with the basic principles underlying the improvements. The two-day stove building courses that have been held, have not gone into the simple theory underlying the improvements and the Lorena stove cooking process. Additionally, the participants in the course have been mainly men, while women are the primary users of the stove. Hence women are forced to learn how the stove functions on their own, or get second-hand (and inadequate) information from their husbands. That some users have an innate ability to adapt and manipulate the technology for use is apparent from the design modifications they have made anyway.

All in all, if there had been a deliberate attempt to integrate the innovation and diffusion processes, and to closely involve the local users/designers in the programme from the beginning, it would have been possible for information to flow in more than one direction, *viz.*: first, from the user to the outside designer in terms of the user's needs, thus enabling the development of a design more appropriate and satisfactory both in terms of efficiency and user-specificity; second, from the indigenous to the outside designer, thus making an appropriate use of indigenous technical knowledge and skills; and third, from the outside designer to the user in terms of basic principles, thus helping to further develop indigenous technical knowledge and skills. In particular, this would have needed the involvement of the village women. As the project had in fact been implemented up to the time of Shaller's study, this had not taken place.

Now consider another example. This relates to an attempt made in rural Ghana to replace the traditional fire by wood-stoves.[42] The model (recommended by the Canadian Hunger Foundation and the Brace Research Institute, and introduced by the Department of Social Welfare and Community Development in the late 1960s) was made from locally available scrap metal and hand-baked clay tile, brick and masonry, and was claimed to bring about a 50% saving in fuel. By the mid-1970s, however, it was clear that many of the women were not using the stoves earlier brought into use, and that the experiment had been a failure.

Hoskins, on the basis of the women's com-

plaints, identified a number of reasons for the failure: the stove needed larger pieces of wood than were available locally; the stove surface was too high for stirring large pots; the sizes of the pot holes were not suitable for many of the pots in use in the house; if the unused holes were not tightly covered or the pot fitted only loosely, smoke escaped, the pots were dirtied, and more rather than less wood was used than before. In other words, the stove design was not suited to the users' needs as there had been little or no interaction between the designer and the women prior to designing the stove. A 'straight transfer' approach had been followed, where adaptation through user-interaction and involvement was necessary. Unlike the Guatemala experiment, however, no attempts were noted here of the users themselves adapting the stoves.

Hoskins also provides some useful general insights into the sort of factors which have prevented the successful diffusion of wood-stoves in the many attempts to introduce them in African countries, such as:

- the failure to identify the key figures in the stove diffusion process, that is, the women who cook on the stoves, the local artisans who can help in designing stoves and utensils plus taking care of repairs and alterations, and the local extension agents;
- the imposition of laboratory-tried models incorporating 'western' standards of improvement and ill-adapted to the local setting and cultural norms;
- the failure to relate the physical elements of stove design to social realities. The adoption of stoves often places additional burdens on the women; for example, in the Ghana study quoted earlier, the new stove needed larger pieces of wood, which meant going further afield – a trade-off which the women were not willing to make.

While more case studies evaluating wood-stove promotion programmes from different parts of the world are clearly called for, these two, on the Guatemala and Ghana experiments, provide significant pointers. They strongly indicate that a close interaction between designers, users, local artisans and extension agents is likely to be a crucial element in the successful diffusion of wood-stoves.

(b) *Economic aspects*

The private financial benefits of investing in an improved wood-stove, as already noted, are likely to be small or nil where wood is still not generally purchased. The private financial cost of the investment would depend on what materials are used to build it. Where built from materials available locally, such as local mud or clay, the expense may be negligible. Where the material is difficult to procure and needs purchasing, some financial expenditure would have to be incurred. There could also be an indirect financial cost if the stove necessitates the purchase of new cooking utensils. Among the non-financial benefits of investing in an improved stove could be the saving of women's labour time, the absence of smoke (although this may not always be seen as a benefit), the greater ease of cooking where the stove is adapted to the most comfortable cooking posture, the saving of cattle-dung (currently burnt as a fuel) which has an alternative use as manure, and being able to maintain or improve nutritional levels.

From this list, it would be apparent that most of the potential benefits from wood-stoves are likely to be non-monetary and often in the form of intangibles, while the costs may in fact be monetary in nature. Also, these benefits may not always be perceived by the person making the decision to adopt, as for instance where the household men make the decisions and the benefits accrue mainly to the women. Further, the benefits, even as they stand, would not necessarily accrue to all the stove adopters. To begin with, the extent of non-financial benefits is in many ways dependent on the economic class of the household. For example, the saving of cattle-dung for manure would only be important to a land-cultivating household and not to a landless one. On the other hand, the effects on nutrition levels would essentially be felt by those households who are on the margin of subsistence, who cannot afford to buy alternative fuels and who therefore have to economize on it.

All these aspects introduce complexities in wood-stove diffusion. Such stoves cannot, for example, merely be placed on the market and promoted through advertisements. Like contraceptives or health-related programmes, their acceptability is determined by a range of factors other than the purely economic.

