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Survival Under Stress in South Asia: A Socio-Ecological Perspective On Farmer Risk Adjustment and Innovations*

by Anil K. Gupta

1. Introduction

The need for closer interaction between natural scientists and farmers in India is becoming increasingly apparent. While natural scientists have concentrated on developing agricultural technologies best suited to ecologically uniform and resource-rich regions such as the irrigated plains, it is more and more clear that a different kind of research is necessary to help farmers trying to survive in high-risk environments. In fact, most national and international centers of agricultural research now recognize the need for on-farm research, which is necessary to understand farmers' risk adjustment strategies and also to abstract the science underlying farmers' agricultural practices. This article reviews existing arguments and evidence which supports the thesis that on-farm research is essential in the context of high-risk agricultural situations. Also, examples of farmer innovations that warrant further research and understanding are provided.

2. Explaining the Scarcity of On-farm Research

The importance of researchers working closely with farmers has long been recognized in the international research community. In 1941,

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Dr. Saver recommended "that the improvement of the genetic base of agricultural crops be predicated on an understanding of the relation of such work to the poorer segments of the society."[1] In India, more than two decades ago, Dr. Y.P. Singh pioneered two of the earliest studies aimed at unravelling the traditional farming wisdom in the context of animal husbandry practices. A decade later, another study was initiated to understand indigenous dry farming practices. By contrast, a review of post-graduate theses in five disciplines from more than two dozen universities and colleges between 1973 and 1983 showed no research on similar subjects.[2] Perhaps the contempt for farmers' knowledge is deeply embedded in the very structure of formal research institutions.

Three important factors influence researchers' interest in conducting on-farm research. First, scientific institutions consider research on farmers' practices and survival strategies to be unglamorous.[3] Peer pressure, monitoring systems in the research bureaucracies, norms of accountability of the scientists towards various constituents, and the inability of a majority of social scientists to act as a bridge between farmers and the natural scientists all contribute toward this problem. Second, it has been found that the socio-economic class background of the scientists has some bearing on their perception of farmers' problems. This is not to say that scientists with well-endowed,

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1 Edmund K. Oasa and Bruce H. Jennings, "Science and Authority in International Agricultural Research," *Bulletin of Concerned Asian Scholars*, 1983, p. 34.

2 This review was based on the abstracts published in H.A.U. Journal of Abstracts, Hissar. Not all agrocultural universities have sent abstracts of all theses on a regular yearly basis. Despite this limitation, the number of theses reviewed totalled 1817, which represents a reasonably good proportion of all theses written.

3 This remains true even though a considerable body of knowledge has accumulated on the link between formal and informal research and development. See, for example: Stephen D. Biggs, "Agricultural Research: A Review of Social Science Analysis," Discussion Paper No. 115, University of East Anglia, SDS, United Kingdom, 1984; Anil K. Gupta, "Communicating with Farmers," IIPA, New Delhi, Mimeo, 1980; "Viable Projects for Unviable Farmers - An Action Research Inquiry into the Structure and Process of Rural Poverty in Arid Regions," IIPA, New Delhi and IIM, Ahmedabad, 1981; Robert E. Rhodes, "Breaking New Ground and Anthropologists in Agricultural Research," International Potato Center, Lima, Peru, 1984; Robert Chambers, *Rural Development: Putting the Last First* (London: Longman, 1983); M.R. Verma and Y.P. Singh, "A Plea for Studies in Traditional Animal Husbandry," *The Allahbad Farmer*, XL, 111 (2), 1969; Lawrence Bush and William B. Lacy, "Sorghum Research and Human Values," *Agricultural Administration*, 15, 1984.

low-risk backgrounds are not competent to do research on problems of small farmers in high-risk environments. However, there is a tendency for such scientists to think that the basic problem is with the farmers, banks, and extension systems, rather than with the technology itself.[4] Third, the purpose of extension in most agricultural universities is merely to extend knowledge from the lab to the land rather than vice versa. The reorientation of research priorities will require taking note of these three factors so that alternative perspectives can be better argued. In general, it remains true that far more scientists have knowledge of farmers' innovations than scientists who actually work with farmers on these innovations.[5]

