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TITLE OF PROPOSED PROJECT **Biotechnology and the Political Ecology of Information in Andhra Pradesh**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ **152,289**	**24** months	**05/30/03**	

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CERTIFICATION PAGE

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By signing and submitting this proposal, the individual applicant or the authorized official of the applicant institution is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding debarment and suspension, drug-free workplace, and lobbying activities (see below), as set forth in Grant Proposal Guide (GPG), NSF 03-2. Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U. S. Code, Title 18, Section 1001).

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The undersigned certifies, to the best of his or her knowledge and belief, that:

(1) No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

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Intellectual Merit. The introduction of genetically modified (GM) crops into developing countries raises major questions in social science. Because of the pivotal role of developing countries in the global debate, there has been voluminous writing by advocates for and against the technology, but little scientific research beyond narrow cost/benefit analyses. Questions on the technology's larger effects are nowhere more pressing than in India, particularly in cotton-growing areas as India had recently released BT cotton as its first GM crop. Fieldwork will be undertaken in several areas of Warangal District of Andhra Pradesh, a cotton area plagued by over-reliance on chemical pesticides.

The study will assess the economic performance of the new GM cotton, but more importantly it will investigate larger effects of the new technology by considering how biotechnology qualitatively changes a crop's *input catchment* to rely more on information. This change may have impacts on endogenously generated management skill that is vital in smallholder farming. Effects on management skill are likely to vary among farmers, as the poorer, less educated, and "tribal" farmers are more peripheral to information flows.

Beyond providing a basic agricultural ethnography of farming communities feeling the first effects of GM cotton, and securing a baseline for future studies of GM crops' effects, the project examines four issues. First it asks how the type and pace of technological change in seed technology affects farmers' ability to absorb new seeds into a system of IMS. Second, it asks how the properties of specific GM crops affect farmers ability to develop management skill on their own. Third, it asks what drives the innovation-adoption process for such a highly politicized agricultural technology, when both "payoff-related" and "biased cultural transmission" models fail to fit a situation in which farmers are being aggressively propagandized. Finally, it asks how GM crops, and the political forces attending their introduction, affect "reskilling" in IPM (Integrated Pest Management) programs.

Field research in Warangal will include agricultural ethnography in two areas, including one with many poor, uneducated "tribal" farmers who are relatively new to cotton cultivation. A detailed farm-level records will be kept on inputs, labor and information, already started among a tribal group, will be expanded. Intensive studies of indigenous management skill will be undertaken, and the manipulation of public information will be charted closely during the next two years as farmers confront the new technology for the first time.

Broader Impacts. Among the project's positive impacts on the study area in Andhra Pradesh, the foremost will be the support to local researchers, an unfunded research center, and a rural school. The Centre for Environmental Studies, led by economist A. Sudarshan Reddy, has conducted several vital research projects in recent years, including the only significant empirical study of causes of the local epidemic of farmer suicides, although its work is severely constrained by lack of facilities, equipment and salary. This project will provide vital support to the center, Sudarshan Reddy, and several graduate students who will participate in the research; the equipment used in the research will remain with the center to facilitate future research. Support for facilities at the Kalleda Rural School will benefit future researchers as well as the school children. Local cotton farmers will benefit not only from stipends for data recording, but by having the experiences of the poorest among them publicized in various ways, including non-technical publication in India. Farm families participating in the farm-level study will benefit from stipends and economic summaries of their operations.

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For font size and page formatting specifications, see GPG section II.C.

*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

Results from Prior NSF Support

PI Stone received an NSF Scholar's Award for Methodological Training in Cultural Anthropology in 2000, entitled "Crop Biotechnology for Developing Countries." This grant supported work during Fall 2000 at the International Laboratory for Tropical Agricultural Biology (ILTAB), in the Donald Danforth Plant Science Center in St. Louis. ILTAB is engaged in genetic modification of tropical crops for subsistence in developing countries. This project involved intensive training by ILTAB biologists, and responsibility for one component of a study of the utility of the cassava PAL-840 promoter in mitigating the problem of post-harvest deterioration in cassava. This project is described in Stone 2002a (in particular the online enhancements) and the training in biotechnology has been crucial in subsequent teaching (as described in the biographical sketch) and research (as reflected in the P.I.'s publications in the reference list).