(c) *Infrastructural aspects*

In the present context, public infrastructure may be seen to serve basically three functions in the diffusion of rural innovations:

(i) in the development of the innovation;
(ii) in spreading knowledge of the innovation to the user: the provision of extension services;
(iii) in making it feasible for the potential user to acquire the innovation: the provision of credit.

What appear at first sight to be fairly straightforward functions of providing physical facilities are in fact complex, since whether or not these facilities serve the needs they are set up to fulfil, depends crucially first on the approach followed in delivering these services, and second on their degree of susceptibility to biases in favour of certain groups over others.

The issue of the appropriate approach to innovation development and extension was dealt with in detail earlier, when we noted how direct user-involvement can be a significant help in adoption, and that the line between innovating and diffusing can be a thin one. The focus here is thus on the biases in extension and credit services. Clearly, many of the issues discussed in this context apply to all rural innovations, and evidence on the bias in access to information on new innovations relates largely to the spread of agricultural technology, especially HYV cereals. In this context, it has been noted both in Asia and Africa that the mass media and extension agents tend to favour the economically and socially privileged households: village level agricultural extension workers typically contact the richer land-owning farmers.[43] The elitist attitudes displayed by extension workers *vis-à-vis* the rural poor have also often been commented upon.[44] Further, extension services tend to favour men over women. In both Asia and Africa, the government extension agents are typically male[45] and generally contact the household men, even when the information is directly relevant to the women, as is say agriculture-related information to women farmers.[46]

If the same biases carry over to programmes relating to improved wood-stoves, these are likely to adversely affect diffusion. For instance, if information is supplied only to men, women would not be in a favourable position to make or influence decisions on stove purchase. Further, appropriate adaptations would not be possible if women, who as users are in the best position to make suggestions, are not consulted. Also, given that in overall terms, women tend to be isolated from the flow of technical information, this is likely to have adverse implications for the accumulation and development of indigenous technical knowledge and skills. (There is clearly a case here for recruiting women extension agents who would not have the same problems as men in gaining access to women users.)

In addition to the noted biases, a related factor is the work conditions of the extension workers. The village extension agent usually has to handle work on a range of issues from agricultural inputs to family planning, but the training he/she receives is often not adequate to provide up-to-date knowledge .[47] Further, it has been observed that extension staff are very frequently transferred, so that any local experience acquired or rapport established with the villagers, cannot be used to full advantage.

The issues are thus two-fold:

(i) the method of bureaucratic functioning in Third World countries, which relates to the aspects of training, transfers etc., and essentially determines the quality of information imparted through the extension system;
(ii) the bias in approach and attitudes of the extension agents which determines to whom the information is imparted.

Next comes the issue of credit availability. This assumes importance to the extent that the stove itself, or the materials for building it, need to be purchased. Of course in absolute terms the expense would be small. But given that many of the potential stove users are the very poor who often have to incur debts even for consumption purposes, any extra spending, even if small, could depend crucially on access to subsidized credit for this purpose. However, just as there is a bias in access to information against the underprivileged groups in the community, so there is a bias in access to credit. There is overwhelming evidence for both Asia and Africa that cooperatives and other rural credit institutions typically tend to be monopolized by the economically and politically powerful groups within the rural community.[48] Also, credit from such institutions is usually given only for productive investments, and in so far as wood-stoves count as consumption items, specific schemes for this purpose would need to be introduced.

(d) *Cultural aspects: attitudes to change*

Not infrequently, problems of rural diffusion are attributed to the 'irrational', 'conservative' attitudes of rural people. Such explanations can be misleading. More often

than not, the problem is located in the potential adopter's particular economic and social position within the community. Further, what may appear to be irrational to an 'outsider' may in fact be perfectly logical within the potential adopter's cultural context, and an understanding to this context would be crucial for successful diffusion.

An interesting illustration is provided by Bajracharya's study of firewood use in Nepal,[49] where he notes how one set of his sample households use wood-stoves and hence less wood than the rest who use the open fire. These different technologies co-exist even though the households are located close to one another and the existence of efficient wood-stoves is common knowledge.

Here one or both of the following explanations could be valid. The first relates to religious beliefs and rituals. The households using the open fire believe that the *pitri devta* or 'family spirit' resides in it, and their reluctance to switch to the stove could be attributed to superstition. They belong to the indigenous caste groups in the area – the *Rais, Gurungs* etc. The stove-using households have migrated from outside, albeit some generations ago. They belong to the *Brahmin* and *Chhetri* castes and have a somewhat different set of religious customs. A second explanation relates to the fact that drinking alcohol is common among the *Rai/Gurung* communities who brew their own liquor. This is done in large pots which need the wider open fire rather than the narrower wood-stoves; among the *Brahmins/Chhetris* liquor is not generally consumed.

Both explanations emerge from the particular cultural milieu within which diffusion is being attempted. In so far as the cause of non-adoption lies in drinking habits, stoves could readily be designed to take this into account, although adaptation to take account of religious beliefs is more difficult. However, beliefs have themselves been known to be adaptable (see Hoskins on the three-stone stove in African communities[50]).