3. Importance of On-Farm Research

On-farm research is essential for understanding the conditions under which farmers in high-risk areas must operate their farms. While single disciplinary research can successfully develop technologies for low-risk and well-endowed irrigated regions, inter- and cross-disciplinary research is necessary for dry-farming areas.[6] A lack of on-farm research has meant that there has been an excessive bias in the technology — generation process toward individual-household oriented alternatives, while common-property-resource oriented solutions have generally been neglected. Yet cooperative management of common problems often can be most effective. For instance, if cooperation during crop sowing could influence pest build up and the eventual intensity of crop damage, research on such alternatives should take precedence over individual-level pest control (pests cannot be controlled efficiently at the individual level in the long term in any case). Soil and water

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[4] This is particularly true of the scientists who have rural backgrounds and some agricultural lands in their families.

[5] This was born out by our study based on the survey of scientists, students, and farmers, "Matching Farmers' Concerns with Technologists' Objectives: A Study of Scientific Goal Setting in Semi-Arid Regions," Anil K. Gupta, N.T. Patel, and Rekha N. Shah, Centre for Management in Agriculture, IIM, Ahmedabad, 1987, Mimeo.

[6] The management principles for the formation of teams to study problems may be different for high-risk areas than for easily predictable or less risky problems. The question of how to build teams to work on farmers' problems when the division of responsibility along disciplinary or functional boundaries can not be clear-cut remains problematic.

conservation and moisture availability at critical crop development stages through common property resources such as ponds and other means of watershed management also call for collective choice alternatives. Historically there are many examples of such cooperation among farmers in relation with specific technological alternatives.[7] Finally, without on-farm research, scientists have often not been able to apprehend the significance of the enterprise mix for farmers' survival options. For instance, studies have shown that "present trends in plant selection may be by-passing two important trade-offs in the objectives of the farmers, i.e., fodder content of cereals or millets and lignin content of cereal stalles which affects biodegradation in the soil and has implications for soil fertility".[8] Recent studies have shown that most technologies, even in dry-farming areas, are evaluated only on the basis of grain yield rather than on the basis of both grain and fodder yield and quality.[9]

Some scholars contend that there would not have been so many famines throughout history if farmers' own innovations had been a sufficient basis for agricultural growth. Our response to this perspective is two fold: first, famine-induced distress was not always caused by a net decline in food availability; the political economy of entitlements, i.e., the problem of distribution, is an important determinant factor. Second, the excessive emphasis on a lab-to-land approach has reduced scientists' appreciation of farmers' own risk adjustment strategies involving a combination of efforts in relation to crop, livestock, craft, etc. I hope to demonstrate that mutual learning is possible by linking formal and informal research and development rather than one substituting for another.[10] A related point is that massive relief-oriented policies of providing food to drought-affected people rather than upgrading their skills and improving the economy of their major assets such as small ruminants, cattle, camels, craft products, etc., also weakened their

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[7] See also, M.S. Swaminathan, "Our Agricultural Balance Sheet: Assets and Liabilities," Sardar Patel Memorial Lectures of the All India Radio, in S. Ramanujam, E.A. Siddiq, V.L. Chopra and S.K. Sinha, eds., *Science and Agriculture*, (New Delhi: Indian Society of Genetics and Plant Breeding, IARI, 1980; M.S. Swaminathan, "Science and Integrated Rural Development", in Ibid.

[8] Robert McDowell, *An Animal Science Perspective on Crop Breeding and Selection Programmes for Warm Climates* (New York: Cornell University Press, 1986).

[9] Gupta, Patel, and Shah, op. cit.

[10] Biggs, op. cit. See also, Gupta, 1980, op. cit.

potential for self-reliance. Instead of strengthening markets, public delivery systems, and local research and development, such regions typically have been used as a cheap source of labor.