Project Description

Genetic modification (GM) is a biotechnology involving the laboratory alteration and/or movement of genes among organisms; case in point is the transfer of CRY genes from BT bacteria into cotton, causing the cotton to produce its own insecticide.[1] Few technologies have ever raised as many diverse and far-reaching questions for sciences concerned with agricultural systems, including many that have featured prominently in media campaigns. Many of the issues cannot be properly understood without the synthetic approach to agricultural systems found in anthropology and closely related disciplines, especially as the debates come to focus increasingly on developing countries (Brush 1993; Stone 2002a; Evenson et al. 2002). This "move south" of the GM issue has brought new attention to issues such as the causes of famine, the nature of agricultural sustainability, the ownership of genes, the effects of multi-national corporations on indigenous communities, and the larger effects of technological change on agricultural systems. While there is the beginnings of a literature on limited (principally economic) questions on GM

[1] *Biotechnology* comprises various methods other than GM, including tissue culture and marker assisted breeding, with which this project is only tangentially concerned. *Gene* is here used to include other functional units of DNA such as promoters. *GM* refers explicitly to changes enacted through laboratory methods that were pioneered in the early 1970s; the claim in pro-GM polemic writing that GM is "simply a modern version of age-old techniques used by farmers" (Popeo 2000) is untenable from the political ecology perspective developed below. BT is *Bacillus thuringiensis*, a bacterial insect pathogen.

crops in developing countries (e.g., Pray et al 2001; Traxler et al. 2001; Ismael et al. 2001), the more synthetic issues that GM crops raise for indigenous agricultural systems have to date been more the province of activists than scientists (e.g., Shiva et al. 2002). This leaves is a serious gap between the magnitude of issues being debated and ability of social science to provide theoretical and empirical grounding for the debates.

This gap was dramatized by the rhetorical uses of the epidemic of suicides by cotton farmers in Warangal District, Andhra Pradesh, India. Warangal farmers began killing themselves, mostly by drinking pesticides, by the hundreds in 1998. This was the same year that India's first release of a GM crop -- Monsanto/Mahyco's Bt ("Bollgard") cotton -- began to be debated, and the situation in Warangal unfolded in perfect time to be seized by both sides of the debate. Monsanto, the world leader in agricultural biotechnology, saw the cause of suicide as crop destruction by pesticide resistant bollworms. They offered the Bollgard that they and their Indian partner, Mahyco, were trying to bring to market, as a solution; their India marketing director even claimed that the suicides could have been averted if GM cotton had been available (Vidal 1999). To anti GM activists such as Vandana Shiva, suicides traced to over reliance on cash cropping, purchased farm inputs, and intrusive technologies; she and other activists maintained that GM crops would only worsen poverty and indebtedness by concentrating power, promoting unstable monocultures, discouraging traditional seed saving and exchange, and lead to farmer "deskilling."[2]

Bollgard was approved by India's Genetic Engineering Approval Committee in Spring 2002, and a wave of other GM crops will soon be seeking approval. While the proximate and latent effects of these crops on Indian farming systems have been the subject of extensive comment by pro- and anti-GM forces, it raises a set of poorly understood issues for the theory of agricultural change. While this research project aims at an ethnographic study of GM technologies in Warangal, the intended contributions to theory cohere around the problem of *information* and its ecological and political aspects, which is emerging as crucial commodity in the interactions between developed and developing countries (Apffel-Marglin and Marglin 1996).

GM and the Political Ecology of Information. Social theorists have pointed out various elements as pivotal in agricultural growth. To White (1943), it was an evolutionary process characterized by increasing (and increasingly efficient) energy capture; to Boserup (1965), a process of population driving increases in production and decreasing efficiency; to Binswanger (1978), a process of induced innovation according to the cost and availability of inputs; to many Marxist analysts, a history of capitalist penetration through "pulling away of natural ground from [its] foundation" (Kloppenburg 1988:19; Magdoff et al. 2000). The current research adopts a perspective centered on the historic pattern of expanding agricultural *input catchments* -- i.e., the input source areas and the institutional arrangements for delivering them to

[2] A detailed study of the dimensions and causes of the Warangal suicides was conducted by Sudarshan Reddy and Rao (1998), with further contributions by Parthasarathy and Shameem (1998), Revathi (1998), Stone (n.d.), Shiva et al. (2002), and several Western journalists (see Stone 2002b). Farmer suicides in neighboring Karnataka State have been analyzed by Deshpande (2002).

