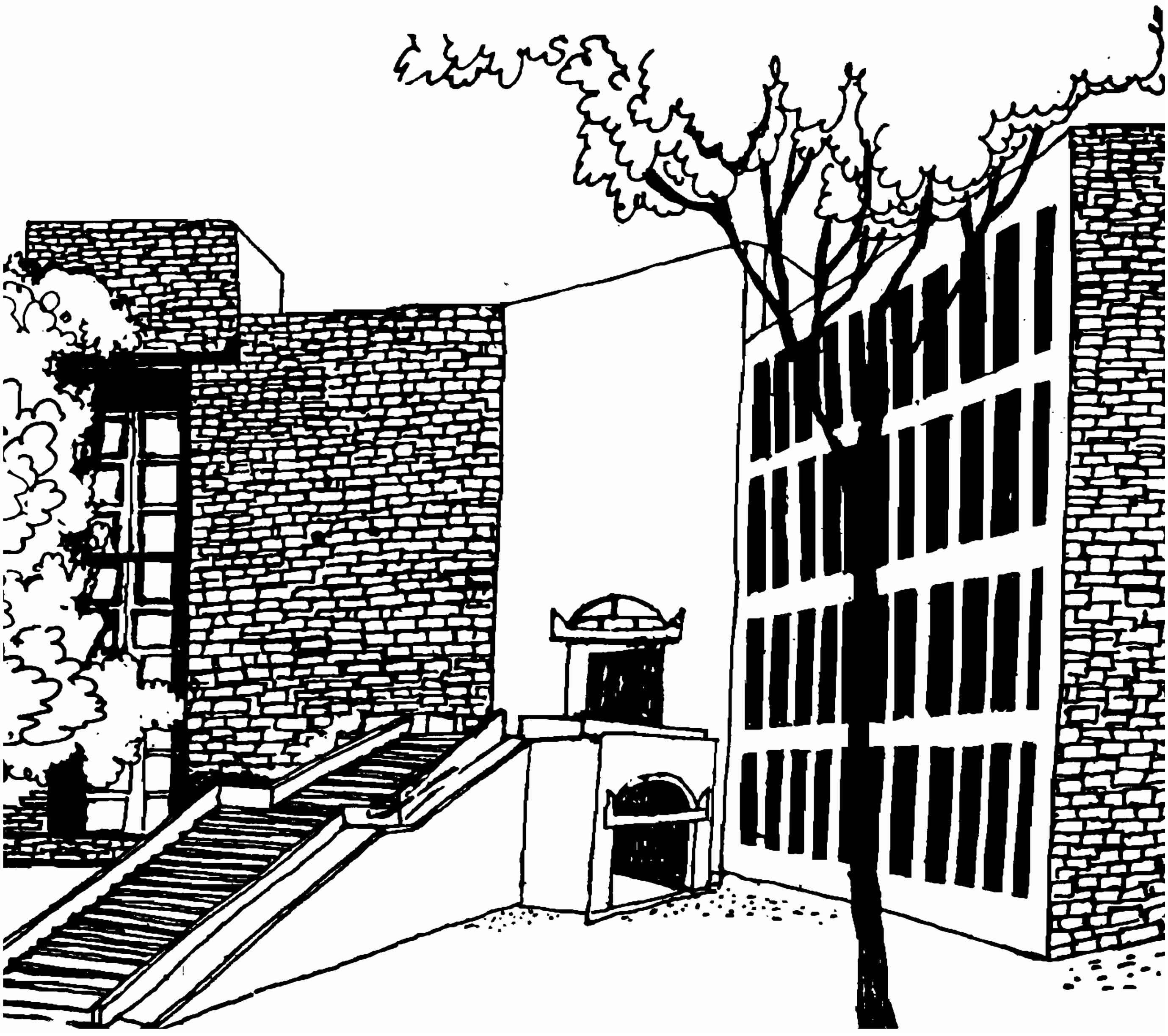
विद्याविनियोगाद्विकासः

IIM AHMEDABAD

Working Paper



ENDOGENOUS TECHNOLOGICAL INNOVATION FOR SUSTAINABLE DEVELOPMENT: THE CASE OF AGRICULTURAL PEST MANAGEMENT

By

A. R. Pastakia

W.P. No.1151
November 1993

INDIAN INSTITUTE OF MANAGEMENT
AHMEDABAD - 380 015
INDIA

Table of Contents

1.0 Research Problem

The developmental history of India after independence, has undergone two distinct moultings. The first phase emhasised self-help, picking up the best in Indian tradition. Concern for sustainability was reflected in policy initiatives (mostly in the agricultural sector) such as the compost campaign, land army for soil and water conservation and "van-mahotsav" (Munshi, 1952).

During the early sixties however, India embarked upon the path of modernisation through rapid industrial and agricultural growth, when large dams and industrial units became the symbols of progress. Short run productivity was given priority, often at the cost of sustainability.

Environmental movements of the seventies and eighties in India and abroad, focused on the non-sustainability of such development. Farmer movements focused on the non-viability of modern agriculture. While some farmers started lobbying for remunerative prices, others began the search for alternative, sustainable technology. With developed countries themselves questioning the sustainability of their high growth models of development, the stage is set for yet another transition in Indian developmental history - the transition to sustainable development (SD).[1]

---

1. Sustainable development as defined in this study refers to a pattern of development that would enable societies/ communities to maintain if not augment the very natural base on which they subsist. The costs of such development would not be externalised either over time or nature. (See section 2.2 for discussion).

The immediate challenge before policy makers is to provide sustainable alternatives while operating through conventional institutions and policy making processes. (In the long run these institutions and processes too would have to be suitably modified.) One way of meeting this challenge is to learn from the efforts and experiences of grassroot innovators involved in the search for alternative technology.

In the agricultural sector, the tradition of invention at the grassroots level continues to be buoyant. The solutions generated by farmers and grassroot entrepreneurs tend to be location-specific and have therefore limited potential for diffusion. On the other hand the high complementarity between technology components endows them with greater capacity to evolve in response t environmental variations both in space and time.

The above characteristics of SD innovations suggest the need for making policies that encourage people to evolve their own innovative solutions, specific to their socio-ecological conditions. Under such a regime, external support agencies would need to adopt a "solutions augmenting" strategy as opposed to the conventional "problem solving" approach. The role of formal R & D institutions would be to uncover the science behind these innovations in order to a) add value to them and b) to pick up the key concepts for diffusion either through farmer net-works or through institutional channels. (This approach is in direct opposition to the conventional wisdom of locating standardised technology for uniform diffusion over large areas). Such policies cannot be evolved without proper understanding of the process of innovation for SD at the grassroots level.

The present study attempts to develop precisely such an understanding, by studying technological innovations for SD at the grassroots level, in the context of agricultural pest management. It will thereby fill an important gap in the literature on innovation.

My choice of problem has been influenced by the historical role played by chemical pesticides in the debate on environment vs. development. Rachel Carson's "Silent Spring" (1962) became a reference point for the environmental movement, highlighting the environmental impact of pesticides. In a sequel to Silent Spring, twenty five years later, Gino et. al.(1987) reported that many of Carson's predictions about environmental toxicity and human health hazards, had come true.

In India, chemical control, promoted by the state, has become the dominant pest management strategy, since the adoption of green revolution technology. The intensive use of pesticides in certain green revolution pockets,[2] have generated localised as well as non-localised environmental externalities, triggering what is known in pest management literature as the "pesticide treadmill" (see Section 3.1 for further details) and creating new health hazards for both sentient and human life forms.

---

2. The average consumption of pesticides in India is only 149 gms.(a.i.)/Ha as compared to 1870 in Europe and 1490 in the U.S.A. This has given rise to the myth that our consumption is well within acceptable limits. It takes only a perusal of the figures on spatial distribution to dispel this myth. The consumption figure for Guntur district, A.P. is as high as 7700 gms./acre, coming close to Japan's figure of 10790 which is the highest in the world (Narayanan 1990).

The treadmill effect is forcing farmers to spend more and more on pesticides achieving less and less control (Shister et.al. 1992, Gipps 1987). It is also contributing to the overall long term decline in farm productivity. This situation has spawned experimentation and innŏvation for alternative , environment- friendly technology. In some countries it has taken the form of a movement for "natural " or "organic' farming.

Accumulating evidence on the persistence of toxic pesticide residue in the environment, and greater understanding of how this residue finds its way into food chains have given credence to the environmenal movement and broadened its base to include health conscious food consumers. (see Section 3.1).

Given the likelihood of the consumer movement for safe and nutritious food, joining forces with the producer movement for alternative technology, the field of pest management provides exciting possibilities for transition to sustainable development.

2.0 The Sustainable Development Paradigm

2.1 Historical Perspective

History has shown that civilisations which failed to build sustainability concerns into their development plans paid the price of extinction.

> "The Carthagiainian, Egyptian and Babylonian civilisations disappeared from the face of the earth as they favored man at the cost of nature."
>
> (Munshi, 1952)

On the other hand, enduring civilisations have been able to sustain themselves by devising special institutional and cultural mechanisms for protection, conservation and augmentation of life support systems. Religious beliefs and customs and institutions for managing ecological commons were among the important mechanisms.

The behavioral norms emanating from religious beliefs and customs sanctified key elements in the life support system, thereby protecting them from non-sustainable exploitation (Dwivedi et.al. 1989, Pereira and Seabrock 1990, Gupta 1991). These beliefs were also instrumental is shaping the world - views of the people (Bruun and Kalland 1992, Sen 1992) - which got reflected in the nature of technology generated. The design of sacred groves in India were based on elaborate ecological principles, as described by Chandrakant and Romm (n.d.) and Gadgil (1992). Examples of institutions for managing village commons include the caring of pedigree bulls in India (Voelcker 1893, Sherry Chand 1993), the "kools" of Bhutan for managing mountain springs (Gupta and Ura 1992, Shingi 1989) and quarantine to prevent spread of diseases in cattle to neighbouring villages (Gupta 1991).

The forces of modernisation and industrialisation have had a debilitating effect on many of these traditional mechanisms and knowledge systems (Pereira & Seabrock 1990, Atte 1989). New policies emphasised growth and short run productivity over sustainability. Much of this "development" was enabled by liquidation of valuable natural wealth (Gadgil & Guha 1992, Guha 1989, Nadkerni 1986 et.al). The loss in biodiversity has implications for the resilience of ecological systems. The disruption of sustainable lifestyles and breakdown of traditional institutions for ecological commons, signify an erosion of cultural and institutional assets for SD.

2.2 Concept

Sri K.M. Munshi, the first Minister for Food and Agriculture in post-independence India, had expounded a philosophy and vision for sustainable development of Indian agriculture, as early as 1952 ("Gospel of the Dirty Hand"). In western literature the term "sustainable development " appeared only in the early 1970s as a constructive response to the development-ecology dilemma faced by industrialised countries. SD gained wide audience as a result of "Our Common Futures" (1987) popularly referred to as the "Brundtland Report".

The challenge in arriving at a satisfactory definition of SD is to capture the holistic nature of the concept without loosing crucial dimensions. It is not surprising that SD has been defined in either too ambiguous (Barbier 1987, WCED 1987) or too narrow terms (see review papers by Lele 1991, and Batie 1989). The popular definition provided by the Brundtland Commission, falls in the first category :

> "SD is development that meets the needs of the present without comprising the ability of future generations to meet their needs".

This definition does not specify, whose needs are to be met within the present generation and at what levels. Whose future generations are being referred to ? How will the needs of stakeholders who are unable to articulate them, be assessed and represented in present resource-use decisions? The ambiguity of such definitions renders them open to mis-interpretation and/or misuse.

In a bid to rectify some of those short-comings I propose the following definition :

> **SD is a process of development that enables communities/ societies to maintain if not augment the very natural base on which they subsist, while ensuring that the costs of development are not externalised either over time or nature.**

2.3 Innovation

Innovation for SD can be technological, institutional or cultural. The primary focus of this study is on technological innovations. Institutional and cultural innovations may be included only where found relevant for the technological innovation under study.