4. Understanding High-Risk Agricultural Situations

Linking the context in which farmers work and the context in which scientists work requires a precise understanding of the risk adjustment mechanisms evolved by different classes of rural producers historically in a given socio-ecological context. Several studies on farmers' adjustments to risks have shown a multi-market, multi-enterprise approach to survival.[11]

The multi-market approach implies that farmers try to adjust to risk through simultaneous operations in different factor and product markets. The factor markets include land, labor, capital, information, etc.; the product markets include crops, livestock, trees, etc., including various technologies of land and water use. The higher the risk in the environment, the greater the dependence between the decisions made in one resource market and those made in others. These links are also important in developed regions, but in these regions, many imperfections in respective markets often can be offset through market mechanisms themselves.

The multi-enterprise framework implies that farmers' adjustments to risks cannot be understood by concentrating on any one enterprise such as crops, livestock, or trees. The four-S-model linking Space, Season, Sector, and Social Stratification is useful to clarify multi-enterprise focus.[12] Each dimension can be dichotomized for purposes of creating ideal types. For instance, "space" can be dichotomized in terms of population density, or low lands and high lands, or undulated and plain topography. "Sector" can be dichotomized as agriculture or industry; public or private; specialized or diversified; single crop or

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[11] N.S. Jodha, "Some Dimensions of Traditional Farming in Semi-Arid Tropical India," ICRISAT, EPPR, No. 4., 1979; Gupta, op. cit.

[12] See, Anil K. Gupta, "On Organizing Equity: Are Solutions the Problems?" *The Journal of Social and Economic Studies*, 2, 4, 1985 and "Design of Resource Delivery Systems," *International Studies in Organization and Management*, XV11, 4, 1989.

diversified crop region; cash crop or food crop dominated asset portfolio. "Season" can be dichotomized into unimodal or bimodal rainfall regions, arid or humid, low rainfall or high rainfall, low seasonality or high seasonality region, and so on.