The potential adopter's attitudes towards particular innovations would also be governed by the person's past experience with innovations; and, equally important, the person's experience with past promoters of innovations. Where the same set of extension agents are used for promoting wood-stoves, as are used for promoting a range of other rural technologies from HYVs and mechanical equipment to contraceptives, their credibility with the potential adopter would depend significantly on the degree of success with these other innovations. In some cases, it is easier to get a completely novel idea accepted compared to an old one. For example, Joseph[51] notes how among the oceanic people who were unused to cooking pots, there was ready acceptance of cooking pots with lids, while in other communities where lid-less pots were common, the tendency was to remove the lids of the new pots as well.

Basically, the above discussion reinforces the need for those promoting the innovation to have a deeper understanding of the way in which the community, of which the potential adopter is a part, operates; it requires an insight into the complex set of factors that govern behaviour and provide an overt or covert logic for doing a certain thing in a certain way.

Such an understanding cannot be gained in the laboratory – it necessitates a closer interaction with the potential user. Hence once more, the issue of innovation adaptation in the field and of user-involvement emerges as being one of significance.

(e) *Social structure: the link*

We now come to the linking issue of social structure. Here, I will attempt to indicate how inequalities in social status and the unequal nature of power balances between different classes/castes etc., and between the sexes are likely to affect wood-stove diffusion. The threads to this have already been provided in the discussion so far. Here it is hoped to show how they interweave.

Consider first the question of women's status. The importance of this had earlier been touched upon only briefly, and the issue needs some elaboration. The status of women within the household could be a significant factor in wood-stove adoption, especially where adoption requires cash expenditure, by virtue of the fact that although women are the potential users of the innovation, and therefore in the best position to assess its advantages and disadvantages, it is men who usually handle the household cash and make decisions on how it is spent.[52] Generally men have been noted to spend the money on items different from those usually bought by women. Women, where they manage to get independent access to money, are observed to spend it on family needs, while men tend to spend it on their own needs, such as drink, clothes, etc.[53] Hence where men make the decisions, the purchase of an improved stove may not get priority, especially where the only advantage

perceived is greater leisure or convenience in cooking for the women. This is also one significant reason (among others already noted) why attempts to promote wood-stoves in the same way as watches and radios (whose primary users and main beneficiaries in the rural areas are men) are likely to be ineffective.

Likewise, the status of women within the community enters as an influencing factor in a number of significant ways. As noted, rural women usually have no direct access to institutional credit or to independently disposable cash income to purchase new innovations/technologies; and they seldom have access to information on new innovations. Also, there is a strong ideological bias in extension services which is likely to work against the direct involvement of, or consultation with, village women in the experimental designing of wood-stoves for their use – an involvement which the Guatemala and Ghana case studies indicated as being a significant feature in effective diffusion. Further, rural women are not usually given the education/training or the opportunity to undertake decision-making roles or responsibilities in the public sphere, which would be necessary in extension work.

Consider next the issue of the balance of power between rural households which differ in their ownership and control of material assets and/or in their social status. (Political power and social status generally, though not always, co-exist with the ownership of wealth.) This affects the ability of different households to purchase with their own incomes technologies which require financial expenditure, and also affects their access to information and to credit.

Further, social hierarchies, whether based on differences in inter-household distribution of material assets, or on gender differences, or defined by some other criteria, are likely to make difficult the setting up of precisely those linkages between indigenous technical knowledge and skills and the more formalized research and development networks, between the user (including the user-innovator) and the scientist/professional, that were identified earlier as being important in the successful diffusion of rural innovations in general, and wood-stoves in particular.

That indigenous technical knowledge and capability does exist in the rural areas of Third World countries can be supported by several examples of innovations, especially in the context of agricultural technologies. For instance, Dommen[54] notes the development of cheap bamboo tubewells by farmers in Bihar (India). Sansom[55] describes the invention of a small centrifugal motor pump by two Vietnamese farmers. The introduction of improved agricultural practices by farmers has been noted by Hayami and Ruttan[56] for Meiji Japan, and by Howes and Chambers[57] for Nigeria. Biggs[58] refers to several cases of farmers in India and Bangladesh bringing about genetic improvements in crops. Improvement in stove designs by local people has already been described in the Shaller study. Dutt[59] provides another example of local skills in the context of wood-stoves in Karnataka, India.

That such innovations usually remain isolated instances, and are rarely picked up and integrated into the formalized research and extension systems, is a pointer essentially to the weakness of existing links between the rural user-innovator, the extension worker and the scientist/professional. And it is precisely the strength of these links which is likely to determine the efficacy of attempts at field adaptation and diffusion of wood-stoves (or any other innovation with similar characteristics) on a mass scale.