Technological innovation has been defined as the commercial use of scientific discovery or invention, by Schumpeter. More recently, Rogers (1983) introduced the idea of perception of innovation : "...an idea, a practice or objective perceived as new by an individual or other unit of adoption."

Although these definitions have found wide acceptance amongst academics, in the context of this study they are deficient in the following aspects:

(i) Not all technological innovation may result in commercial use. Home remedies and recipies are examples of user-innovations which enable communities to survive in high risk environments where typically both market forces and public institution interventions are low.

(ii) Perception of newness of an idea is determined by the context. The same idea may be perceived as innovative in one context but not in a another.

(iii) World-views of innovators and outsiders determine how they perceive a given idea.

(iv) Sometimes the innovativeness of a person's idea may not be obvious to himself/ herself; other times it may not be obvious to outsiders.

In this study I take a comprehensive view of innovation which recognises the following characteristics as fundamental to the phenomenon :

(i) Innovation involves a new and significantly better way of doing things.

(ii) It is inevitably associated with improved productivity or savings in costs, effort or time.

(iii) An idea, a practice or a product may be perceived as innovation by the innovator or by an outsider. Sometimes however, this may not be so obvious to either party.

(iv) An idea a practice or a product may be considered an innovation, depending upon the world-views of the people involved.

Certain characteristics of technological innovations for SD, set them apart from non-sustainable ones:

a) They tend to be location specific. It is argued that technology which ignores socio-ecological variability will either be rejected or if adopted without suitable adaptationon not perform well in the long run.[3] (Gupta 1986, Ashby 1981, Pacey 1990).

b) They tend to rely on internal resources (usually non-monetary) and knowledge systems. Over-dependence on external resources and knowledge undermines the autonomy and self-correcting capabilities of a system so essential for its sustainability. (Hedberg, 1976, Wildavsky 1972).

c) They are value-driven. The concern for nature and for future generations is reflected in the fact that these innovations generate minimal or zero environmental externalities and are non-exploitative. They stress co-evolution of man and nature and stewardship in order to ensure the rights of future generations for use of limited natural resources.(WCED 1987, Colby 1990, Dilworth 1993, Thompson 1992).

Significantly, the literature on technological innovation, especially in the agricultural sector, reveals neglect of all three dimensions. Innovations with high eco-specificity, high non-monetary components and low standardisability have been ignored, perhaps due to their limited potential for large-scaled diffusion. Endogenous (including indigenous)[4] innovations had not received much attention until the sixties when a small group of Indian scientists recognised the need to reverse their top-

---

3 The anthropologist Paul Richards, quoted by Pacey (1990) talks about this in terms of "ecological particularism".

4 While indigenous technology relies entirely on internal resources and knowledge systems for its genesis, the term endogenous implies development within a system irrespective of the source of knowledge or resources, many contemporary grassroot innovations rely on a fusion of traditional (indigenous) and exogenous knowledge and resources (Sec.6.1).

down approach to agricultural research.[5] Although Dr.Y.P.Singh and colleagues had raised this issue as early as 1969, (Verma and Singh, 1969), the scientific community in India did not take heed until western scientists (Chambers 1989, Biggs 1980, etc.) started recognising its importance. The studies by Hiranand (1979), Gupta (1980) were notable exceptions. While innovation literature has given considerable attention to the motivation and psychological profile of innovators,[6] the value system of innovators has never been treated as an independent variable, thus under-estimating the potential of values to influence the heuristics.

This study will attempt to fill these gaps by : a) focusing on autonomous, endogenous, innovations at grassroots level. b) considering value system as an explicit, independent variable and c) including both major as well as minor (adaptive) innovations.

3.0 Agricultural Pest Management

3.1 Non-Sustainability of existing Pest management

Since the adoption of green revolution technology, pest management in India has relied heavily on chemical control (National Commission on Agriculture 1980). The VIth and VIIth plan documents indicate a policy shift suggesting the need to rationalise the use of chemicals and to complement them with

---

5. Dr.Y.P. Singh guided two thesis in the area of indigenous animal husbandry, Verma (1969) and Khanna (1969) which attempted to bring about interaction between formal and informal research.

6. For a review of literature on "the creative personality", see Helson in Grouhaug and Kaufmann (ed.) 1988.

more environment-friendly technologies (Kashyap 1990, DARE, Working Group Report 1985).

> "..... during the next 10 - 15 years, our future strategy in plant protection should revolve around intensive survellance and monitoring; studies on ecology and dynamics of pest-diseases, uses of hormones etc. biological control, threshold-systems, improved pesticides applications technology and finally cost effective methods of pest management acceptable to our farmers..."
>
> DARE - Report of Working Group for VIIth Five Year Plan (1985-90).

The "in - use" policy as distinct from "espoused" policy (Argyris, 1978)[6] however, continues to favor chemical control. The consumption of pesticides is expected to rise from 69500 tons (active ingredient) in 1991 to about 1 lakh tons by 2000 A.D. (Ministry of Chemicals & Fertilisers). The VIIth plan document recorded the registration of 27 new and more potent pesticide products[7] as well as significant reductions in import and excise duty for selected pesticides (Kashyap,1990).

Evidence on the negative impact of this strategy on the sustainability of Indian agriculture has begun to accumulate.[8] The productivity index of external agricultural inputs had declined from 100 with base year 1970-71 to less than 60 in 1987-88 (CMIE in Gupta and Singh, 1991).

---

6. Argyris used the terms "in use" and "espoused" to describe theories. The same terminology can be adapted to distinguish between policies that are merely stated from ones that are actually practiced.

7. Although a recent expert committee set up by the Insecticides Board has recommended the banning of 2 out of the 12 pesticides which were under review.

8. Most of this evidence is indirect in nature since longitudinal studies on agricultural systems productivity in India are conscious by their absence.

Pesticide resistance against pests, suppression of natural predators and other ecological responses have triggered the pesticide treadmill (Shister et al 1992, Gipps 1987) (see Fig.1). Alagh (1988) has given number of examples of relatively minor pests becoming major pests in recent years. Some of the important ones are American boll-worm in cotton,[9] white fly in cotton, and tobacco caterpillar. Pyrilla a traditional pest of sugarcane has now extended its domain to maize, sorghum and paddy crops. American bollworm has reportedly become resistant to synthetic pyrethroides introduced recently. According to Pimbert (1991), there are now at least 450 species of insects and mites, 100 species of plant pathogens, and 48 species of weeds resistant to one or more pesticides, worldwide. The data on resistance in Indian context has been reviewed by Bhatia (1986), and Mehrotra (1993). Among agricultural pests, pesticide resistance has been encountered in five pest species in the field viz., Singhara beetle, tobacco caterpillar, diamond block moth, mustard aphid and american bollworm (Mehrotra, 1993). Among stored grain pests, eight pests have been observed to develop resistance (ibid).

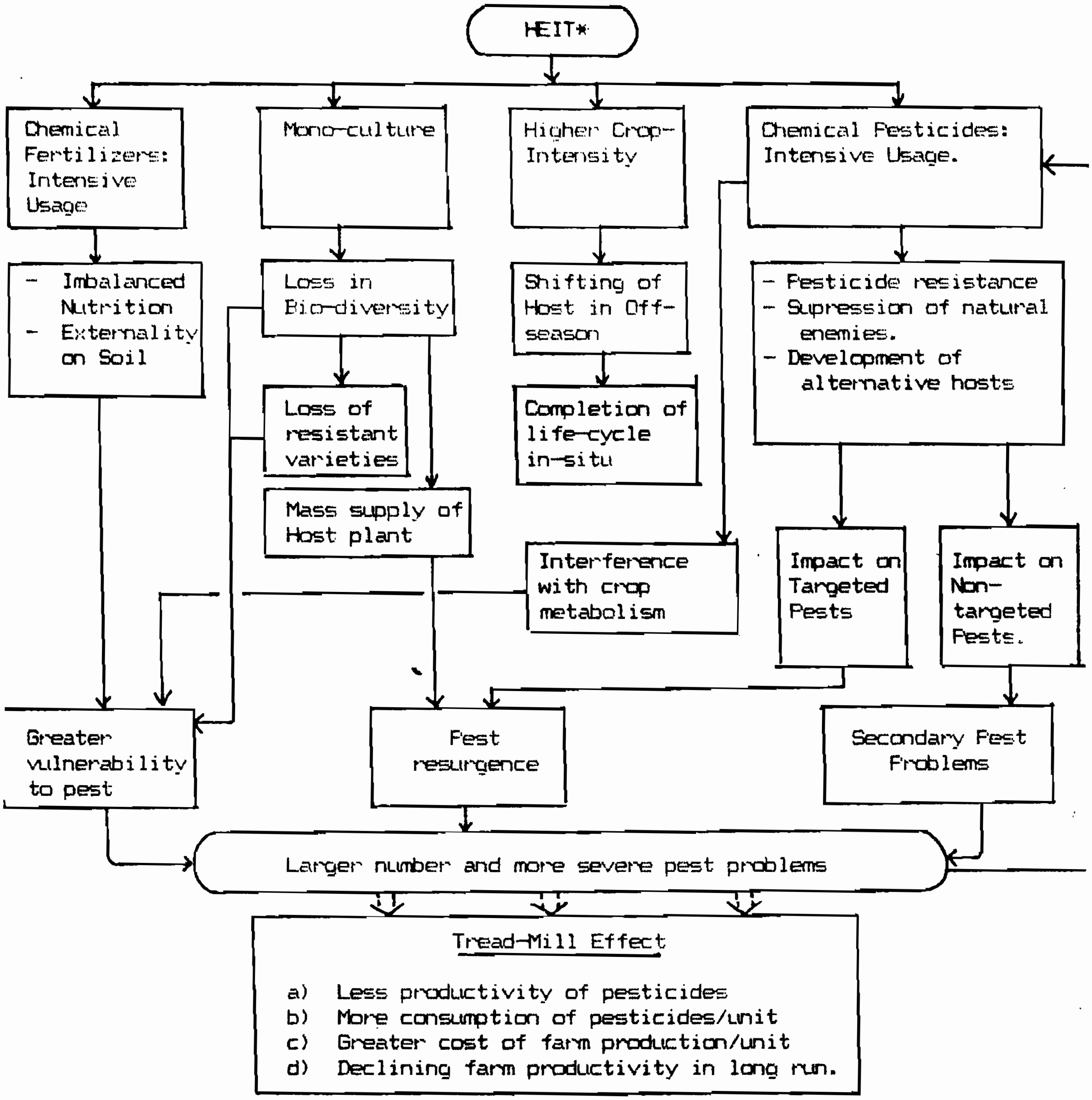
The pathways by which toxic chemical residue accumulate in food, fodder, air and water ultimately affecting both human and non-human life form is shown in Fig.2. The health impacts of these residues on human are indicated in Fig.3. For a review of

---

9. The loss in cotton crop on account of this pest was estimated at Rs.110 crore during 1987 from Guntur District alone. Several suicide deaths took place during that year in Guntur on account failure of chemical pesticides (Guntur Cotton Report, Dept. of Agril. 1990).