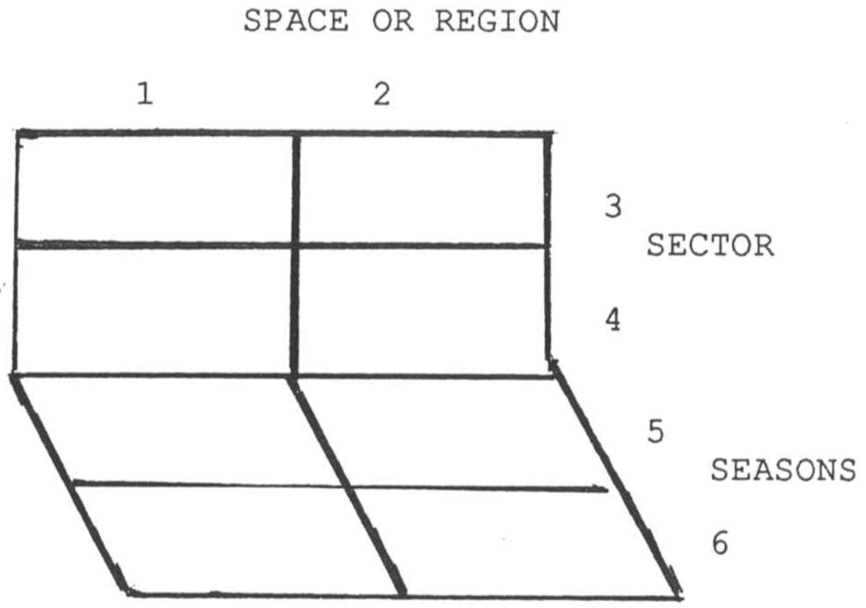
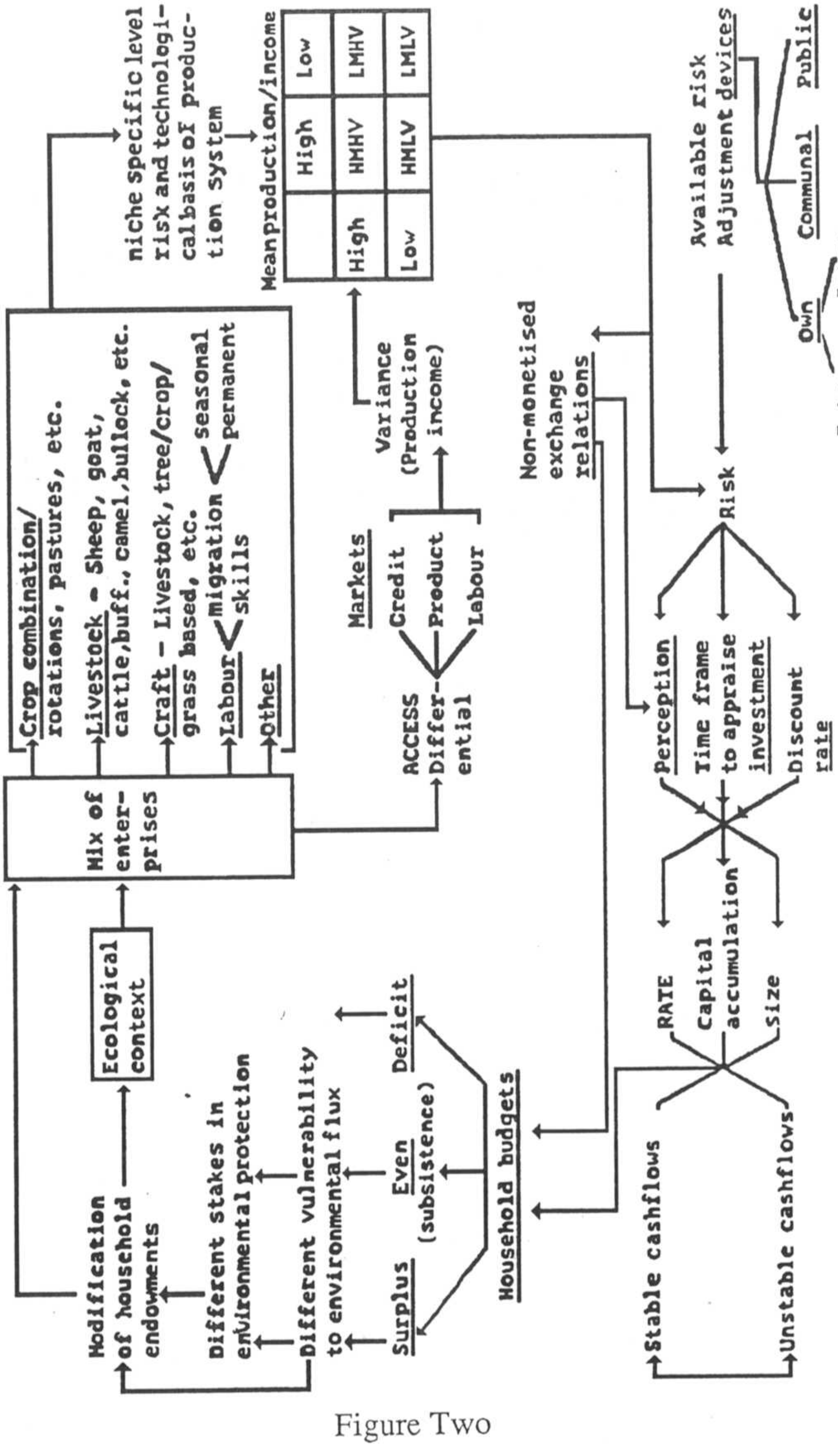