the farm (Stone n.d.). This framework focuses on the political processes involved in transferring energy from the catchment to the crop. It recognizes *information* as a key component in the agro-ecosystem (Flannery 1972), and takes the central feature of agricultural GM to be expansion of the agricultural catchment to include informational inputs. Crop GM is a process by which, as Monsanto's Robert Shapiro tellingly (if inelegantly) put it, "information replaces 'stuff'" (Charles 2001:270).[3] If the primary dynamic of 20th century agriculture was transforming production to run on industrial inputs (Cochrane 1993), the driving feature in 21st century agriculture will be transforming the system to run on the fuel of information and intellectual property, led by crop GM (Brush and Stabinsky 1996; Cleveland and Murray 1997).

Even earlier stages of the evolution of input catchments, which were driven principally by material inputs such as fertilizer, pesticides, machinery and seed, hinged in part on expansion of informational catchments. For instance, the intensification based on natural fertilizer sources and the attendant "nitrogen imperialism" was facilitated by the mid-19th Century emergence of a science of agricultural chemistry (Rossiter 1975; Foster and Magdoff 2000). The introduction of hybrid maize changed American farmers from seed breeders to seed purchasers in large part because of information management (Fitzgerald 1990; Kloppenburg 1988). US farmers even participated in the early stages of hybrid breeding until the *scale* and *informational requirements* of hybrid breeding became too great (Fitzgerald 1993:335). Such catchment changes may be analyzed on the *quantitative* scale of energetics (Turner and Doolittle 1978; Pimentel and Pimental 1979), but there are also attendant *qualitative* changes in the agricultural system. With hybrid maize, the increasing demands for corporate information management paralleled a loss in farmer knowledge of the qualities and genealogy of the seeds they were planting. Only 20 years after substantial yield increases had been achieved by a USDA program encouraging farmers to take greater control over corn breeding, farmers were cautioned by seed companies against even trying to choose which seeds to purchase.[4] Ziegenhorn (2000) even shows how US farmers were for years systematically misled on the nature of the seeds they were buying.

The information gap that hybrid maize opened was expanded by the spread of agricultural insecticides following WW2. Unlike fertilizer use, which involved readily observable processes familiar to farmers, insecticides affected covert processes that were much harder for farmers to apprehend (Bentley 1989). It has also proved to be a self-widening information gap: the less the farmer knows about insect ecology, the more insecticide is used (Vandeman 1995), often leading to insecticide resistance and chaotic fluctuations in insect populations (Brogdon and McAllister 1998). Farmers are less able to "skill" on the basis of their own observations; they are led to new reliances on government and corporate agricultural extension, may have to buy commodified

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[3] Or as Pollan (2001:212) puts it, "What is perhaps most striking about [GM potatoes]... is the added human intelligence that the insertion of the Bacillus thuringiensis gene represents. In the past that intelligence resided outside the plant, in the minds of the organic farmers and gardeners... who used Bt, commonly in the form of spray, to manipulate the ecological relationship between certain insects and a certain bacterium in order to foil those insects."

[4] "You may not know which strain to order. Just order FUNK'S HYBRID CORN. We will supply you with the hybrid best adapted to your locality" (Funk Bros. 1936 Seed Catalog, quoted in Fitzgerald 1993:339)

knowledge from agricultural consultants, and are often still left operating with a significant information gap. One of the most significant, and virtually unstudied, aspects of such changes in input catchments are the divergent effects on farmers who, in developing countries, vary dramatically in their access to information.

Such transformative effects of hybrid crops and pesticides have been called "deskilling" (Fitzgerald 1993; Vandeman 1995), alluding to a process described for factory production (Braverman 1974). However the transformation of the ecology of information in agriculture is more complex, more variable, and less understood than Braverman's processes of industrial mechanization and relegation of laborers to lower-skilled tasks, and as well as Latour's (1992) process of "delegation.". The need to understand the transformation of agricultural skill has taken on a new importance with the new stage in evolution of informational catchments. The biotechnology revolution took hold in the 1980s, when methods of recombinant DNA (pioneered in the 1970s) were rendered lucrative by a series of court decisions allowing strong intellectual property control over genes and altered organisms (Stone 2003). By the end of the 20th Century, information-based increases in value added to crops were overtaking material-based additions. Although still mostly unstudied, the movement of GM crops into developing countries has already brought charges of deskilling, especially in the "biotech battleground" of India (Ecologist 2000; Simms 2000).