Typically, there is an absence of a two-way interaction – a dialogue – between the scientists/professionals, the village extension agents and the poor peasants or other underprivileged (in particular women) users of innovations.[60] The bias of government extension workers who enjoy a certain status in the village as part of a well-entrenched bureaucratic hierarchy (even if they may be at the lowest rung of that hierarchy) in favour of rich landowners and against the poor peasants, has already been noted. But the problem is only partly one of economic inequalities. Underlying the divide between the scientists/professionals (usually urban based) and the rural users of innovations (including user-innovators) whose knowledge comes more from field experience than from formal education, for example, is also usually the divide between mental and physical labour, between town and countryside, and between the genders.

This is not to say that examples of localized experiments to establish these links, manifesting a 'participative' (of the rural poor) rather than a 'top-down' approach to diffusion, do not exist. In fact there are several micro-level success stories (some of which are discussed below) which serve to demonstrate, on the positive side, what can be achieved through a dialogue between those seeking to diffuse innovations or innovative ideas, and those whose lives are directly affected by the

programme. At the same time, they also point to the need for more comprehensive social changes if these experiments are to become general and wide-based. Two illustrative examples from India are the Banki piped water supply project in Uttar Pradesh (U.P.), and the Jamkhed community health project in Maharashtra.

In the Banki project[61] the 'innovation' that was sought to be introduced was piped drinking water to a population which until then had used open wells. Initial attempts made in the 1950s by the State Irrigation Department, which supplied tubewell water to the fields, to construct overhead tanks in some villages, lay pipes and provide public standposts, met with failure. A survey in 1962 revealed that 96.1% of the population in these villages still used open wells. Little attempt had been made to involve the local people in project planning and implementation. The approach of the Banki project, which was started in 1962 in seven of these villages by the U.P. Planning Research and Action Institute (and funded mainly by UNICEF and WHO, with land and small sums being contributed by the Panchayat head and some villagers), was in sharp contrast to the Irrigation Department's 'top-down' method. It aimed in fact at developing a scheme where the people would have their own installations and would ultimately be able to administer the system independently. It was sought initially, through a base-line survey, to understand why people were reluctant to accept the innovation. Some of the apprehensions expressed related to the tastelessness of tap water, the possible harmful effect of drinking electrically pumped water, anticipated water charges, fears that the water was medicated to reduce fertility, etc. In order to remove misconceptions and create a positive attitude to the scheme, discussions were organized with the villagers in informal evening 'sittings'. To demonstrate the importance of clean drinking water, a health education programme was simultaneously started. By 1966, a substantial proportion of the households were using piped water, and by 1973 all the families were doing so. Over a third had taken private home connections. The villagers had also assumed full responsibility for the management and general maintenance of the system, through its Waterworks Executive Committee composed of seven villagers (one from each village), which was recognized by the State Government.

In the Jamkhed comprehensive rural health project initiated in 1970 by two doctors (a husband-and-wife team), the emphasis again has been on community participation in decision-making, with the ultimate objective that the villagers will run the programme themselves.[62] Till then, the services available in this drought prone area of Maharashtra had been inadequate (a dearth of doctors willing to go to the villagers) and costly (high costs of doctors' fees, medicines prescribed, and travel etc.). The project has sought to provide an alternative, low cost health service through a team of locally trained paramedics working with the doctor-couple, with a referral system, in case of need, to other doctors. Local women (whose names have usually been suggested by the villagers themselves in group meetings) have been trained, initially as auxiliary nurses-cum-midwives and later as Village Health Workers to promote curative and preventive health care. Although the majority of these women are illiterate, they are quick to learn, and their ability to communicate with and gain the confidence of the other village women (helped by commonality of diction, tradition and values) has been one of the main strengths of the programme. There is a conscious attempt to overcome caste barriers (the paramedics come from all castes and have to attend to the needs of all castes), and to maintain a relationship of equality between the professionals and the non-professionals.

The results have been impressive in terms both of health statistics and of developing self-reliance and organizational ability among the poor. Initially begun in eight villages, the project has now spread to over 70. It is noteworthy that one of the main impediments in programme implementation is reported to be the attitude of the town doctors who 'feel that a decentralized health care service offered through paramedics will reduce their practice and affect their income'.[63]

These experiences are not merely of general relevance in the context of rural diffusion programmes; they are also of specific interest in the context of wood-stove diffusion, because the basic characteristics of public health care, rural piped water supply and wood-stove diffusion programmes are similar, in many respects. For instance, they all provide mainly non-financial benefits to the users, and usually involve little private financial cost; for effectiveness they need to cover large sections of the underprivileged population; and the primary persons who need to be incorporated in each are the rural women who bear the main burden of family illnesses and of fetching water and firewood.

The experiments described provide a noteworthy demonstration of the effectiveness *and* necessity of an alternative approach to diffusion. They also represent significant beginnings. At the same time, it cannot be ignored that, at present, they remain micro in nature in terms of the percentages of total populations covered, and exceptions relative to the large numbers of experiments/projects which continue to rely on the 'top-down' approach. Underlying their exceptional nature, however, is precisely the difficulty of operating such programmes within well-entrenched, hierarchical, social structures. Basically, to sustain and spread such programmes, there is need not merely for a much wider recognition of the importance of an alternative approach to the diffusion of rural innovations which are aimed at mass acceptance, but of basic structural changes to promote equality of material assets and of attitudes between households, between the genders, and between people of different professions and work backgrounds. Only thus can the specific become the general.