Figure One

Given any two parameters the third can be predicted. For instance, in a region with low population density and high seasonality (e.g., low rainfall) sectoral characteristics are expected to be highly diversified. Instead of a single crop, farmers may prefer mixed or intercropping. Households may simultaneously pursue many of these activities at the same time rather than being dependent on any one enterprise such as crops, livestock, or trees. The social stratification in such regions will be quite different compared to the regions with high population density, low seasonality, and specialized sectoral activities involving only one or few enterprises. In high risk environments, households may draw assurances from kinship and extended family networks in order to hedge risks. We may find in these environments a preponderance of non-monetary exchanges and the pooling of bullocks, implements, and so on. In this manner, the farmers try to deal with the differential demand for draft power or inputs in different villages or plots at different points of time due to the erratic nature of rainfall through informal social and economic networks.



Socio-ecological Framework for Analysing Household Economy

Figure Two

The socio-ecological paradigm shown in Figure Two[13] illustrates how household adjustment to risk can be studied in a multi enterprise, multi market context. The socio-ecological paradigm illustrates the interactions between space, season, and sector which generate a range of choices not equally available to rich and poor farming households. Understanding these differences may help natural scientists in developing technologies which will either be amenable to easy adaptation by the farmers or will make minimal demands on the system in the short run. In developed regions no such constraints need be taken into account because of the existence of strong market forces; e.g., if a technology required several inputs simultaneously, in a particular proportion, this would be organized relatively easily in well-endowed regions. In sum, plant architecture cannot be divorced from the social and institutional architecture evolved in a given region in a given historical context.

The socio-ecological paradigm involves essentially two assumptions: (1) ecology defines the range of economic enterprises that can be sustained in a given region; (2) the scale at which different classes of rural producers manage each enterprise depends upon the access of the households to factor and product markets, kinship networks, public and other relief mechanisms, and common property resources (such as common grazing land, water tanks, tree groves, etc). The portfolio/bundle is a mix of enterprises which evolved in a given ecological region resulting in specific production conditions. These conditions can be understood with the help of a mean and variance matrix as shown in Figure Three. (See next page).

Households having portfolios with low mean productivity with high variance in output would be most vulnerable. Historically, poverty usually has been most intense in regions where low mean return and high variance are the dominant characteristics of the portfolio. Survival under such conditions of high risk, involving experimentation and innovations by the farmers, is discussed below.

In the socio-ecological paradigm, we see that the time frame and the discount rate chosen to appraise the investment choices depends upon: a) portfolio characteristics; b) access to kinship networks; c)

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13 *Ecodevelopment News*, No.32-33, March-June, 1985, 68-74.

access to intra-and-inter-household risk adjustments; and d) communal and public risk-adjustment options. The time frame also has a bearing on the sustainability of a technological choice. The shorter the time frame

Mean Return

Variance	Low	High
Low	Local Low varieties of Millets, Cattle, long gestation, multi-purpose Tree species, etc.	Mexican varities of Wheat, well adopted small scale vegetable cultivation.
High	Pulses, Oilseed crops, sheep herd, etc.	Crossbred Cattle, Hybrid varieties of Millets, Cotton, other cash crops, etc.

Figure Three

in which households (or even the scientists) appraise their choices, the less likely it is for technology to be sustainable. The discount rate indicates the way future returns from present investments would be converted into a net present value. The more uncertain the outcome, the higher may be the discount rate. Certainty itself depends upon: a) previous experience with a particular enterprise/crop; b) immediate past experience; c) successive losses or gains; d) accumulated deficits or surpluses in the household cashflow; e) future expectations of returns, and f) complementarity between other assets/enterprises and the proposed investment.

Intra-household risk adjustment mechanisms include asset disposal, migration, and modified consumption. Inter-household strategies include tenancy, credit, and labor contracts.[14] The communal

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[14] For further details, see N.S. Jodha and A.C. Mascarenhas, "Adjustment to Climatic

risk adjustment strategies available to different classes of households may result in some households having deficit/subsistence budgets while others have surplus budgets. This will have a bearing on the stakes different classes have in the sustainable ecological balance in the given region. Finally, there will be a feedback effect into the portfolios of economic enterprises evolved by different classes.