While most of GM's effects on agricultural systems in developing countries remain unknown, there are reasons to expect fundamentally different outcomes than what has been seen in industrialized countries like the US. Farmers now comprise only 2% of the economically active population in the US; most are obligate consumers of high volumes of industrial inputs and government subsidies, underwritten by a steady flow of information from sales and extension offices, often augmented by commodified information from agricultural consultants. In developing countries the situation is different: in Africa and Asia, close to 60% of the economically active population are farmers,[5] and there are key differences in the ecology of information, which raises some broad and very timely questions.

Ecology of Indigenous Agriculture. Leading synthetic studies of nonindustrial agriculture agree that indigenous technical knowledge or indigenous management skill (IMS) is the *sine qua non* of sustainability. This is particularly true in intensive systems. In his analysis of intensive smallholder farming, Netting stresses that under high population density, "skill replaces scale" (1993:9), and the household becomes the central social unit of production largely because it is suited to nurturing and managing highly skilled labor. In Asian rice economies, Bray (1986:113) identifies the key difference between process of change in those systems as the "increase in the use of skilled manual labor accompanied by "the development of managerial skills" (as compared to the trend in western industrial intensive farming of replacing labour with machinery -- she called them "skill-oriented technologies," in which "sophisticated management skills produce higher yields." Harold Brookfield's synthesis of agrodiversity pivots on indigenous management strategies; agrodiversity is even defined in terms of management practices based on local knowledge (2001:9,43; Brookfield and Padoch 1994:9). In Indigenous

[5] Figures for EAP in agriculture in 1997 were: Africa 59%, Asia 58%, Oceania 19%, Latin America & Carrib. 21%, Europe 10%, North America 2% (ILO 1997; Ferleger 2002).

Agricultural Revolution, Richards (1985:55) treats shifting cultivation as "a compendium of skills" that provide the basis of management of non-shifting cultivation as well.

Skill does not refer here simply to knowledge of plants and agronomic processes, or to proficiency at agricultural tasks, but to a farmer *performance* (Richards 1989) based on agronomic knowledge, farm management strategy, prediction a range of factors, and manipulation of socially mediated resources. Such skill cannot be understood as objective information that exists *sui generis*; much of it is generated, maintained, and implemented socially. Farmers are "skilled" through observing, discussing and often participating in each other's operations. They acquire seeds from each other, and information expressed in locally meaningful concepts moves along with seeds, between farmers and communities (Richards 1989; Brush 1997; Sillitoe 2000). Agroecological processes become embedded in cultural concepts (Thrupp 1989; Brodt 1999, 2001), and communal skills requiring coordination across multiple farms -- e.g., for pest control and irrigation management -- may be embedded cultural institutions that individuals may not fully understand (Lansing 1991, Netting 1974). Therefore discerning the effects of the informational evolution of agriculture requires looking beyond "what the farmer knows" to how technologies become incorporated into systems of management skill.

This does not mean that IMS is static (which is why "traditional" is a misleading characterization) or infallible (Bentley 1989). IMS may be corrupted or may fail to adapt to new technologies. The Warangal cotton farmers, who are depicted as potential victims of deskilling by GM crops (Ecologist 2000; Simms 2000), are already struggling with varying degrees of corrupted IMS. This was particularly apparent among the marginal and poorly-educated farmers that have accounted for a large portion of the district's suicides (Sudarshan Reddy and Rao 1998). Stone's surveys in 2000-2002 showed tribal Lambada farmers applying up to 8 insecticides, often in inexplicable combinations, in up to 15 sprayings per season. Decimation of beneficial predators was causing explosions of previously minor cotton pests (like Spodoptera and whitefly), while the primary pest (American bollworm) was rapidly developing resistance. This pesticide treadmill leads farmers to a capital treadmill, with increasing purchase of pesticide, on credit at usurious rates from input dealers, prompting increasingly desperate use of pesticides to get a large enough harvest to pay off the debt (see Thrupp 1990). This failure of IMS has spurred the leap in the informational evolution of Indian agriculture, as the intractable pesticide management problem was cited as justification for introduction of Bt cotton which offers reduced susceptibility to American bollworm.