5. IN CONCLUSION

This paper has sought to demonstrate how the effectiveness of a particular approach in the diffusion of rural innovations is likely to be conditioned by the technical, economic and social characteristics of these innovations. It is argued here that innovations which require adaptation to the user's needs, which entail a financial cost but provide marginal or no financial benefits, and which are aimed at a mass of economically and socially disadvantaged people, are unlikely to find ready acceptance through a market-oriented approach to promotion.

The example of improved wood-burning stoves has been used here both to illustrate the above point, and because it is of specific and immediate interest in the context of the rural energy crisis facing large parts of the Third World today. It is noted that the familiarity of the stove designer with the cultural milieu of the community where the stoves are to be promoted, and the adaptation of the stoves to suit specific users' needs, is a crucial factor in adoption, requiring a close interaction of the designer with the local artisans and the users of the stoves. At the same time, the possibility of involving the local people in innovation design and adaptation is seen to depend crucially on the structure of economic and social relationships characterizing the area. While ongoing localized experiments, seeking the participation of the rural poor in programme implementation, provide significant beginnings, class, gender and other social hierarchies remain serious constraints to the more general spread of this approach, requiring much wider material and ideological changes.

NOTES

1. The term 'innovations', here and subsequently, has been used in a broad sense to include both objects and practices perceived as being new by an individual or group, even if they have previously been in existence or in use elsewhere.
2. See especially Rogers (1961, 1971, 1977).
3. A good deal of literature on rural diffusion in fact is concerned mainly with the process of *information* diffusion. Among studies relating to India, see Sen (1969); Gaikwad *et al.* (1972); Kivlin *et al.* (1968).
4. Rogers, 1978, p. 28; emphasis mine.
5. It is only very recently that some of the earlier adherents to this approach (including Rogers himself), have begun to examine these underlying assumptions and have been seeking to 'modify' the 'classical model of diffusion' (see Rogers, 1980, especially pp. 6–12).
6. Griliches (1957, 1960).
7. Rosenberg (1975), p. 29.
8. For both Rosenberg and Griliches, innovation adaptation to the user's environment is seen to help diffusion essentially by increasing the economic profitability of the innovation, which in turn is seen as one of the principal factors affecting diffusion.
9. Johnston (1969), p. 61; also see Hayami and Ruttan (1971), p. 157.
10. Ishikawa (1975).
11. Howes and Chambers (1979), p. 7.
12. Bell (1979), p. 47.
13. Cooper (1979), p. 404.
14. Hapgood (1968), p. 10.
15. Bell (1979), p. 47; Herrera (1975), p. 44.
16. Hayami and Ruttan, (1971), see especially pp. 197–198 and 212–214.
17. See Dasgupta (1977) and Byres (1972) on India; Griffin (1971) more generally on the Asian experience; and Hapgood (1968) on experiences in Africa.
18. Leonard (1977).
19. Lele (1975); IADP (1966).
20. IADP (1969); Moulik (1979); Montgomery (1965).
21. See e.g. Dasgupta (1977); Hapgood (1965).
22. Non-financial costs could be in the form of labour time put in for a task, say for building a stove; non-financial benefits, similarly, could

relate to the prestige of owning an article, or an increase in leisure time, etc. In other words, they would cover all costs and benefits where no cash transactions are involved.