5. Farmer Innovations

The scientific context of research on farmers' innovations is biased towards certain tools and techniques. As Richards suggests, scholars sometimes present peasant knowledge as practice without theory.[15] In an historical account of Indian science and technology in the eighteenth century, it was noted that many of the scientific discoveries being made in Europe were preceded by actual farming practices based on the same principles in India.[16] What are the processes which snapped the link between technologies evolved by the farmers and the researchers who tried to derive scientific basis of the same? Why did the formal research systems in developing countries neglect their own reserve of ancient peasant knowledge? Is it possible that farmers sometimes may do the right things for the wrong reasons? If so, how do we discriminate between ritual and rationality? Is there a comparative advantage in tropical countries with so-called backward agriculture in high-risk environments?

In this section, we review some of the contemporary as well as ancient practices evolved by farmers in high-risk environments. This may help us to reinitiate a process of reverse transfer of knowledge and concepts. This may also help in building bridges between what farmers know and thus demand and what they do not know and therefore cannot demand. We have argued elsewhere that no farmer had demanded dwarf

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Variability in Self Provisioning Societies: Some Evidence from India and Tanzania," *ICRISAT*, EPPR No. 48, 1983.

15 Paul Richards, "Farming Systems and Agrarian Change in West Africa," *Progress in Human Geography*, 9,1,1983.

16 Alexander Waller, in *Indian Agriculture*, 1, 1, p. 85, quoted in DharmaPal, *Indian Science and Technology in the Eighteenth Century* (Hyderabad: Academy of Gandhian Studies, 1983).

wheat simply because they did not know that such a plant type was possible.[17] The role for supply-side interventions by the scientists cannot therefore be ignored or underplayed. But in high-risk environments, because of the complexity inherent in the farming systems, close interaction between scientists and farmers will be productive and efficient.

I have tried to understand why scientists are curious about peasant innovations but do not subject these innovations to formal scientific scrutiny.[18] While arguing for transferring science (not just technology) to farmers, I have also posited the need for abstracting the science underlying farmers' practices. Any value added to such knowledge when transferred back to farmers would have far greater diffusion potential. Classifying peasant innovations and building a theory of innovations for survival vis-a-vis innovations for accumulations are beyond the scope of this paper. However, it is worthwhile to list some of the practices which hold the key to the issue of survival under risk through experimentation and innovation. Examples are drawn from historical studies in India, China, and other parts of the world dating back to the second century B.C.

6. Chinese Knowledge in First Century B.C. and the Sixth Century.

Rich accounts of farmers' knowledge in the first century B.C.[19] and the sixth century[20] provide instances where research on peasant innovations may extend the frontiers of science. Examples of these

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17 Anil K. Gupta, "Organizing and Managing the Poor Client Oriented Research System: Can the Tail Wag the Dog?" First draft presented at the workshop on Farmer Participatory Research Complementary Methods at IDS, Sussex, July, 1987. Revised and enlarged version presented at the Advisory Committee Meeting and Workshop on On-Farm Plant Oriented Research, ISNAR, The Hague, October, 1987.

18 Anil K. Gupta, "Scientific Perception of Farmers' Innovations in Dry Regions: Barriers to Scientific Curiosity," Paper presented at IDS workshop on Farmers Participatory Research, Sussex, July 1987.

19 Sheng-han Shih, *An Agriculturist Hand Book of China of First Century B.C.* (Peking, China: Science Press, 1982).

20 Sheng-han Shih, "*A Preliminary Survey of the Book Ch'I MIN Yao SHU. An Agricultural Encyclopedia of the 6th Century* (Peking, China: Science Press, 1982).

practices are summarized without detailed comments, with the hope that readers consider this evidence valuable in and of itself.