Figure 1

Pesticide Tread Mill

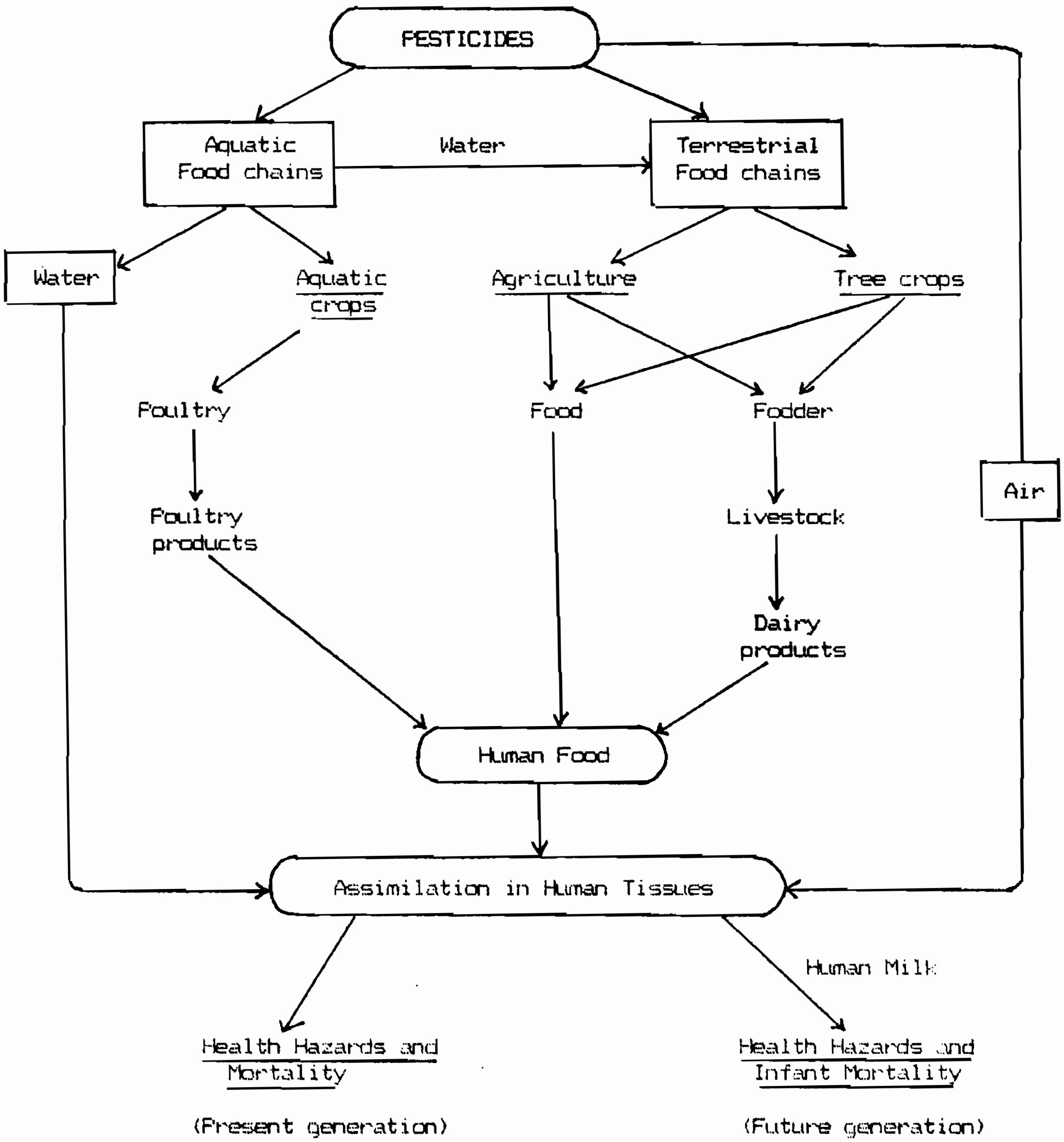


* HEIT = High External Input Farming (Green Revolution Technology)

Source: Based on Shister et.al. (1990), Yepsen (1966) and personal communication with Prof. A.K. Gupta, IIM, Ahmedabad, and Dr. R. Gopichandran, Centre for Environmental Education, Ahmedabad.

Figure 2

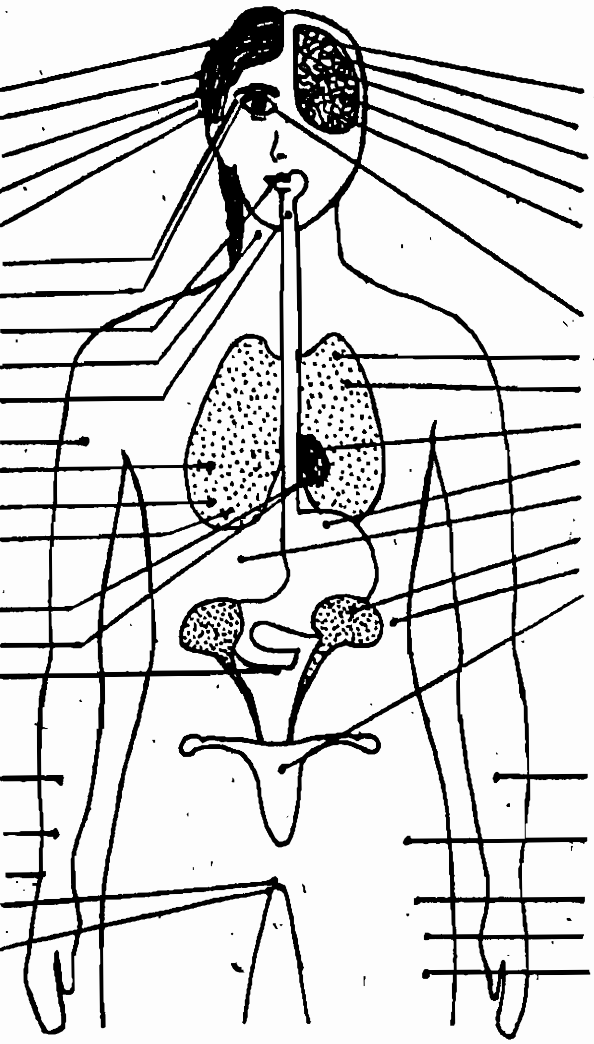
Pathways of Pesticide Residue in Bio-assimilation



Source: Based on Carson (1962), Gino et.al. 1987, WHO, 1990, Kalra and Chawla 1986, Dhaliwal and Singh 1993.

Citizens for Alternatives to Pesticides (CAP) ■ 20 Sunny Acres, Baie d'Urfe, Quebec H9X 3B6 ■ (514) 457-4347

EFFECTS OF CHEMICAL PESTICIDES ON HUMAN HEALTH



Please note:

1. Fetuses and young children (whose immune systems are immature) are especially vulnerable to the toxic effects of pesticides. Specifically, children tend to suffer from increased rates of behavioural and learning problems, and cancer[6,7,8]. People with impaired immune systems are also especially at risk[8].
2. Many pesticides are excreted in mother's milk and can affect nursing babies.[2,3] (This is not to imply that cow's milk is necessarily any safer for infants, however!)
3. Farm animals and pets are also at risk. One recent study showed a significant association between a cancer in dogs (canine malignant lymphoma) and owner's use of 2,4-D herbicides. The histology and epidemiology of this disease is similar to non-Hodgkin's lymphoma in humans.[4]
4. Clearly, not *all* pesticides are associated with *all* these effects. (For example, herbicides cause some effects; insecticides, others.) For detailed data, contact CAP.

Sources:

1 American Defender Network (1989) *Questions and answers about lawn chemical dangers*. Illinois.
2 Canadian Centre for Occupational Health and Safety (1990) Personal communication with Ms. H. Nadeau and reprints from various published sources supplied by the Centre. (Contact CAP for details.)
3 Environment Canada (1989) *Pesticides: the right amount*. Ottawa.
4 Hayes, HM et al (1991) Case-control study of canine malignant lymphoma: positive association with dog owner's use of 2,4-Dichlorophenoxyacetic acid herbicides. *Journal of the National Cancer Institute*, 83:1226-31.
5 Hayes, WJ & Laws, ER (eds) (1991) *Handbook of pesticide toxicology*. San Diego: Academic Press.
6 Dr. June Irwin, M.D. Various published sources. (Contact CAP for details.)
7 Lowengart, R. et al (1989) Childhood leukemia and parents' occupational and home exposure to pesticides. *Journal of the National Cancer Institute*, 79:39-46.
8 Urban Pesticide Caucus (1991) *Regulating urban cosmetic use of synthetic pesticides: action plan for Ontario*. Toronto.
9 United States General Accounting Office (1986, 1990) Reports on pesticides and their risks. Washington.
10 United States Navy (1982) *Emergency medical treatment for acute pesticide poisoning*. Jacksonville, Florida.
11 Wigle, DT et al (1990) Mortality study of Canadian male farm operators: non-Hodgkin's lymphoma mortality and agricultural practices in Saskatchewan. *J. Nat. Cancer Instit*, 82:575-582 *and see*
Zahm, SH et al (1990) Case-control study of non-Hodgkin's lymphoma and the herbicide 2,4-D in Eastern Nebraska. *Epidemiology*, 1:349-356.

PESTICIDES ARE POISONS! WHY RISK IT? WHY TAKE THE CHANCE?

public health impact of pesticides used in agriculture, world-wide (see WHO 1990). Studies on pesticide residue in Indian food- stuff, have been reviewed by Kalra and Chawla (1986) and more recently by Dhaliwal and Singh (1993). The Consumer Education Society, Ahmedabad organised a conference on pesticide residue on food-stuff in 1989. One comparative study showed that 25% of the Indian sample was contaminated with DDT & HCH residues at levels beyond tolerance levels as compared to 1.2% in developed countries (Kalra 1989). Research on bio-accumulation of pesticides in the Indian environment has been reviewed by David et.al. (1993).

3.2 Sustainable pest Management

3.2.1 Concept

Organisms that destroy or consume crops are generally referred to as pests. They may range from micro-organisms like bacteria and virus to vertebrates like rodents and large ungulates. The conventional approach to pest management has been to identify the pest as man's enemy and launch attacks to exterminate the enemy. In the war against pests man has increasingly come to rely on chemical weapons.

The problem of SPM is to minimise pest damage to crops while ensuring that the methods deployed do not create either localised or dispersed externalities which may have adverse long-term impact on productivity of the system. There are three main dimensions of the problem: (a) Ecological, (b) Economic, and (c) Institutional.

Ecological: The literature on SD indicates two main approaches/philosophies in dealing with the problem (Colby 1990, Dilworth 1993). The "techno-economic" school believes that this can be done with the help of new technology for which the financing would come from economic surpluses generated by a high growth economy. According to the "ecological school," a paradigm shift is called for.

Under the new paradigm, agriculture is perceived as a biological system in which the population of various species are held in delicate balance. Any disruption in the system may upset this balance. When the populations of organisms that feed on the crop exceed normal levels such organisms assume the status of pests (see "Functions of Nature" by Groot 1992). The control effort would be directed towards restoring the balance, and/or removing the original source of disruption. These alternative pest control methods may be termed "natural" since the underlying principle involves working with nature rather than against it. These have been well documented in developed countries (Yepsen 1966, Fukuoka 1970, Stoll 1988, Thurston 1992, back issues of "Acres USA" for past 20 years) as well as in India (Gupta, Capoor and Shah 1990, Balasubramaniam 1988, Mukhopadhyay (n.d.), Sukhatme 1990, back issues of "Honey Bee" 1990 to 1993).

Economic: Natural methods are often perceived as inefficient especially in the short run. For those making a transition from chemical to natural methods the short term losses may be significant. Management of the transition phase become critical, particularly for those farmers who do not have the necessary economic buffer.

Institutional: An innovation may be ecologically sound and economically sustainable and yet generate non-sustainable outcomes, if the institutions which monitor, support, tolerate or sanction its usage are not sustainable. Two important conditions for institutional sustainability in the context of SD are (i) self-designing capability (Hedberg 1976, 1978, Gupta (n.d.), Wildavski 1972), and (ii) commitment to bio-ethics - i.e. ethics based on values of ecological sustainability (O'Riordan 1988) While studying innovations for SPM all three dimensions of the problem will be kept in focus.