Even before any Warangal farmer had (legally) bought a single Bollgard seed, it was clear that, because of both the traits of the technology and the global conflicts over it, Bollgard would bring contentious and contradictory flows of management information. For instance, during the past year:

❍ Separate meetings around seed-buying time featured the respected head of the Warangal agricultural research station and one of India's leading biologists, who warned farmers of potential dangers such as horizontal transfer of antibiotic resistance. (Stone's later interviews revealed farmers' understandings of the arguments to range from highly astute to completely garbled. Farmers at these meetings asked how to deal with this advice which contradicted government advice, but were not given a clear answer.

❍ Mayhco/Monsanto brought all approved vendors of GM cotton to an daylong workshop where they were schooled in transgenics and taught how to answer farmers' questions.

They were also trained to advocate a stewardship program centered on convincing farmers the plant Bt refugia. Some dealers later told farmers that the refugia strip around the Bt crop would act as a barrier to bollworms (which is untrue).

❍ Several cotton IPM (Integrated Pest Management) projects have been active in Warangal. Interviews in 2000-02 revealed that although these projects ostensibly have the same goals, the advice they give on GM cotton differs according to their funding source.

❍ At harvest time, an anti-GM NGO held a meeting in Warangal featuring testimonials by dissatisfied Bollgard planters.[6] The NGO director then gave an impassioned and inaccurate speech about the long-term toxicity of the Bt insecticide, which several farmers said was the final straw convincing them not to plant Bollgard again.

The key point, which is missed in economic studies of the new crops' performance and of patterns of adoption, is that this change in a crop's informational catchment has much wider effects on agriculture than the mere appearance of a plant with new agronomic properties. It has novel and widespread effects on how and by whom information is marshalled, on the criteria farmers use in making management decisions, and on the process by farmers are able to "skill" on the new technology. Moreover, these farmers cannot be considered as a monolithic bloc; they vary dramatically in their present IMS and their ability to access new information. This technology, promoted as a great boon to the poor and marginal farmer in the developing world, may have effects that vary with how poor and marginal that farmer is to information flows. These are exceedingly timely issues since GM cotton has just been marketed this year. The current project aims to investigate these pressing issues in the political ecology of information through the following four research questions.

1) How do the type and pace of technological change in seeds affect farmers' ability to absorb new seeds into a system of IMS? Strenuous claims are made that poor farmers need cutting edge biotechnology (as the USDA argues in defense of its development of "Terminator" and other gene use restriction technologies); however the benefit of the continual updating to products that theoretically have marginally higher yield may be outweighed by the cost in IMS and thus sustainability. Products also vary in how amenable they are to farmer skilling (Tripp 2001a).[7] We need to look more analytically at technological change trajectories in terms of be

[6] The farmers' complaints all pertained to qualities of the MECH-162 cotton hybrid in which the Bt gene has been inserted, not to the performance of the Bt gene, although none of the farmers Stone interviewed appreciated the difference.

[7] For instance, first-generation Green Revolution seeds were readily identifiable, allowing farmers to quickly learn from experiment, while subsequent seeds became harder to

type of change, the rapidity of replacements, and the observability of the new traits. A study of Philippine farmers showed that 40% were not growing the improved variety they thought; "the implications of this type of uncertainty for proposed transgenic varieties that feature a single additional resistance gene are obvious" (Tripp 2001a). We anticipate that the information gap is greater with cotton than other major crops such as rice; that it is greatest among poorest and least educated farmers.

2) How do the properties of specific GM crops affect farmers ability to "skill" on their own? The changes in political economy of agriculture attending hybrids did not prevent farmers from collecting their own information based on observation and discussion over many years: in Iowa the period from first awareness to adoption averaged nine years (Rogers 1995:33). However, in Warangal insect populations fluctuate wildly: the disastrous 1997 cotton crop was ravaged by *Spodoptera litura* and whiteflies while the next year the main pest was American bollworm (*Helicoverpa ameriga*). The chaotic fluctuations have eroded farmers' ability to monitor multiyear patterning. Stone has seen Warangal farmers abandon practices that were relatively successful the year before, and repeat practices that had failed the year before, explaining both in terms of the yearly variations that seem to be predictable only in being unpredictable. GM cotton may bring its own impediments to assessment by farmers. Resistance to the CRY gene in Bollgard is very likely to appear in Helicoverpa within 5-7 years, and it will likely be replaced by a CRY gene with different properties. This should cause farmers to begin a new set of observations on crop performance, but the farmers are unlikely to be aware of the change. Finally, Warangal farmers use highly variable (and often nonsensical) mixtures of insecticide sprays, which keeps fields from being telling experiments for local farmers. The question is how skilling processes change with the adoption of GM cotton.