1. To develop drought-tolerant cereal seedlings, the seeds were mixed with a paste of excrement of polyvoltine silkworms and melted snow. "After five or six days, when the excrement becomes well softened, rub it between hands."[21]

2. The treatment of seeds in extract of certain types of bones from which a decoction is obtained helps seeds better withstand stress. If the prescribed bones are not available, the boiled steep of silk reeling basins may be used. When the rains fall in the sowing season of wheat, treatment with sour rice drink (lactic fermentation of cooked rice steep) may help the wheat become drought resistant while bombyxine excrement may improve wheat cold tolerance.

Analyses of these practices suggest that the calcium carbonate in the bombyxine excrement is mixed with lactic and acetic acids produced by the fermentation of the sour rice.[22] These acids dissolve the calcium carbonate and form a solution of calcium salts of organic acids. It has been found that wheat seeds treated with a solution of CaC12 enhances the drought resistance of wheat seedlings.[23] The author has suggested that the first century B.C. prescription by Sheng-Chih of treating wheat corn with organic calcium salts might have the same effect. It has also been noted that silkworm excrement is very hygroscopic. Sowing millet seeds side by side with silkworm excrement might increase soil moisture in the immediate vicinity of the seed through vapor condensation from atmospheric air, possibly improving germination. Bombyxine excrement also contains good amounts of easily available potassium, nitrogen and phosphorus, together with auxins and vitamins derived from

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21 Sheng-han, 1963, op. cit., p. 13.

22 Ibid., p. 59.

23 Information based upon the work of Prof. Henckel, Timiriazeff Institute of Moscow.

mulberry tree leaves and microbial action. Perhaps under suboptimal temperature and humidity conditions, such an inoculation of microbes and nutrients triggered physiological activities, which then raised the temperature and moisture to the optimal level.

The author has critically analyzed the significance of melted snow as a substitute for bone decoction for treating the seed. In arid north-western China, river and well water were heavily charged by soluable salts present in the soils. Perhaps the sodium and magnesium salts had an undesirable effect on soil microbes and seeds. The melted snow would have far lower salt content and thus be devoid of harmful ions.

3. The bombyxine excrement when mixed with seeds of spiked millet is assumed to protect the millet from insects and pests.

4. To prevent frost injuries in spiked millet it is advised to look at the night temperature 80-90 days after the sowing. If frost or white dew was suspected, two persons facing each other could drag a rope horizontally right through the crop to remove frost or dew. This should be stopped only after sunrise. Interestingly, precisely this practice of taking a rope or even a bamboo pole through the paddy nursery in the early hours of the day has been noted in Bangladesh. The explanation offered was that this gave protection from the frost, but more importantly it provided dew to the plant roots. Formal research on physiological aspects of such a practice had not been initiated in Bangladesh or other countries.

5. Drawing upon the work of Yao Shu, who compiled a sort of agricultural encyclopedia in the sixth century, several suggestions have been given for linking the type of bone decoction recommended for treating the seeds with the soil type. For instance, the bone decoction of oxen has been suggested, for red hard soil, while the bone decoction of hogs has been suggested for sowing in clay soil. Research on the effect of gelatinous coats and salts on moisture

absorption and microbial activity remains to be seriously pursued.

6. Extremely meticulous recipes have been given for preparing shallow pit manure for growing melons and other crops. In a study on indigenous knowledge of women on homestead production in Bangladesh, we found a similarly rich variety of manure compositions.

It is interesting to note that Chinese philosophical thinking very strongly emphasized the harmony of three cardinal factors — proper season, proper ground, and proper human effort — similar to our 4-S model developed independently centuries later.

7. The Contemporary Indian Experience

We have a vast inventory of practices recorded from different parts of the country including both drought and flood prone regions. The following examples will underscore the importance of generating hypotheses from farmers' practices for formal research.