3.2.2 Innovation

The evidence on grassroot innovation for SPM was collected from news paper reports (Sémetreck Aug. 1992, Singh Anil June 1992, and July 1992, Kumar V.B. July 1992) as well as documentation studies (listed in previous section). The "Honey Bee" network initiated by Prof.Anil Gupta at IIMA[10], has published

---

10. "Honey Bee" is a journal devoted to documentation and promotion of farmer initiatives for SD. It also serves as the official news-letter of a network of farmers, scientists and academics that have made it happen.

over the past four years more than 450 such innovations in the area of agriculture and animal husbandry, about 70 of which are on agricultural pest management.[11]

In order to develop field level sensitivity I did two field studies - one based on news-paper reports of a vermiculture enterprise at Pune and another based on Honey Bee reports of innovation by farmers in Valiya and Dediapada talukas of Valsad, Gujarat. A classification of SPM innovtions has been developed on the basis of these initial studies (Figure 4) which shows how different conceptualisations of the problem lead to differences in the heuristics used to arrive at the solution.

These initial studies lead to certain propositions which are treated as assumptions for this study :

a) A variety of heuristics are being used by innovators for SD technology.

b) Many of these heuristics are different from the ones used by innovators for non-SD technology.

c) Heuristics used are guided by the manner in which a problem is conceptualised. This in turn is influenced by the world-view, knowledge-base and socio-ecological context of the innovator.

---

11. The total number of innovations documented over the past four years is about 1200. Out of the balance of 750 unpublished innovations, about another 70 are on agricultural pest management.

Figure 4

PRELIMINARY CATEGORISATION OF SPM INNOVATIONS

Perception of problem	Pest control		Nutritional imbalance		Agro-ecological imbalance
Nature of innovation					
a) Target	Pest	Pest	Crop	Soil	Farm
b) Heuristics	Cost effective & envn. friendly pesticide substitutes	Restoring pest-pred. balance	Restoring nutn. balance	Restoring soil health	Enabling positive homeo-statis
Stage of Intervention					
(Preventive)	++	++	++	+++	+++
(Curative)	+++	+++	+++	++	++
(Salvage)	+	+	+	+	+
Time frame for evaluation ST	x	x			
MT		x	x		
LT				x	x
Examples of innovation	Bio-degradable pesticide eg. Naffatia	Classical bio-control eg. attracting birds to prey on pests	Spray of sea-weed & liquified fish formulation	Vermi-culture	Organic farming

---

Source: Self-compiled.

4.0 Research Objectives

4.1 General

Innovations can be classified into endogenous or exogenous depending on whether knowledge base and resources used are internal or external to a system (be it a community, an organisation or a society) (see Fig 5). Endogenous innovations may be either traditional or contemporary. They may rely on internal knowledge or on external knowledge which has been assimilated. They rely mostly on internal resources. The outcome of both exogenous and endogenous innovations could either be sustainable or non-sustainable, although exogenous innovations tend to generate non-sustainable outcomes because of high dependence on external resources and knowhow.

The purpose of the study is to develop insights into the process of innovation for SD, which would prove useful in designing institutional and policy support for SD innovators. The broad objective of this research to study endogenous, technological innovations for SD at the grassroots level.

4.2 Specific

The specific research objectives may be stated as follows .

(1) To identify the heuristics used by grass root innovators for SD.

(2) To identify the key contextual, and innovator specific variables that influence the evolution and use of these heuristics.

Figure 5

A CLASSIFICATION OF INNOVATION-BASED ON KNOWLEDGE AND RESOURCE BASE

	Endogenous		Exogenous
	Indigenous*	Blended*	
1. Knowledge base			
Internal	+++	++	-
External			
a) Assimilated	+	++	-
b) Non-Assimilated	-	-	+++
2. Resource Base			
Internal	+++	+++	-
External	-	+	+++

* Can be futhur classified into Traditional and Contemporary.

Source: Self-compiled.

(3) To develop criteria for discriminating between sustainable and non-sustainable heuristics and between high and low sustainability heuristics.

(4) To identify the policy and institutional variables that need to be manipulated/influenced/appreciated in order to spot, stimulate, support and sustain grass root innovators for SD.

5.0 Framework for Analysis

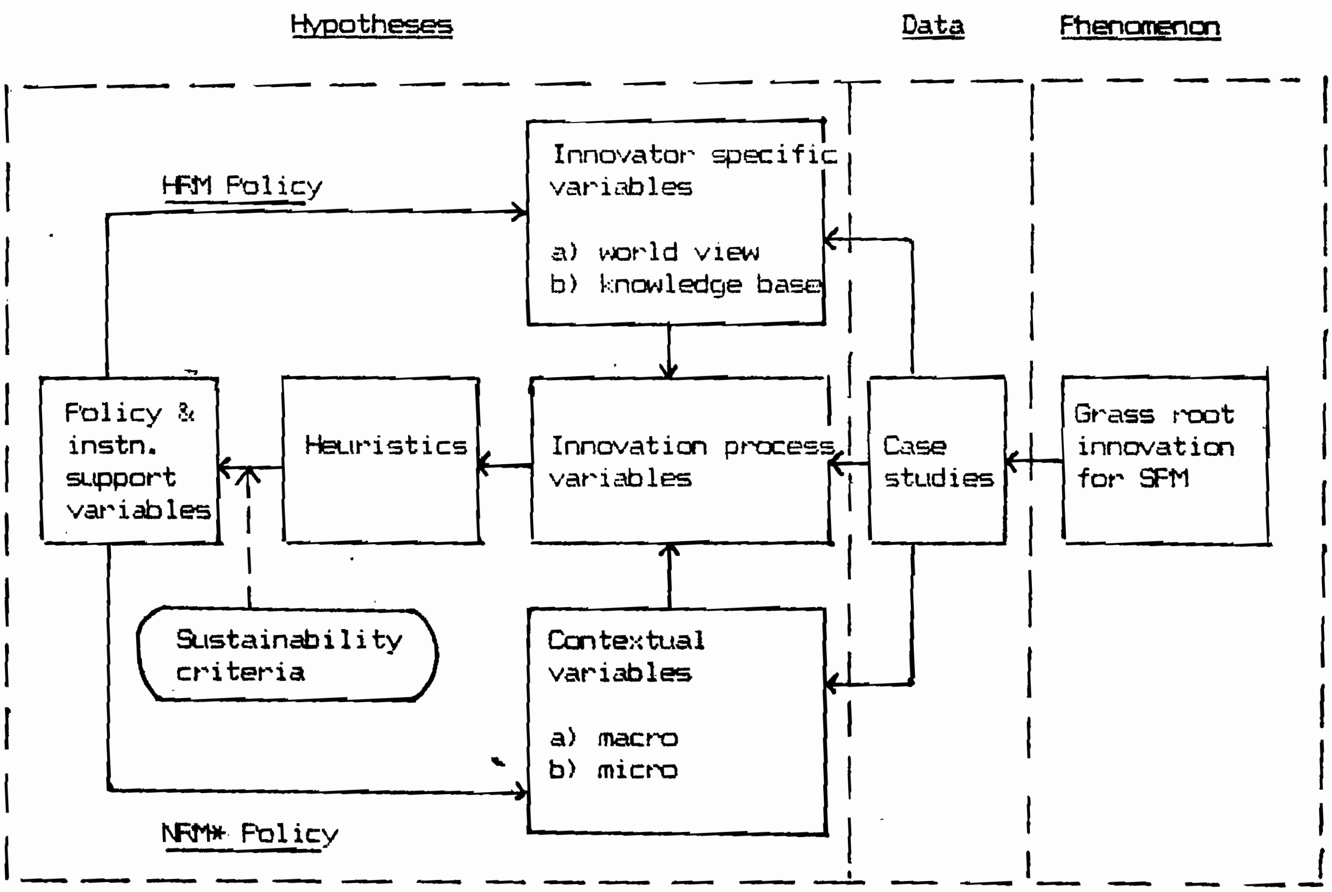
The broad constructs identified so far as well as their hypothesised relationships are presented in Figure 6. Data generated through case studies of innovation would be used to identify key variables within these broad constructs as well as to test the hypothesis made about their inter-relationships. Given the phenomenological approach adopted in this study (see Sec. on methodology), new variables and constructs as well as new hypotheses about their relationships may be introduced as and when they are discovered. I provide below a brief discussion of each of these constructs.

Heuristics

The Longman's dictionary defines heuristics as the use of experience and practical efforts to find solutions and improve performance. Heuristics in the innovation literature is referred to as thumb-rules for decision making (Manimalai 1986). It has received significant attention from researchers on decision making process (March and Simon 1958, Braybrooke and Lindblom 1963, Cohen et.al. 1972).

Figure 6

FRAMEWORK FOR ANALYSIS



Source: Self-compiled.

*HRM = Human Resource Management
NRM = Natural Resource Management

Thumb-rules however are only single decision heuritics. Multiple decision heuristics are more complex and often more effective - since they address more than one contingency (Mize 1964). Since heuristics evolve out of expe:ential knowledge of user or user groups/communities, they throw light on the world-views and knowledge base of the latter. The same heuristics may be used by different innovators or by the same innovators for different innovations. Hence they provide a useful basis of studying innovations in clusters.

The process variables listed in Table 1 are drawn from the literature on innovation process to serve as a guide for uncovering the heuristics. The problem -solving literature identifies the stages of problem definition, implementation and judgment (review by Kaufman 1988). Often, judgment includes the process of validation. After this stage the innovation is considered fit for self - use or diffusion, provided it is economically viable.

Biggs (1989) pointed out in the context of agricultural technology that diffusion process involves "simultaneous innovation" leading to evolution of the technology. This happens because farmers innovate to adopt technology to their specific ecological conditions. The more recent work of Von Hippel (1976) on user-innovation, supports this notion.

Another stream of innovation literature has pointed out the role of serendipity (Royston 1989, Beveridge 1980). Also, not all innovations are addressed to solving problems. Some times sheer curiosity may result in an unintended discovery. This literature

Table 1

Innovation Process Variables

Construct	Variables Change
1. Triggers	Trigger events, change in perspective, metaphors, chance discovery of materials, techniques, properties, etc.
2. Perception of problem	Enemy, systemic break-down, systemic imbalance, etc.
3. Sources of ideas	Other farmers, other micro-climates, media, extension agencies, elders, trigger events
4. Cognitive process	Recombination, substitution recalibration, integration
5. Experimentation	Natural vs. field trials, partial plot vs. whole farm, individual vs. group autonomous vs. collaborative
6. Evaluation a) Means b) Ends	Utilitarian vs. value based short term vs. long term
7. Validation	
a) Spatial	No. of micro-climates
b) Temporal	No. of years

Source: Self-compiled

stresses the importance of surprise, trigger events, analogies and metaphors (Miller 1986).

Theories on the cognitive process of innovation (Barnett 1953) make it possible to study the generation of solution ideas as a separate variable.

Tentatively, the main process variables selected include, **triggers, conceptualisation of problem,** generation of solution ideas (which includes **sources of ideas** and **cognitive process), experimentation, evaluation** (of means and ends) **and validation.**

Contextual variables

Context variables have figured prominently in the innovation process literature (Kaufman 1988, Manimalai 1986).

The **ecological context** determines the range of options available to an innovator (Gupta 1984). The **economic context** determines the nature of stakes involved as well as the ability to take risks associated with the innovation process (Gupta 1986). The **social/cultural context** determines the nature of support that an innovator can expect from his/her peer group. A community may decide either to tolerate, support or sanction the innovative efforts of an individual member depending on its collective judgments or norms. A preliminary list of context variables classified under **eco-physical** and **socio-economic** categories is presented in table 2.