3) What drives the innovation-adoption process for a highly politicized agricultural technology? In the US, the introduction of hybrid maize brought some politicization of agricultural information. Within government and academic institutions, and between those institutions and the emerging seed companies, there were tensions on the merits of eliminating the farmers' role in breeding (Fitzgerald 1990). Still, farmers had access to substantial "payoff-related" information on which to base decisions about whether (and how) to adopt the new technology: i.e., "environmental learning" provided the bases for skilling. Studies of diffusion of hybrid maize based on environmental learning, most notably by Ryan and Gross (1943), led to the classic S-curve of innovation adoption (Rogers 1995:23). Early studies on GM crop adoption on US farms have used the same framework, with independent variables including farm size, human capital, and risk preferences (Alexander et al. 2000; Fernandez-Cornejo and Mcbride 2000, 2002)

Adoption of GM crops is new to developing countries and so has only been the subject of very preliminary empirical research (Traxler et al. 2001), but several issues militate for examining adoption from a new perspective. The practical constraints on environmental learning

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distinguish (Tripp 2001a). In many areas IMS has failed to keep up with these later generations of seeds (Price 2001).

playing a role in skilling and adoption are considerable, for reasons noted in the preceding question. Moreover, recent theoretical work has cast doubt on the role of environmental learning in technology adoption. Even when environmental learning does play a role, adoption S-curves are generated mainly by biased cultural transmission. Biases include direct bias (for traits favored by out social learning psychology even if unrelated to performance), prestige bias (for traits associated with successful actors even if the trait did not contribute to that success), and conformist bias (for traits that have been widely adopted by others) (Henrich 2001).

It is highly likely that GM cotton adoption in Warangal will be driven not by acquisition of IMS through environmental learning, but rather by biased cultural transmission. We intend to examine the role of cultural biases noted above, but also to focus on a set of other biases that are outgrowths of the expansion of agriculture's informational catchment and the attendant political struggles. There is "campaign" bias that is an artifact of the effectiveness of the marketing of pro- or anti-GM media. Warangal cotton farmers are subjected to intensive media, funded by international pro- and anti-biotech lobbies, since before GM cotton was released. Traditional sources of agricultural information give high contradictory advise. There is also "technical understanding" bias results from how the farmer makes sense of biotechnological issues that are not even fully understood by science.

Of particular interest will be the differences in how bias and adoption decisions vary with poverty, which covaries with education, access to credit, and risk-taking. Early studies have shown that adoption of Bt crops can be scale-dependent in the US but preliminary reports from developing countries are equivocal.[8]

4) How do GM crops, and the political forces attending their introduction, affect "reskilling" movements? Virtually all stakeholders (possibly excepting input dealers and manufacturers) agree that current Warangal cotton farming is unsustainable, but biotechnology is not the only potential solution. IPM and NPM (Non-Pesticide Management) projects have shown considerable promise in Asia (Pretty and Hine 2000) and several different kinds of IPM projects have been started in Warangal District. These projects offer a contrast to GM crops because, rather than expanding the input catchment to incorporate information in the seed, they emphasize simpler technologies and skilling of farmers. Farmer understanding of pest ecology is widely understood to be vital to successful IPM (AAS 1999) but it is unknown how GM crops will affect such skilling: the A.M.E. project in Sangem Mandal of Warangal District (partly funded by a biotechnology multinational) sponsors insect identification workshops, but also advocates GM crops; the MARI project in Parvagathiri Mandal (largely funded by European philanthropies) sees GM as antithetical to agricultural sustainability. As noted above, GM cotton was introduced along with misinformation about refugia from GM purveyors, and India has been awash in misinformation about biotechnology from green activists since 1997. We intend to examine how information on GM cotton coming from interested parties, including IPM projects themselves, impacts farmers' inclination to adopt IPM methods and, more generally, their ability

[8] In the US, Fernandez-Cornejo and McBride (2002) report that adoption rates for Bt corn are twice as high for large farms (>500 acres) than small farms (<100 acres). In China, Pray et al. (2001) reported only minor scale differences in adoption of Bt cotton, but in Mexico Traxler et al. (2001) reported that farms adopting Bt cotton were 48-72% larger than non-adopting farms.

to close the information gap especially as regards agricultural entomology.