23. These cover many of the familiar rural innovations introduced in recent years in Third World countries.
24. Private costs/benefits: those relating to the individual (person or household); social costs/benefits: those relating jointly to a community of people.
25. The individual's failure to perceive the benefits of an innovation could of course be the result of a whole range of additional factors including misinformation given by the extension agent. However, the concern here is solely with the implications of the economic and social characteristics.
26. Arnold and Jongma (1977), p. 3.
27. Knowland and Ulinski (1979), Appendix Table 1.
28. See e.g. Fleuret and Fleuret (1978); Howe (1977); and Uhart (1976).
29. Arnold and Jongma (1977), p. 6.
30. Floor (1977), p. 69.
31. Ernst (1977).
32. The commercial exploitation (often illegally) of forests for timber, or the clearing of forests for agricultural purposes are often significant reasons for deforestation.
33. See Arnold (1978), p. 13 for Nepal and Haiti; Floor (1977), p. 6, for the African Sahel; Hughart (1979), p. 27 for Bangladesh.
34. Digerness (1977), p. 16.
35. Eckholm (1975), p. 7.
36. In any case, even when women do wage work they are still usually responsible for collecting firewood for household needs (e.g. see Fleuret and Fleuret, 1978).
37. Shaller (1979).
38. In general terms, the principle underlying stove improvement is to regulate the inflow and outflow of air currents in such a way as to ensure as complete a combustion of wood as possible, and make maximum use of the heat generated. Improvements over the open fire usually include one or more of the following features: the regulation of air flows through a system of flues (channels carrying combustible gases), the prevention/minimization of heat loss by means of a fire door, the use of fire dampers, the covering of pot holes when not in use, ensuring that the pots fit the holes well, the addition of a chimney, and so on.
39. In practical terms, the 'efficiency' of a wood-stove would relate to the amount of wood needed by the user to cook the household's everyday meal. However, efficiency parameters as obtained by standard stove testing procedures, such as by heating water to boiling point, or by cooking a 'typical' meal, may not hold in practice, since there are likely to be variations according to the skill of the user, the quantity of food cooked (a doubling of quantity does not double fuel needs), the sequence in which different foods are cooked, and so on. (For a further elaboration on the question of wood-stove efficiency see Agarwal, 1980, pp. 30–38.)
40. An understanding of user-specific needs becomes even more necessary when we consider that within a given region there may be several culturally distinct, indigenous communities, as Shaller (1979, p. 3) for instance, notes exist in highland Guatemala.
41. Shaller, 1979, p. 13.
42. See Hoskins (1979), especially pp. 33, 34, 38.
43. See e.g. Dasgupta (1977), and Griffin (1971), on the Asian experience; Leonard (1977), on Kenya; and Lele (1975), and Hapgood (1965), on the African experience in general.
44. E.g. see Leonard (1977), on the Kenyan extension service.
45. A possible exception would be health services where women are sometimes trained for the extension of contraceptive advice to rural women. However, other government health workers such as those responsible for innoculation/vaccination campaigns etc. are again usually men. Non-government voluntary organizations working in the field of community health also sometimes seek to train local women as paramedics (e.g. see Malgavkar, 1981, on the Jamkhed experiment in Maharashtra, India), but again these would constitute the exceptions and not the rule.
46. See Staudt (1976), p. 91; Lele (1975), pp. 76–78. In the African context, in particular, women have long been farmers in their own right in many areas – see e.g. Boserup (1970) and Agarwal (1981).
47. IADP (1966); Lele (1975).
48. See Dasgapta (1977), pp. 115–116 for India; and Apthorpe (1970) for Africa. Also see Dumont (1973) on credit cooperatives in Bangladesh.
49. Bajracharya (1981).
50. Hoskins (1979), p. 41.
51. Joseph (1980).
52. Here we would expect differences between African and Asian households. In the former, women are often cultivators and/or traders in their own right and are more likely to have some independent access to cash, compared to Asian women who rarely cultivate plots separately from their husbands. However, in practice the difference might be marginal, since even in the African context the cash is still frequently controlled by men (see e.g. Bukh, 1979, p. 29).
53. See Bukh (1979), p. 51; Hanger and Moris (1973), p. 234; Arens and Van Beurden (1977), p. 45; Consortium of International Development, Vol. III (1978), p. A-53.
54. Dommen (1975); also see Clay (1980).
55. Sansom (1969).
56. Hayami and Ruttan (1971), p. 157.
57. Howes and Chambers (1979), p. 6.
58. Biggs (1980); also see Biggs and Clay (1981).
59. Dutt (c. 1978), p. 6, note 7.
60. An illustrative example of the gap which often exists between the needs of the rural poor and

the perceptions of scientists/professionals as regards those needs, is provided by Herrera (1981), pp. 33–34 in the context of a rural housing project, undertaken in South India, which turned out to be 'an expensive failure'. He also makes the general point that 'the scientist is working with problems that belong to his own economic, social and cultural background so he has a tendency to apply the same criteria to a completely different environment. He frequently assumes that he has to satisfy the same needs but on a lower level, due to limitations posed by the local economic conditions'.

61. See Misra (1975).
62. See Sethi (1980), and Malgavkar (1981).
63. See Malgavkar (1981), pp. 8–9.

REFERENCES

Agarwal, Bina, *The Woodfuel Problem and The Diffusion of Rural Innovations,* monograph (Science Policy Research Unit, University of Sussex, UK, November 1980).

Agarwal, Bina, *Agricultural Modernisation and Third World Women: Pointers from the Literature and an Empirical Analysis,* World Employment Programme Research Working Paper No. WEP 10/WP 21 (Geneva: International Labour Organisation, 1981).

Apthorpe, R. J. (ed.), *Rural Co-operatives and Planned Change in Africa: Case Materials* (Geneva:United Nations Research Institute for Social Development, 1970).

Arens, Jenneke and Jos Van Beurden, *Jhagrapur: Poor Peasants and Women in a Village in Bangladesh* (Amsterdam: 1977).

Arnold J. E. M., 'Wood energy and rural communities', mimeo, Forestry Department, FAO Rome; paper presented at the 8th World Forestry Congress, Jakarta, Indonesia (October 1978).

Arnold, J. E. M. and J. H. Jongma, 'Fuelwood and charcoal in developing countries', *Unasylva,* FAO, Vol. 29, No. 118 (1977).

Bajracharya, Deepak, *Constraints of Energy and the Implications for Appropriate Technology and Rural Development in Nepal,* D. Phil dissertation, (HSSS, University of Sussex, UK, 1981).