The existing policy with respect to management of natural and human resources affect the access to resources, skills and knowledge and thereby constitute what may be labeled as **policy context.** Policy variables can be manipulated to influence both

Table 2

Contextual Variables

Constructs		Variables
I. ECO-PHYSICAL		
(A) Farming Micro-Climate Level		
1. Soil	–	Fertility levels
2. Climate	–	Arid semi-arid, semi-tropical tropical, micro-climatic variability.
3. Cropping pattern	–	Cropping intensity (single crop, multiple crop)
	–	Croping diversity (mixed crop, inter crop, integration with other biological production)
4. Bio-diversity	–	Species to genus ratio
	–	Variety to species ratio
	–	Mono-cot/Di-cot ratio.
(B) Farm Level		
1. Nature of crop	–	Resistant vs. susceptible variables High yielding vs. traditional variables Irrigated vs. unirrigated Commercial vs. subsistence High mean vs. low mean value High variance vs. low variance in value Legume vs. non-legume Short duration vs. long duration
2. Nature of pest attack	–	Specific vs. general pest Chromic vs. sporadic attack Acute vs. mild attack Visible vs. non-visible pest Known vs. unknown etiology Single pest vs. complex of pests predictable vs. unpredictable pest Emergent vs. declining pest Localised vs. dispersed.

Table 2 (contd.)

3.	Relationship of pest with micro climate	-	Associated with or influenced by: - soil factors - climatic factors - cropping pattern - bio-diversity neighbourhood ecology - field - swamps	
		-	Phyto-association	
4.	Awareness of environmental externalities	a) Human	- Direct exposure - Indirect exposure - Residue in food	
		b) Non-human	- Damage to birds - Aquatic system - Micro flore & fauna	
II.	SOCIO-ECONOMIC			
(A)	<u>Community Level</u>			
1.	Extent of control on individual action		- Consumption decisions - Production decisions - Disposal decisions	
2.	Extent of support to individual action		Material, moral, manual, mental	
3.	History of community action		- CPR institutions - Episodal institutions - Group actions - Factionalism	
4.	Religious/Spiritual value		- Supportive - Non-supportive	
(B)	<u>Individual/Family Level</u>			
1.	Access to knowledge a) indigenous b) exogenous		 - Bhuas, elders, family - VLWs, teachers etc.	
2.	Access to resources a) own b) borrowed/leased		- Land, labour, capital -do-	
3.	Support of family members		- Material, moral, manual, mental	

<u>Source</u>: self-compiled

contextual and innovator specific variables. Given their importance for this study, they are discussed separately.

Innovator Specific Variables

Two types of innovator specific variables have been identified a) world-view and b) knowledge base (Table 3).

World-view has been defined by Counelis (1984) as :

> "....the intersect between cosmology and ethos held and practiced by persons within the bounds of a particular time and place, with the intersect directed towards particular goals or teleos."

The cosmology and teleos as defined by Counelis together provide a **vision for development**, while the ethos has reference to the underlying **value system**. The world-view variables are therefore organised under these two sub-constructs.

The **knowledge base** includes both knowledge as well as skills. This knowledge may be specialised or general. Often specialised knowledge or skills become critical for an innovation to materialise. The knowledge may be exogenous or endogenous. It may be embodied in the means of production or it may represent disembodied knowledge. From the pattern of agricultural practices, the input-mix, the nature of implements used etc. it is possible to asses the ratio between exogenous and endogenous knowledge in use.

The pattern of ownership and control of knowledge will also have a bearing on the access of specific knowledge to innovators. Knowledge variables are listed under three categories: (a) **genesis**, (b) **sociology**, and (c) **nature/type**.

Table 3

Innovator Specific Variables

Construct	Variables
I. WORLD VIEW VARIABLES	
1. Vision of Development	
Means and Ends	- anthropocentric vs. eco-centre - wholistic vs. atomistic - exclusive vs. inclusive - worldly vs. other worldly - evolutionary vs. radical - local vs. global - integrated vs. segmented
2. Value System	
attitude towards life	- materialism vs. spiritualism
attitude towards nature	- domination vs. co-evolution
attitude towards fellow humans	- exploitation vs. co-development
attitude towards future generations	- concern vs. indifference
attitude towards natural resources	- conservation vs. exploitation
II. KNOWLEDGE BASE	
1. Genesis of Knowledge	
exogenous	- schooling migration contact with extension/ change agents
indigenous	- folk-lore (enculturalised knowledge) - skills - taxonomies

Table 3 (contd.)

2. Sociology of Knowledge	
ownership	open access, common property, private
control	on innovation, on diffusion of innovation, on rights of usage, on norms for transfer of knowledge
3. Nature of Knowledge	
embodied in mode of production	ratio of exogenous/ indigenous ratio of specialised/ general
disembodied knowledge	exogenous/indigenous specialised/general

Source : self-compiled

Discriminating Criteria

The sustainability criteria may be divided in two parts viz. **outcome** and **process** (Table 4). The outcome criteria are further divided into **utilitarian** and **value based** criteria. Utilitarian criteria involve assessment of short and long term effectiveness of the technology vis a vis cost. The assessment of costs include the whole range of farm level externalities that affect productivity. The value based criteria seek to ascertain whether the given technology or innovation generates or is likely to generate environmental externalities that affect either present or future generations of human or sentient beings. Greater reliance on short term utilitarian criteria is expected to lead to un-sustainable development - although emphasis on value-based criteria to the total neglect of efficiency would very much produce the same results. A minimal efficiency cut-off will be fixed. Value-based criteria also include the attitude towards extraction and use of scarce natural resources.

The process criterion has to do with the **plasticity of the technology.** The greater the scope for users to recombine components of the technology the greater are the possibilities of (a) addressing the need of eco-specificity, and (b) making mid-course corrections.

Policy Support Variables

Several factors affect the degree and nature of response of an administration to the problems of SD and of SD innovators. The response depends both on the nature (model) of policy making in vogue in a given context as well as the underlying socio-political structure. Of the several "systems-oriented normative

Table 4

Sustainability Criteria

Construct	Varia
I. IMPACT OF TECHNOLOGY	
(A) Utilitarian	
1. Short term (within season)	
a) Benefit	- % control (fo - % avoidance (- extent of cro - positive exte
b) Cost	- out of pocket - imputed costs - negative exte crop
2. Long term (across seasons)	
a) Benefit trends	- % control/avo - trend in crop - positive exte
b) Cost trends	- out of pocket - imputed costs - negative exte
(B) Value Based	
1. Present generation externalities (positive & negative)	
a) On human life	- health & mort - stock of rene non-renewable
b) On sentient life	-do-
2. Future generation externalities	
a) On human life	- health & mor - stock of reso
b) On sentient life	-do-

Table 4 (contd.)

II.	NATURE OF TECHNOLOGY	
1.	Plasticity	- scope to re-combine or re-asemble components - scope to moderate dosage, intensity of use etc.
2.	Location specificity	- compatibility with existing resource use - compatibility with prevailing social norms

Source: Self-compiled

models" that seek to explain public policy working[12], Lindblom's "incremental change model" has received wide-spread recognition, suggesting that most policies tend to be evolutionary rather than revolutionary.[13]

The responsiveness and openness of policy institutions and policy makers is also determined by the political structure and climate of a nation. Bosso (1987) identified three distinct political images of policy making: (a) sub-governments, (b) issue-networks, and (c) pluralist[14]. While the first two have been used to project the reality in most states, the "pluralist" model is held as an ideal for a democratic system.

In a pluralist society, policy making is seen as a process of negotiation between different client groups and policy makers. Both sides are influenced by domestic and international

---

12. A review by Dror (1968) yielded six models of policy making ranging from "pure-rational" and "economically rational" to "satisfising" and "extra-rational".

13. However, see the debate between Miller and Starbuck on evolutionary versus revolutionary policy making in the context of organisational change (Nystrom & Starbuck, ed. 1981).

14. Sub-governments are described as informal but enduring series of "Iron Triangles" linking bureaucrats, elected representatives and interest group clienteles with a stake in particular programmes in whom policy dominance is vested (Bosso 1987).

    In the Indian context the metaphor of "Iron Triangle" has been used to explain the liquidation of forest resources for industrial growth and the resultant poverty of tribals dependent on these resources for survival (Gadgil 1989).

    The "issue networks" model describes the "webs of influence" exercised on key decision-makers. These webs or networks may comprise of large number of participants, viz., elected representatives, bureaucrats, media people, policy experts, social workers, etc. (Bosso 1987).

influencers/events in their assessment of policy needs. How different groups of stake-holders articulate their concerns and get their interests represented determine the nature of policy response (see "Articulation-response model", Gupta 1991).

More often than not, policies fail either due to lack of appropriate articulation/representation of people's needs or due to lack of appropriate response of policy makers. This might lead to either a condition of learned helplessness or to the exploration of **self-help route.** Perhaps the most potent form of self-help is technological and institutional change through endogenous innovation, (See Figure 7).

The nature of policy and institutional support needed to facilitate self-help is very different from that needed in responding to articulated needs. Support to innovators for SPM can be extended through indirect and direct interventions, the support variables (see Table 5) are therefore listed under these two headings:

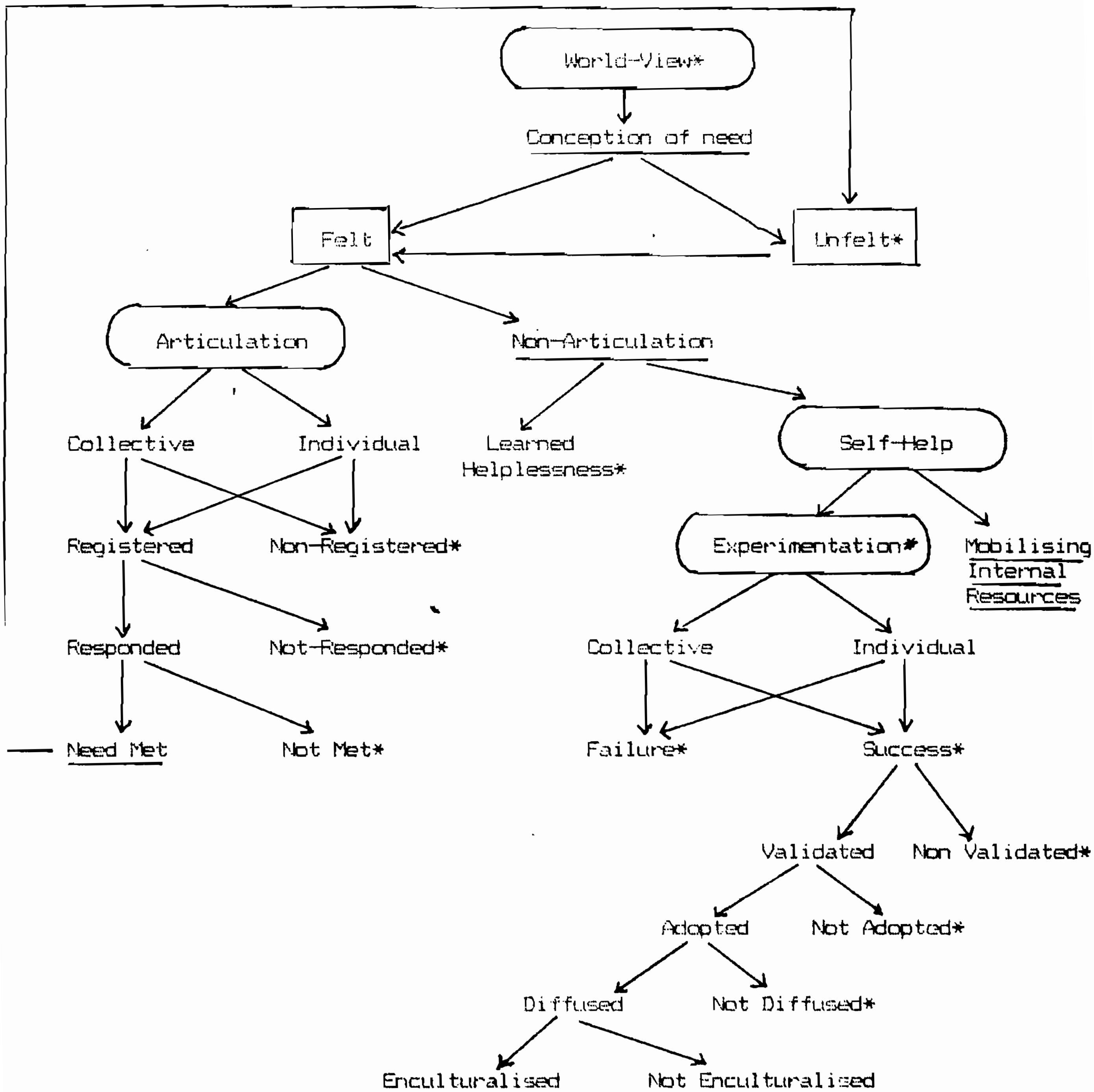
(a) **Indirect Intervention**

At a broad policy level two types of variables have been identified:

(i) Human resource policies and (ii) natural resources policies. While the former would have an indirect influence on innovators by influencing their world views and knowledge base, the latter has implications for access to resources and knowledge of various types. Together these policies constitute the policy environment in which grass root innovators operate. Reorientation of these

Figure 7

Opportunities for Policy Response



* Opportunities for Policy Response.