Methods

To date, research on GM crops in developing countries has focused on the most readily quantifiable aspects of GM crops, such as short-term direct costs and benefits (Pray et al. 2001; Traxler et al. 2001; Ismael et al. 2001). Such studies are of limited value as they cannot illuminate the more synthetic or emergent effects likely to attend this step in the informational evolution of agriculture. The current project is designed as a self-contained research endeavor, but its quantitative and qualitative findings will also as a baseline in a longer-term research planned for this area, as GM crops are expected to grow in importance over the decade. Methodologies for the current research comprise a suite of methods including quantification where it is meaningful and practical, combined with qualitative methods. The methodology is also designed to capitalize on participation of three social scientists with complementary specialties: an anthropologist who studies agrarian ecology (P.I., G. Stone), an anthropologist with extensive experience studying formal institutions and agricultural extension (R. Tripp), and an agricultural economist who has studies rural issues in the study area for 20 years (A. Sudarshan Reddy).

Study Sites. At the center of this project is a multi-faceted study of farming (particularly cotton) in two mandals of Warangal District: Parvagathiri and Atmakur. These were selected to give representative coverage of the district, to allow controlled comparison of farmers differing in IMS, and to capitalize on existing baseline data. In both mandals, over 75% of farmers have planted some cotton in the past two years, but beyond this are marked differences. Atmakur contains much "black cotton soil" that is desirable for cotton farming; its farmers were among the earliest to enter cotton farming, and today over 50% of its cropped land is in cotton. Parvagathiri soils are mainly sandy loams; many of its farmers have only recently turned to cotton, and under 20% of its cropped land is in cotton. was one of the earliest. Unlike Atmakur, Parvagathiri has a sizeable population of Lambada (Ghor) tribals, most of whom are poor, illiterate, and peripheral to flows of information from government, seed companies, and NGO's. Sudarshan Reddy has 15 years worth of data on agricultural practice in one Atmakur village, and Stone has been collecting detailed data on agricultural practice in two Parvagathiri villages since 2000.

Limited data will be collected in two additional locations. Kapula Kanaparthi in Sangem Mandal is the location of the A.M.E. Project noted above; it is actively engaged in farmer education and it informs farmers that GM cotton should be a component in farm management. This project and the local farmer response to it will provide a valuable window into effects of campaigns in which the biotechnology is directly involved. Finally, Gunavathi village in Rohtak Dist., Haryana, offers a population of farmers who are still planting indigenous (deshi) varieties of cotton with very little use of pesticide. Seeds are recovered from the gin and replanted, and there is a continuity in technology allowing farmers to develop and maintain IMS. Sudarshan Reddy has been collecting data on them since 1999, and they will provide an example of a largely self-skilled group of cotton cultivators.

In the two principal study sites, we will pursue the questions outlined above through 5 programs, designated A-E.

(A) Socio-agricultural survey. A basic agricultural ethnography will provide both

grounding for analysis of the issues described herein and also baseline data for monitoring effects well into the future. For a sample of 150 households (stratified on caste, education and size of farm operation) in each site, censuses will be completed with data on social and economic organization, history of cotton farming; it will also include information on pest management, including patterns of pesticide use. Design of the census will incorporate elements already tested by Sudarshan Reddy's field work in Atkamur and Stone's trial censuses in Parvagathiri from summer 2002. Every farmer in the area who adopts Bollgard during the study will automatically be added to the sample.

(B) Inputs analysis. Since 2000, trial versions of a Daily Inputs Study have been run among 12 farmers in and around Kalleda village (after GDS trained the participants, the study has been managed by Rural Development Foundation, which emails data weekly). The study is based on intensive input studies done with the Kofyar and Tiv, which provided the basis for analysis of the adjustment of social organization of labor to local ecology (Stone et al. 1990), agricultural movement and settlement pattern (Stone 1996), gender division of labor (Stone et al. 1995), and the relationship between intensification and inter-tribal conflict (Stone 1997). In Warangal the study has greater emphasis on purchased inputs, hired labor, and credit. Entries reflecting agricultural performance are also accompanied by commentary. The inputs study will be refined and expanded to include 20 farmers in each study site. Every farmer in the area who adopts Bollgard during the study will be added to this study as well (the budget uses a figure of 48 total households).

As a parallel to this study, we will conduct a more limited survey of Bollgard planters including a cost/benefit analysis. The costs and benefits of the first year of Bollgard planting had become hotly contested even before the harvest was finished (Venkateshwarlu 2002; Hindu 2002), but studies were coming only from advocates for or against GM crops in India.