Bell, Martin, 'The exploitation of indigenous knowledge or the indigenous exploitation of knowledge: whose use of what for what?', in *Rural Development: Whose Knowledge Counts? Institute of Development Studies (IDS) Bulletin,* UK, Vol. 10, No. 2 (January 1979).

Biggs, Stephen, D., 'Research by farmers: the importance of the informal agricultural R and D system in developing countries', mimeo (Institute of Development Studies, University of Sussex, UK, February 1980).

Biggs, D. Stephen and Edward J. Clay, 'Sources of innovation in agricultural technology', *World Development,* Vol. 9, No. 4 (April 1981).

Boserup, Ester, *Women's Role in Economic Development* (New York: St. Martin's Press, 1970).

Bukh, Jette, *Village Women in Ghana* (Uppsala: Center for Development Research, Scandinavian Institute of African Studies, 1979).

Byres, T. J., 'The dialectic of India's Green Revolution', *South Asian Review,* London, Vol. 5, No. 2 (January 1972).

Consortium for International Development, *Proceedings and Papers of the International Conference on Women and Food, Vol. III,* (8–11 January, University of Arizona. Tucson, Arizona, 1978).

Cooper, Charles, 'A summing up of the Conference', in Austin Robinson (ed.), *Appropriate Technologies for Third World Development,* proceedings of a conference held by the International Economic Association at Teheran, Iran (London: Macmillan, 1979).

Dasgupta, Biplab, *Agrarian Change and the New Technology in India,* Report No. 77.2 (Geneva: United Nations Research Institute for Social Development, 1977).

Digerness, Turi Hammer, 'Wood for fuel – the energy situation in Bara, the Sudan', mimeo (Department of Geography, University of Bergen, Norway, July 1977).

Dommen, Arthur J., 'The bamboo Tubewell: a note on an example of indigenous technology', *Economic Development and Cultural Change,* Vol. 23, No. 3 (April 1975).

Dumont, Rene, 'A self-reliant rural development policy for the poor peasantry of Sonar Bangladesh' (Dacca: Ford Foundation, May 1973).

Dutt, G. S., 'Improved wood-burning cooking stoves for LDCs', mimeo (Princeton: Center for Environmental Studies, Princeton University, 1978).

Eckholm, Erik P., 'The other energy crisis', *World watch Paper* No. 1 (Washington D.C.: Worldwatch Institute, September, 1975).

Ernst, Elizabeth, *'Fuel consumption among rural families in Upper Volta, West Africa',* mimeo (Ouayadougou, Peace Corps, 5 July 1977).

Fleuret, Patrick C. and Anne K. Fleuret, 'Fuelwood use in a peasant community: a tanzanian case study', *The Journal of Developing Areas,* 12 (April 1978).

Floor, W. M., 'The energy sector of the Sahelian countries', mimeo (Policy Planning Section, Ministry of Foreign Affairs, The Netherlands, April 1977).

Gaikwad, V. R., B. L. Tripati and G. S. Bhatnagar, *Opinion Leaders and Communication in Indian Villages* (Ahmedabad, India: Center for Management of Agriculture, Indian Institute of Management 1972).

Griffin, Keith, *The Green Revolution: An Economic Analysis,* United Nations Research Institute for Social Development, Report No. 72. 6 (Geneva: 1971).

Griliches, Zvi, 'Hybrid corn: an exploration in the economics of technological change', *Econometrica,* Vol. 25, No. 4 (October 1957).

Griliches, Zvi, 'Hybrid corn and the economics of innovation', *Science,* 132 (1960).

Hanger, Jane and Jon Moris, 'Women and the household economy' in *An Irrigated Rice Settlement in Kenya,* Robert Chambers and Jon Moris (eds.), Afrika Studien No. 83 (Munchen: Ifo-Institut for Wirschaftsforchung Munchen, Afrika Studien, Stelle, 1973).

Hapgood, David, *Policies for Promoting Agricultural Development,* report of a Conference on Productivity and Innovation in Agriculture in the Underdeveloped Countries, Report No. C/65-3, (Cambridge, USA: Center for International Studies, MIT, 1965).

Hapgood, David, 'The politics of agriculture', *Africa Report* (November 1968).

Hayami, Yujiro and V. W. Ruttan, *Agricultural Development: An International Perspective* (Baltimore, Maryland: The Johns Hopkins Press, 1971).

Herrera, A., 'Scientific and traditional technologies in developing countries', mimeo (Science Policy Research Unit, University of Sussex, UK, 1975).

Herrera, Amilcar O., 'The generation of technologies in rural areas', *World Development,* Vol. 9, No. 1 (January 1981).

Hoskins, Marilyn W., 'Community participation in African fuelwood production, transformation and utilisation', discussion paper prepared for a Workshop on Fuelwood and Other Renewable Fuels in Africa, Paris, Overseas Development Council, AID (29–30 November 1979).

Howe, James W. and Staff of the Overseas Development Council, *Energy for the Villages of Africa: Recommendations for African Governments and Outside Donors* (Washington D.C. Overseas Development Council, 2 February 1977).