Source: Extension of Articulation Response Model of Anil Gupta (1992)

Table 5

Policy and Institute Support Variables

Construct	Variables
I. POLICY	
1. Natural resource policies	- ownership rights of resources - use rights over resources - valuation of natural resources - technology promoted - monitoring rate of exploitation of natural resources
2. Human resources policies	- nature of knowledge/skills promoted - world-view being promoted
II. INSTITUTIONAL	
1. Self-Help Route	- facilitating innovation - facilitating value-addition to local innovation - facilitating farmer to farmer diffusion
2. Articulation-Response Route	- supply of exogenous knowledge - diffusion of farm innovations through institutional channels

Source: Self-compiled

policies would provide a more favorable environment for them. A list of policy support variables is provided in Table 5.

b) **Direct Intervention**

Considerable experimental knowledge on alternative methods used by developmental agencies (mostly NGOs) which enable people to adopt the self-help route, has accumulated over the past three decades (Bhatt 1989, Alfonso 1986, Heredero 1990, Pastakia 1990, etc).

However, examples of agencies promoting technological innovation at the grass-root level are rare. One such example is the Lok Swasthya Parampara Samvardhan Samithi, which is a voluntary network organisation involved in promotion of "local health tradition". The experience of these agencies can provide some clues and lessons in playing the facilitative role.

Key decisions in a given heuristic may serve as the nodal points for intervention by a support institution. The nature of support could be **informational, instrumental, organisational, material or moral.** The mix of policy support would be determined by the nature of decision, the type of outcomes, and the scope for value addition to the innovative efforts of the farmer/entrepreneur. Intervention may not be possible and even advisable, at all decision points. In such cases an appreciation of the farmer's position may prove more constructive than intervention - which may be construed as interference.

6.0 Methodology

6.1 Approach

I propose to adopt a "phenomenological" approach for this study. Bogdau and Taylor (1975) have traced the origin of this theoretical perspective to the works of Max Weber (Economy and Society, 3 vols.) where the phenomenology is concerned with understanding human behavior from the actors' own frame of reference. It differs from the dominant theoretical perspective viz. positivism in social science and classical management research (i.e. operations research, structural and functional analysis etc.) in the several significant ways:

> "the positivist searches for 'facts' and 'causes' through methods such as survey questionnaires, inventories and demographic analysis, which produce quantitative data and which allow him or her to statistically prove relationships between operationally defined variables. The phenomenologist on the other hand, seeks understanding through such qualitative methods as participant observation, open-ended interviewing and personal documents. These methods yield descriptive data which enable the phenomenologist to see the world as subjects see it" (ibid.).

This approach to research may also be seen as an ethnographic one. Ethnography which has its moorings in cultural anthropology is defined as a process of studying and describing the culture of any given community from the view-points of its members (Mouly and Shankaran 1993). Shingi (1981) described it as an iterative, interactive and conflictive approach to develop a review from within. As Malinocosk (1992) in Mouly and Shankaran (1993) pointed out, ethnography enables the researchers to grasp the world view of the subjects. For Spradley (1980), it involves "learning from people rather than studying them".

Recent development of **ethnographic research methods** has further strengthened this theoretical perspective. The methodological differences between ethnographic and other social science research is elaborated by Spradley. The essential difference is that "while the latter tends to follow a linear pattern of investigation, the former follows a cyclic pattern (see Figs. 9 & 8). However, a good deal of complimentarity exists between different ethnographic and survey methods,[15] providing scope for using them in tandem.

6.2 Methodology

I propose to use a multiple-case method for this study. The overall scheme of data collection, validation and analysis is presented in Fig. 10.

Selection of Cases

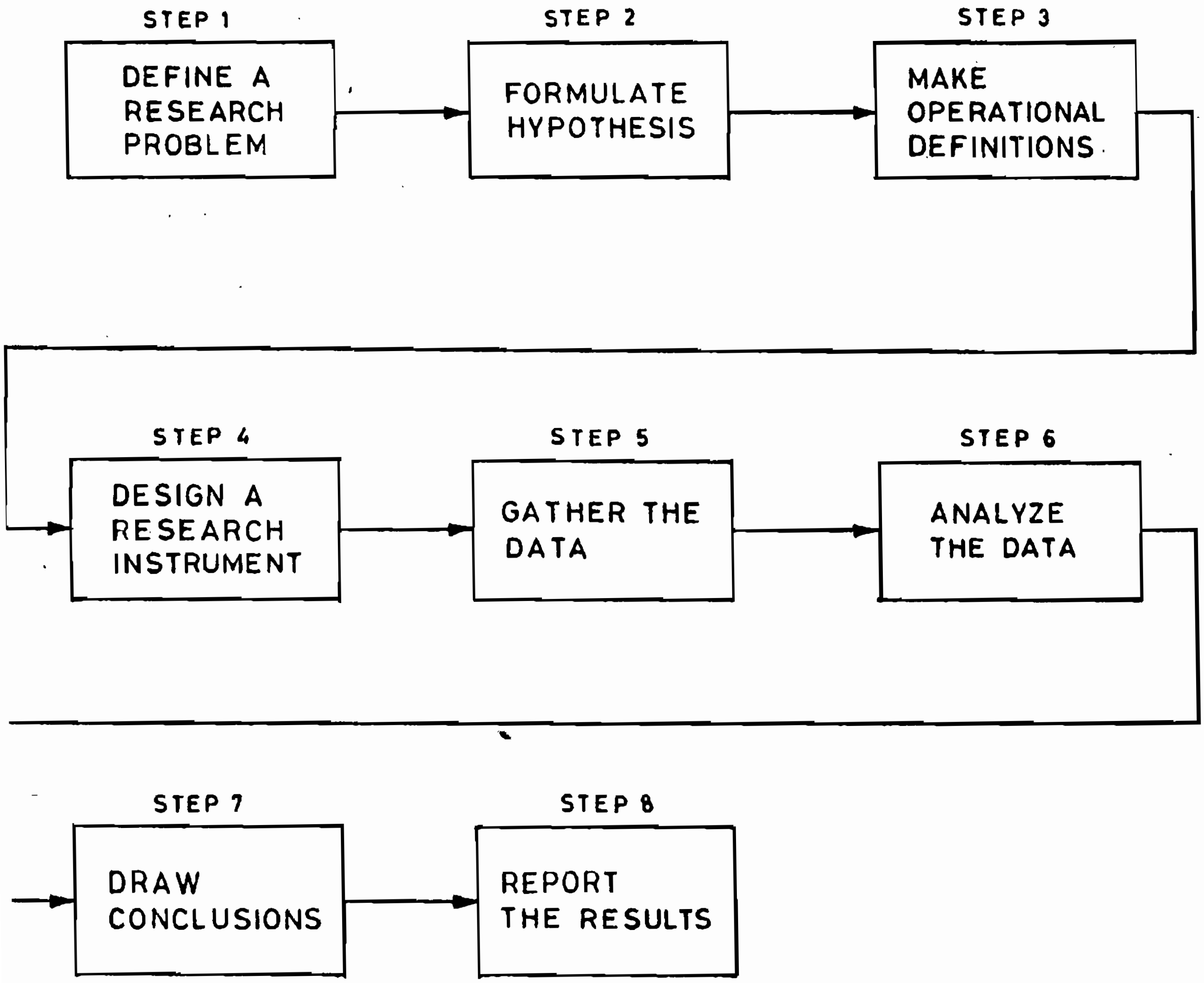
A list of prospective cases of SPM innovations will be drawn from Honey Bee issues, newspapers reports and other documentation studies. A preliminary survey using a semi-structured questionnaire will be carried out to generate systematic information on

- nature of innovation: contemporary/traditional
- nature of pest problem
- nature of solution
- perceived effective
- perceived environmental impact

---

15. For a detailed comparison of the strengths and weaknesses of ethnographic and survey methods, see Mouly and Shankaran (1993).

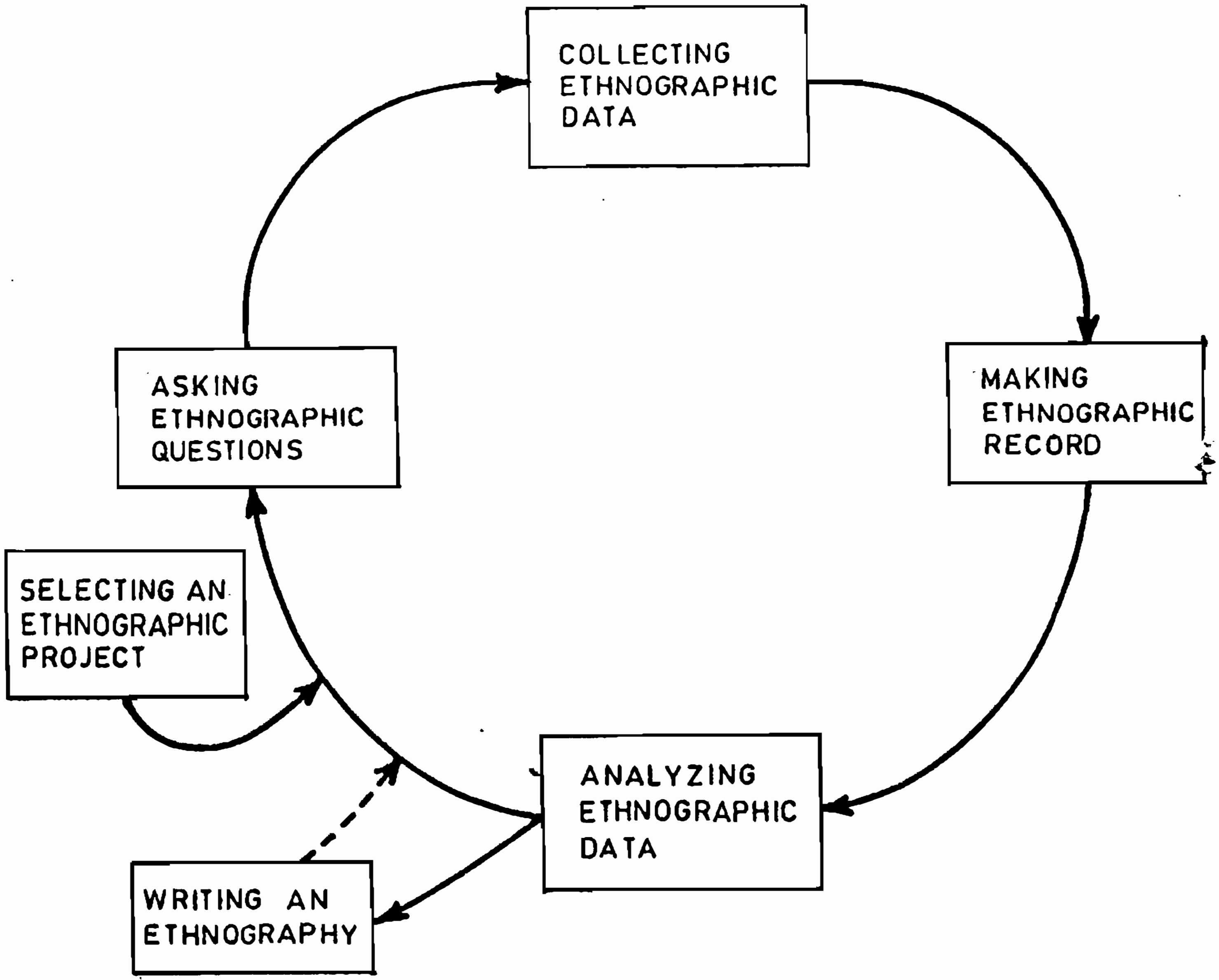
Figure 8



LINEAR SEQUENCE IN SOCIAL SCIENCE RESEARCH.