1. Early planting of gram: During our field work in 1985, in collaboration with Drs. Hiranand and Mandavkar, and as a part of our study on Matching Farmers' Concerns with Technologists' Objectives in Dry Regions, we studied the issue of farmers' innovations and their recognition (or the lack of it) by scientists. In some cases, we took the example of the so-called irrational practice of the farmer from the interview with the scientists. We pursued with farmers more in-depth explanations of the rationality of the practises.

Early planting of gram was reported to make it more vulnerable to wilt attack. Sowing was begun in the month of October and the main factor taken into account was soil temperature. The method of taking soil temperature varied in different villages at a small distance in the area of the study in Western Haryana. Soils in the village of Kasoli were predominantly loam rather than sandy loam. The soil temperature was taken either by walking with bare feet at noon time or by smelling the odor which emanated when water was dropped on the ground. In some other villages another indicator, e.g., rising dust in the evening when animals returned after grazing, was used. Some other farmers felt that the blooming of some other plants or sighting of certain birds could also indicate the appropriateness of the temperature. A farmer proposed a counter hypothesis about wilt attack and early sowing of gram. He felt that grams sown early might yield more despite higher vulnerability to wilt attack because grain setting was completed by mid February. By this time the strong winds or a temperature increase might affect the crop adversely. Perhaps the damage by this problem was more serious than from other problems.

It is possible that none of the hypotheses mentioned above may be valid even if the practice was still considered to be useful. The issue is not whether hypotheses derived by the farmers would prove superior to the ones generated by the scientists. Rather, the issue is, are there some relationships between the biotic, edaphic, climatic, and human factors important for survival of crops and the cultivators which people have derived intuitively, if not systematically? This intuitive hypothesis deserves to be scientifically probed.

2. PPST (Patriotic and People Oriented Science and Technology Foundation, Madras) recently brought out a bibliography on Indian Agriculture and Plant Sciences[24] which is a rich source of references on the subject. Perhaps the issue of linking formal and informal research cannot be delayed or ignored any further. The Academy of Development Science (Karjat, Maharashtra), and the Academy of Young Scientists (Chandigarh), are two other groups which are engaged in research on indigenous knowledge systems including plant sciences. It is hoped that scientists would consider initiating not only a formal dialogue but also institutional innovation that can link

[24] *A Bibliography on Indian Agriculture and Plant Sciences*, PPST Bulletin No. 10, April, 1987 (PPST, No. 6 Second Cross Strerpagam Gardens, Adyar, Madras, India 600020).

knowledge that people have with the knowledge that they need to have to improve their livelihood systems.[25]

8. Conclusion

Some of the institutional factors which influence perceptions of peasant innovations have been reviewed, and some of the specific examples of farmer experimentation in high risk environments in China, India, and Bangladesh have been drawn upon. My contention is that while in some cases rituals might dominate the rationality of peasant survival mechanisms, there are many cases where knowledge deserves to be systematically understood, analyzed, and built upon while generating new alternatives for technological development. In this process we must not only start the process of transferring science (not only technologies) to farmers, but also generate an alternative college of peers involving poor farmers, pastoralists, tenants, etc., who would collaborate in research and in validating knowledge so produced. I concede the fact that there would remain a case for some research purely guided by scientists' own vision and imagination. What I am submitting is a small step - linking peasant science with so-called modern science and technology in a manner that the knowledge-generating systems in the rural areas are not converted into knowledge-receiving systems alone. Farmers' experimentation cannot be the only source of generating new technologies. The role of scientists in anticipating future needs of marginal farmers and generating technological options will always remain. What we must add, however, is the extraordinary contributions that indigenous knowledge of the peasants can make in generating at least a few *new* relationships among *old* variables.

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[25] I recently spent a year with agricultural scientists in Bangladesh at the request of their government to strengthen the development of methodologies and systems for On-Farm Research using the Socio-Ecological Paradigm. This framework essentially builds upon the access that households have to factor and product markets, ecological and other resources; assurances regarding risks, especially climatic, social (i.e., how others behave given one's own behavior), and temporal (i.e., future returns from present investments); and skills or abilities of households to convert access into investments.