Howes, Michael and Robert Chambers, 'Indigenous technical knowledge: analysis, implications and issues', *IDS Bulletin,* UK, Vol. 10, No. 2 (January 1979).

Hughart, David, Prospects for traditional and non-conventional energy sources in developing countries', *World Bank Staff Working Paper* No. 346 (Washington: World Bank, July 1979).

IADP, *Intensive Agricultural Development Programme, Second Report* (1960–65) (Expert Committee on Assessment and Evaluation, Ministry of Food, Agriculture, Community Development and Cooperation, Government of India, 1966).

IADP, *Modernizing Indian Agriculture: Fourth Report on the Intensive Agricultural Development Programme* (1960–68) Vol. 1, (Expert Committee on Assessment and Evaluation, Ministry of Food, Agriculture, Community Development and Cooperation, Government of India, 1969).

Ishikawa, Shigeru, 'The Chinese method of technological development: the case of the agricultural machinery and implement industry', *The Developing Economies,* Vol. 13, No. 4 (December 1975).

Johnston, Bruce F., 'The Japanese "model" of agricultural development: its relevance to developing nations', Kazushi Ohkawa, Bruce F. Johnston and Hiromitsu Kaneda (eds), *Agriculture and Economic Growth - Japan's Experience* (University of Princeton Press, University of Tokyo Press 1969).

Joseph, Stephan, 'Initiating and implementing a stove programme', chaper of a book under preparation (London: ITDG, 1980).

Kivlin, Joseph E., Pradipto Roy, Fredrick C. Fliegel and Lalit K. Sen, *Communication in India: Experiments in Introducing Change,* project on the Diffusion of Innovations in Rural Societies, National Institute of Community Development, Hyderabad, India (1968).

Knowland, Bill and Carol Ulinski, *Traditional Fuels: Present Data, Past Experience and Possible Strategies* (USAID, September 1979).

Lele, Uma, *The Design of Rural Development: Lessons from Africa* (Baltimore and London: the Johns Hopkins University Press, 1975).

Leonard, David K., *Reaching the Peasant Farmer: Organisation Theory and Practice in Kenya* (Chicago and London: The University of Chicago Press, 1977).

Malgavkar, P. D, *Rural Health Care: The Jamkhed Project* (New Delhi: Center for Policy Research, August 1981).

Misra, K. K., 'Safe water in rural areas: an experiment in promoting community participation in India', *International Journal of Health Education,* Vol. XVIII, No. 1 (1975).

Montgomery, John D., 'The bureaucracy as a modernizing elite: can government routines lead to development', Appendix D in David Hapgood (ed.), *Policies for Promoting Agricultural Development,* (report of a Conference on Productivity and Innovation, Report No. C/65-3, (Cambridge, Center for International Studies, MIT, 1965).

Moulik, T. K., 'Strategies of implementation of rural development programmes in India', mimeo (Ahmedabad, India: Indian Institute of Management, March 1979).

Rogers, Everett M., 'Characteristics of Agricultural innovators and other adopter categories', Research Bulletin No. 882 (Wooster, Ohio: Ohio Agricultural Experiment Station, May 1961).

Rogers, Everett M., 'Network analysis of the diffusion of innovations: family planning in Korean villages', in D. Lerner and L. M. Nelson (eds.), *Communication Research - A Half-Century Appraisal,* (Hawaii: East-West Center, 1977).

Rogers, Everett M., and F. Floyd Shoemaker, *Communication of Innovation: A Cross-Cultural Approach* (New York: The Free Press, 1971).

Rogers, Everett M., 'The diffusion of technical innovations: application to renewable energy resources in developing areas', paper prepared for the panel on the Introduction and Diffusion of Renewable Energy Technologies, National Academy of Sciences, Washington D.C. (November 1980).

Rosenberg, Nathan, 'Factors affecting the payoff to technological innovations', mimeo (Science Policy Research Unit, University of Sussex, UK, 1975).

Sansom, Robert L., 'The motor pump: a case study of innovation and development', *Oxford Economic Papers*, Vol. 21, No. 1 (March 1969).

Sen, Lalit, K., *Opinion Leadership in India: A study of Interpersonal Communications in Eight Villages* (Hyderabad, India: National Institute of Community Development, 1969).

Sethi, Harsh, 'Alternative development strategies – a look at some micro experiments', in Kamla Bhasin and Vimala R. (eds.), *Readings in Poverty, Politics and Development*, Freedom from Hunger Campaign/Action for Development (Rome: Food and Agricultural Organization, 1980).

Shaller, Dale V., 'Socio-cultural assessment of the Lorena stove and its diffusion in highland Gautemala', mimeo (Maryland, USA. VITA, Volunteers in Technical Assistance, 1979).

Staudt, Kathleen A., 'Women farmers and inequities in agricultural services', *Rural Africana*, No. 29 (African Studies Center, Michigan, winter 1976).

Uhart, E., 'The wood charcoal industry in Africa', memo. African Forestry Commission Fourth Session, Bangui, Central African Republic (22–27 March 1976).