(Reproduced from Spradley 1980)

<u>Figure 9</u>

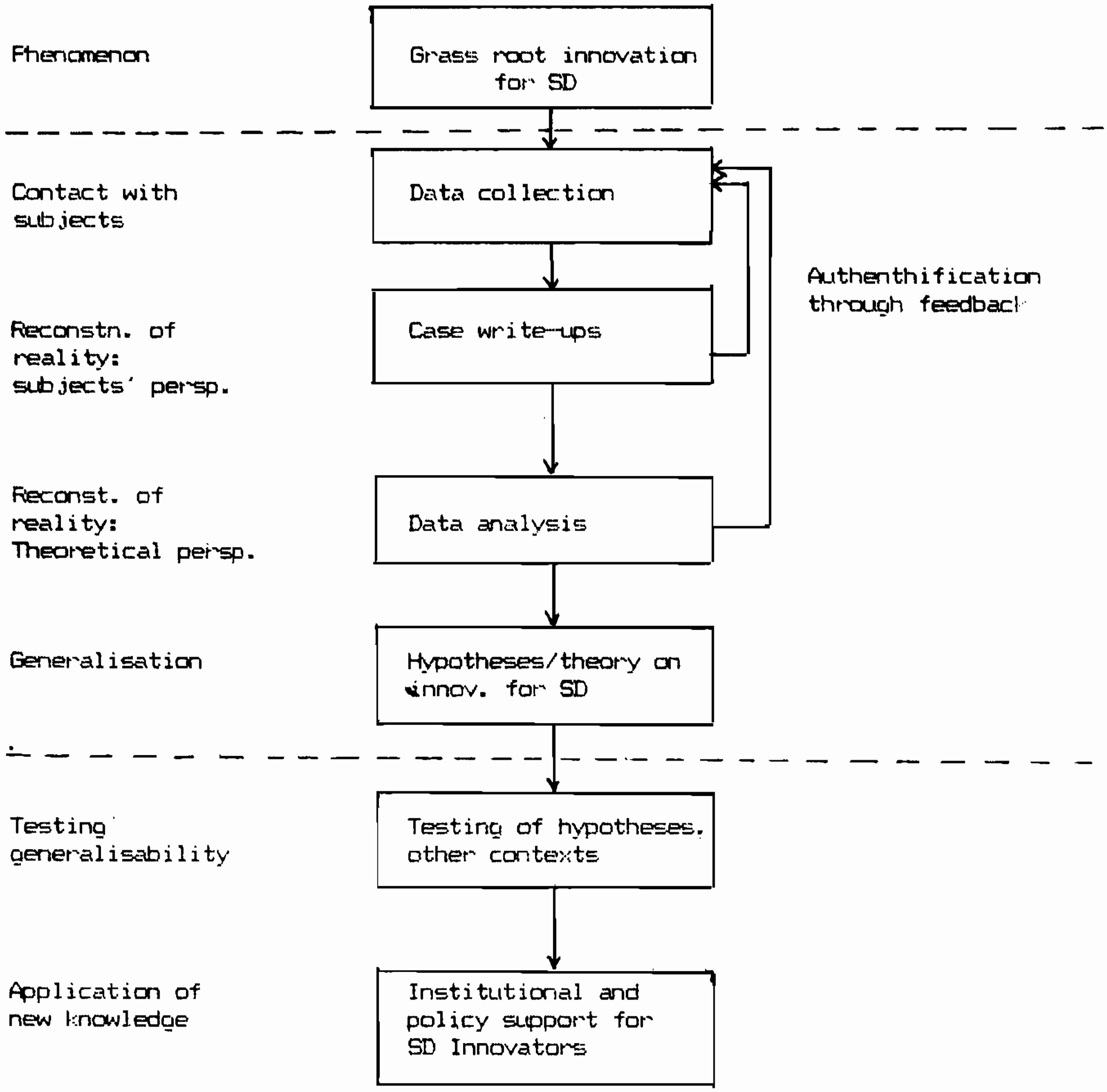


THE ETHNOGRAPHIC RESEARCH CYCLE.

(Reproduced from Spradley 1980)

Figure 10

STAGES OF RESEARCH AND ITS UTILISATION



Source: self-compiled

- perceived cost/benefit
- trigger events
- extent of diffusion

This will serve as the data base for selection of cases for indepth study. First preference will be given to contemporary innovations.[16]

Innovators in this second list will be contacted to find out their willingness to participate in the study. If the list of willing respondents is too large, the sample will be selected in a way that ensures maximum representation of (a) different categories of pests, and (b) types of heuristics. If the data on negative externalities suggest violation of sustainability criteria such innovations will be dropped from the list. Only those practices currently in use will be included.

The **number of cases** selected would depend on the availability of cases which fit the above mentioned requirements, and which have potential to throw light on the phenomenon. The trade-offs between depth and breadth of understanding have been pointed out by Satia (1992), and Yin (1984). Single case studies are good for studying unique situations, for testing existing theories in new contexts, for generating in-depth understanding of a phenomenon, and for developing new insights and hypotheses. On the other hand multiple-case studies are more appropriate for discovering patterns and making comparisons (ibid). In this study I propose to take up between 6-10 cases for in-depth analysis.

---

16. In traditional innovations the original innovators are not available since they belonged to previous generations. Hence authentic data on process variables cannot be collected.

This decision is based on the need to balance depth with breadth of understanding, of the phenomenon.

Generation of Case Data

Detailed case studies will be carried out using techniques such as unstructured, iterative interview and participant observation. Data will be collected from innovators, early adopters, discontinuers and non-adopters.

Validity and Authenticity of Data

A pilot study with one case would be used to firm up the procedure of data collection. The same procedure with some built-in flexibility would be used for the remaining cases in order to ensure the replicability of the procedure. Validation of the data is likely to be more challenging. One way is to organise group meetings where the differences in perception between innovators, early adopters, non-adopters and discontinuers can be brought out and discussed. In case of highly subjective data such as values of individual actors, triangulation will be attempted by direct assessment as well as indirect assessment - by looking at the heuristics as an alternative source of data. The data would be authenthicated by feeding it back to the respondent in order to ensure that it accurately represents his/her perspective. The iterative method of interview will facilitate such authenthification.

6.3 Data Analysis and Theory Building

The enthnographic case studies facilitate construction of the reality from the perspective of the subjects. Theoretical constructs can be isolated from this raw data and interrelations analysed either through a system of coding as suggested by Strauss and Corben (1990) or through "Domain analysis" as suggested by Spradley (1980). For analysis of "soft" variables such as world-view variables, Semiological analysis would be done as outlined by Berger (1982). Sets of hypotheses and overall themes/patterns can then be discerned and presented for further testing.

7.0 Expected Contributions and limitations

The study has been designed in a way that will generate insights for remodeling public policy for innovation in general and SPM innovation in particular. The insights gained would help not just policy makers but would also be of use to voluntary groups and academic activists involved in the work of strengthening capabilities of grassroot innovators.

While much of the findings are expected to be context specific, some of it will be presented at a higher level of abstraction and would therefore be generalisable across other biological production systems. The major theoretical contribution will be to make possible the discrimination of heuristics for innovation on the basis of sustainability criteria.

It should however be noted that the study is essentially exploratory in nature. Hence while hypotheses will be generated they will not be taken up for empirical testing. Several such studies in different sectors would be needed to test the generalisability of the findings.

BIBLIOGRAPHY

1. Anon, Guntur Cotton Report, Guntur : Andhra Pradesh Department of Agriculture, 1990.

2. Alag, Y.K., "Pesticides in Indian Agriculture", Economic & Political Weekly, September 1988, pp. 1959.

3. Alfonso F.B., "Empowering Rural Communities" in IcKis J.C. et.al. (ed), Beyond Bureaucracy, West Harfort, Connecticut : Kumarian Press, 1986, 256 p.

4. Argyris Chris and Schon Donald, Organisational Learning : A Theory of Action Perspective, Reading, Massachusetts : Addison-Wesley Publishing Co., 1978.

5. Ashby J.A., "Technology and Ecology : Implications for Innovation Research in Peasant Agriculture", Colombia : CIAT, 1981.

6. Atte David O., "Indigenous Local Knowledge as a key to local level development : Possibilities, Constraints and Planning Issues in the Context of Africa", in Proceedings of Seminar on Reviving Local Self-Reliance : Challenges for Rural/Regional Development in Eastern and Southern Africa, Arustia, Tanzania : United Nations Centre for Regional Development and IRDAFRICA, 1989.

7. Balasubramanian, A., "Traditional Plant Protection Methods in Tamil Nadu", in Proceedings K. Vijayalakshmi (ed), Biooogical Methods of Pest Control, Madras : Patriotic and People-Oriented Science and Technology Foundation, 1988.

8. Barnett, H.G. Innovation : The Basis of Cultural Change, New York : McGraw-Hill, 1953, 462 p.

9. Batie, Sandra S., "Sustainable Development : Challenges to the Profession of Agri. Economics", American Journal of Agricultural Economics, Vol. 71, No. 5, Dec. 1989, pp. 1083-1116.

10. Barbier Edward B., "The Concept of Sustainable Economic Development", Environmental Conservation, Vol. 14, No. 2, 1987.

11. Berger Arthur A., Media Analysis Techniques, Beverly Hills : Sage Publications, 1982, 160 p.

12. Beveridge W.I.B., Seeds of Discovery, London : Heinemann Educational Books Ltd., 1980, 130 p.

13. Bhatia, S.K., "Pesticide Resistance in Agricultural Pests in India", Pandian T.J., Dharo M., and Janak Raj (eds), Proceedings, INSA Seminar, Plant Protection in the Year 2000 A.D., New Delhi : Indian National Science Academy, 1986.

14. Bhatt, Anil, Poverty, Tribals and Development : A Rehabilitation Approach, New Delhi : Manohar, 1990, 93 p.

15. Biggs, Stephen D., "Informal R&D", Ceres Vol. No. 76, July-August, 1980.

16. Biggs, S.D., "Resource-Poor Farmer Participation in Research : A Synthesis of Experiences from Nine National Agricultural Research Systems", The Hague : ISNAR, 1989.

17. Bogdan R. and Taylor S.J., Introduction to Qualitative Research Methods, New York : John Wiley, 1975.

18. Bosso, Cristopher, Pesticides and Politics : The Life Cycle of a Public Issue, Pittsburgh : University of Pittsburgh Press, 1987, p. 294.

19. Braybrooke D. and Lindblom C., A Strategy of Decision, New York : Free Press, 1963.

20. Bruun Ole and Kalland Arne (eds), Asian Perceptions of Nature, Nordic Proceedings in Asian Studies, No. 3, Copenhagen : Nordic Institute of Asian Studies, 1992.

21. Carson, Rachel Louise, Silent Spring, Boston : Houghton Mifflin Company, 1962.

22. Colby Michael, E., Environmental Management in Development : The Evolution of Paradigms, W.B. Discussion Paper No. 80, Washington D.C : World Bank, 1990.

23. Cohen M.D., March J.G. and Olsen J.P., A Garbage Can Model of Organisational Choice", Administrative Science Quarterly, 17 : 1-25, 1972.

24. Chambers, Robert (ed), Farmer First : Farmer Innovation and Agricultural Research, London : Intermediate Technology Publication, 1989, 218 p.

25. Chandra Kanth, M.G. and Romm Jeff, "Sacred Forests, Secular Forest Policies and People's Action", National Resource Journal, University of New Mexico (n.d.).

26. Consumer Education and Research Centre, Pesticides Residue in Food, Proceedings of Seminar, Ahmedabad : CERC, 1989.

27. Counelis James S., "Knowledge, Values and World Views : A Framework for Synthesis", in Sardar Ziauddin, The Touch of Midas, Manchester : Manchester University Press, 1984.

28. David, B.V., Tamilselvan, C. and Manickavasagam, S., "Bio-accumulation of Pesticides in Environment : An Overview", in Dhaliwal G.S. and Balwinder, Singh (eds), Pesticides : Their Ecological Impact in Developing Countries, New Delhi : Commonwealth Publishers, 1993.

29. Department of Agricultural Research and Education, "Report of the Working Group on Agricultural Research and Education for VIIth Five Year Plan (1985-90)", New Delhi : Ministry of Agriculture, Government of India.

30. Dhaliwal G.S. and Balwinder Singh (eds), Pesticides : Their Ecological Impact in Developing Countries, New Delhi : Commonwealth Publishers, 1993.

31. Dilworth, Craig, "Two Perspectives of Sustainable Development" in Scientific Progress, 3rd edition, Kulwer, Dordrecht, 1993 (forthcoming).

32. Dror, Yehezkel, Public Policy Re-examined, New York : Chandler Publishing Co., 1968, pp. 320.

33. Dwivedi, O.P. (ed), World Religions and the Environment, New Delhi : Gitanjali Publishing House, 1989.

34. Fukuoka, Masanobu, The One-Straw Resolution : An Introduction to Natural Farming, Rasulia, Hoshangabhad : Friends Rural Centre, 1978 (Indian Edition: 1984).

35. Gadgil, M. and Subash Chandar, M.D., "Sacred Grooves" in Sen, Geeti (ed), Indigenous Vision : People's of India. Attitudes to the Environment, New Delhi : Sage Publications and India International Centre, 1992.

36. Ganapathy, R.S., "On Methodologies for Policy Analysis" in Ganapathy, R.S. et.al. (eds), Public Policy and Policy Analysis in India, New Delhi : Sage Publications, 1985.

37. Gino, Marco J., Hollingworth Robert M. and Durham William, Silent Spring Revisited, Washington D.C : American Chemical Society, 1987.

38. Gips, Terry, Breaking the Pesticide Habit : Alternatives to Twelve Hazardous Pesticides, Minnesota : IASA Publication, 1987, 372 p.

39. Groot de R.S. Function of Nature, Amsterdam : Wolters-Noordhoff, 1992.

40. Guha, R. and Gadgil, Madhav, This Fissured Land : An Ecological History of India. New Delhi : Oxford University Press. 1992. 274 p.

41. Guha, Ramachandran, The Unquiet Woods : Ecological Change and Peasant Resistance in the Himalaya, New Delhi : Oxford University Press, 1989, 214 p.

42. Gupta, Anil K., "Tragedy of the Commons or the Commoner's Strategy : Towards Understanding Ecological Crisis in India", Draft Paper for IASCP, October 1990.

43. Gupta, A.K. and Ura Karma, "Blending Cultural Values, Indigenous Technology and Environment : The Experience of Bhutan", W.P. No. 883, IIMA, August 1990.

44. Gupta, A.K., Capoor Jyoti and Shah, Rekha, "Inventory of Peasant Innovations for Sustainable Development : An Annotated Bibliography", Ahmedabad : CMA, IIMA, 1990.

45. Gupta, A.K., "Building Self-Design Capacities in Developmental Organization", CMA, Discussion Note-2, Ahmedabad : IIMA (mimeographed), n.d.

46. Gupta, A.K., "Household Survival Through Commons : Performance in an Uncertain World", IIMA Working Paper No. 940, Ahmedabad : IIMA, 1991.

47. Gupta, A.K. and Singh, Rakesh, "Corporate Investment in Agriculture Research : Issues in Sustainable Development", W.P. No. 932, Ahmedabad : IIMA, May 1991.

48. Gupta, Anil K., et.al., "Designing an Accessible and Accountable Administrative System; Why do not People Protest?" New Delhi : Oxford & IBH, 1992, 150 p.

49. Gupta, A.K., Patel, Kirit and Patil, B.L., "Conserving Diversity for Sustainable Development : The Case of Plants of Insecticidal and Veterinary Medicine Importance", W.P. No. 1003, Ahmedabad : IIMA, January 1992.

50. Hedberg, Bol T., Paul Nystrom and William Starbuck, "Camping on Seesaws : Perscriptions for a Self-Designing Organisation", Administration Science Quarterly, March 1976, Vol. 21.

51. Heredero J.M., Education for Development, New Delhi : Manohar Publications, 1989, 144 p.

52. Hippel, Eric Von, The Sources of Innovation, New York : Oxford University Press, 1988.

53. Kashyap, Subhash, C., National Policy Studies, Lok Sabha Secretariat, New Delhi : Tata McGraw-Hill Publishing Co. Ltd., 1990.

54. Khanna, B.M., A Study of the Indigenous System of Veterinary Medicine Practiced by the Farmers of Hissar Block, Thesis, Department of Extension Education, College of Veterinary Medicine, Hissar : Punjab Agricultural University, 1967.

55. Kumar, K.G., "Reddy's Revolution", Business India, (June 22-July 5, 1992), 141.

56. Lele, Sharachchandra, "Sustainable Development : A Critical Review", World Development, Vol. 19, No. 6, 1991, pp. 607-621.

57. March J.G. and Simon H.A., Organisations, New York : John Wiley and Sons, 1958.

58. Manimala, M.J., Managerial Heuristics of Pioneering Innovative (PI) Entrepreneurs - An Exploratory Study, Thesis (FPM), Ahmedabad : Indian Institute of Management, 1988.

59. Mehrotra K.A., "Status of Insecticide Resistance in Insect Pests", in Dhaliwal G.S. and Singh, B. (ed), Pesticides : Their Ecological Impact in Developing Countries, New Delhi : Commonwealth Publishers, 1993.

60. Miller Arthur I., Imagery in Scientific Thought, Cambridge, Massachusetts : MIT Press, 1986.

61. Miller and Starbuck, in Nystrom and Starbuck (ed), Handbook of Organisational Design, Vol. 2, New York : Oxford University Press, 1981.

62. Mouly S.V. and Sankaran, J.K., Organisational Ethnography : An Illustrative Application in the Study of Indian R&D Settings, Sage Publications (forthcoming), 1993.

63. Ministry of Chemicals and Fertilizers, Report of the Working Group on Pesticide Industry (VIIth Five Year Plan, New Delhi : Government of India, 1984.

64. Mukhopadhyay, S.K., "Emerging Problems and Advances in Weed Management", Proceedings, Indian Science Congress Association, Sectional Presidential Address, 79th Session, Calcutta, ISCA (n.d.).

65. Munshi, K.M. "The Gospel of the Direct Hand", New Delhi : Ministry of Information and Broadcasting, Government of India, 1951.

66. Nadkarni, M.V. Pasha, S.A., and Prabhakar, L.S., The Political Economy of Forest Use and Management, 1986.

67. National Commission on Agriculture, New Delhi : Department of Agricultural Research and Extension, Government of India, 1980.

68. O'Riordan Timothy, "The Politics of Sustainability" in Turner Karry (ed), Sustainable Environmental Management : Principles and Practices, Boulder, Colorado : Westview Press, 1988.

69. Pacey Arnold, The Culture of Technology, Oxford : Basil Blackwell, 1983.

70. Pastakia, A.R., "Technology Development and Diffusion in Tree Growers' Cooperatives in a Coastal Saline Region of Gujarat : A Learning Environmental Approach", Working Paper No. 917, Ahmedabad : IIMA, 1991.

71. Pereira, Winin, and Jeremy Seabrook, Asking the Earth : The Spread of Unstainable Development, Goa : The Other India Press, 1992.

72. Pimbert, Michael P., "Designing Intergrated Pest Management for Sustainable and Productive Futures", IIED Gatekeeper Series, No. 29, London : IIED, 1991.

73. Rogers, E.M., Diffusion of Innovation, New York : Free Press of Glencoe, 1962, 367 p.

74. Royston R.M., Serendipity : Accidental Discoveries in Science, New York : Wiley, 1989, 270 p.

75. Satia, J.K., "The Case Method of Research", SHODH Lecture Series No. 1, Ahmedabad : Indian Institute of Management, 1992.

76. Sen, Geeti (ed), Indigenous Vision : People's of India, Attitudes to the Environment, New Delhi : Sage Publications and India International Centre, 1992.

77. Shistar, Terry, Susan Cooper and Jay Feldman, "The Myth of Pesticide Benefits", (excerpts from NCAMP's book Unnecessary Risks), in Pesticides and You, National Coalition Against the Misuse of Pesticides, Vol. 12, No. 2, June 1992.

78. Shingi, P.M. and Bella Mody, "Farmers Ignorance and the Role of Television", CMA Monograph No. 49, Ahmedabad : IIMA, 1974, 103 p.

79. Shingi, P.M., "Institutional Context of Agricultural Extension", Mimographed, Ahmedabad : IIMA, 1988.

80. Singh, Anil, "Earthworms Boost Farm Yield", Times of India, (19th June 1992), p. 4.

81. Singh, Anil, "Farming Sans Fertilizers, Pesticides and Ploughing", Times of India, (9th July 1992).

82. Smetacek, Peter, "When the Worm Turns", Times of India, (30th August 1992).

83. Spradley, J.P. The Ethnographic Interview, USA : Holt, Rinehart and Winston, 1979.

84. Stoll, Gaby, National Crop Protection in the Tropics, Weikersheim, FRG : Margraf Publishers Scientific Books, 1988.

85. Sukhatme, M.N., Indiara : Non-Toxic Herbal Pesticide, Pune : Herringer Bright Chemicals Pvt. Ltd.

86. Thompson P.B., "The Varieties of Sustainability", Agricultural and Human Values, Summer 1992.

87. Thurston, David, Sustainable Practices for Plant Disease Management in Traditional Farming Systems, New Delhi : Oxford and IBH Publishing Co., 1992.

88. Verma, M.R., Study of Indigenous System of Animal Husbandry Practiced by Gujjar Community, Thesis, Department of Extension Education, College of Veterinary Medicine, Hissar : Punjab Agricultural University.

89. Vijay Shery Chand, "School Dropouts as Barefoot Veterinarians : Lessons from a Non-formal Education Project", Mimeographed, Ahmedabad : IIMA, 1993.

90. Voelcker, John Augustus, Report on the Improvement of Indian Agriculture, London : Eyre and Spottiswoode, 1893, Reprinted New Delhi : Agricole Reprints Corp., 1986.

91. Wildavsky, Aaron, "The Self-Evaluating Organisation", Public Administrative Review, No. 32, 1972, pp. 509-520.

92. World Commission on Environment and Development, Our Common Future, Delhi : Oxford University Press, 1987.

93. World Health Organisation, Public Health Impact of Pesticides Used in Agriculture, Geneva : 1990, 128 p.

94. Yepsen, Roger B. (ed), Organic Plant Protection, Eummaus, Pennsylvania : Rodale Press Inc., 1966.

95. Yin, Robert K., Case Study Research, Design and Methods, Beverty Hills : Sage Publications, 1984.