(C) IMS study. For the 40+ households in (B), detailed interviews will be conducted on farmer understandings of insects and pesticide actions and local concepts underlying farmer models (Brodt 2001) and sources of information and skilling (which other farmers were emulated and why; how various sources of information on biotechnology, cotton, and agriculture in general are weighted). The input analysis will not only give a quantitative picture of the agricultural change, but also provide a basis for detailed retrospective interviews on farmers' decision-making processes. This material will be used for qualitative analysis (Barr and Sillitoe 2000). These interviews will be augmented by consensus studies in each of the study sites. Post-harvest interviews will then be conducted in which the farmer's strategies will be compared to yields and insect load data; the farmer will report what he learned from each pesticide control action, how the action may be altered the next year, and how his interpretation accords with neighbor's interpretations.

(D) Formal Institutional Analysis. While the previous analyses target cultural (informal) institutions of skilling and IMS, there are also various formal institutions with major impacts on farmer skilling, that will themselves being affected by the advent of GM crops. In this project we target three types of institutions. First are the agricultural input dealers in Warangal city and rural villages. Second are the companies and agencies involved in the commodification of agricultural extension. Third are the IPM projects in Warangal. Indigenous management skill, both from instruction and "self-learning" (Pretty and Ward 2001:217), are pivotal in IPM projects. The A.M.E. and Rural Development Foundation (RDF) projects in

Warangal District offer contrasting approaches to "re-skilling" cotton farmers and both will be struggling with decisions regarding the use of GM cotton over the next several years. A.M.E. is funded in part by Novartis, and its approach is to deliver management information and skill from European-trained experts. RDF's approach is best described as "IPM from Below": its staff read IPM literature and attend IPM workshops based on external management skill, but methods and practices are chosen (or invented) by the director of the RDF agriculture program, who is a local farmer. The two projects will be evaluated in terms of their ability to "skill" farmers in sustainable methods.

(E) Information flow study. Indian publications, including The Hindu and Economic and Political Weekly, are available online and already being monitored by a student assistants at Washington Univ. Local publications that are read by most literate farmers will be monitored closely by Sudarshan Reddy. Sudarshan Reddy will also carefully track meetings, announcements, and events in Warangal District that bear on the GM issue in particular and agricultural skilling in general. Tripp will study Warangal input dealers in 2003, with repeats in 2004 and 2005, to monitor what information they get and how they pass it on to farmers.

Broader Impacts. Education and research in Warangal are severely constrained by lack of funding, and this project has been consciously designed to simultaneously further social science theory and to have positive local impacts including mitigate the "knowledge gap" and strengthening the research/teaching infrastructure.

It will provide vital financial and intellectual support to local researchers on social and agricultural issues, notably A. Sudarshan Reddy (who is retiring from college teaching and wishes to conduct research) and other social scientists and students he chooses to assist in data gathering. Over the past 15 years, Sudarshan Reddy along with 6 other scholars and numerous students have conducted research on social - environmental issues for an NGO called Centre for Environmental Studies (CES). As opposed to the professional NGO sector, CES projects are conducted on a voluntary (unpaid) basis, sometimes with funding by sources such as the Inst. for Gandhian Studies and sometimes without funding. Despite the lack of resources, and the fact that the NGO's only office is a room in Sudarshan Reddy's house in Warangal, this group carried out the only substantial empirical study of the suicide epidemic of 1997-98 (a 163 p. study available only on Stone's website at http://artsci.wustl.edu/~stone/suicide.html). This funding will allow such research to continue, expand, and publish results. It will also Sudarshan Reddy to employ and train numerous masters-level students in fieldwork (the project will its data available to these and other students for theses). The computers, cameras and tape recorders left for C.E.S. at the conclusion of the project will be invaluable to future researchers there.

In Parvagathiri mandal, a field office will be established in the Kalleda Rural School (run by the RDF) and fees paid for lodging, food, translation, transportation, and internet services, while low by US standards, will be invaluable to the school. With the state school system in this area in disarray, RDF has started two rural schools, tuition-free and offering nutritious midday meals, and with large numbers of places earmarked for girls and harijans. The directors of the school look forward to the educational benefits of the research being quartered here. The computer will remain at the school not only for future research use but for student instruction. The trial version of the inputs study has been employing 8 schoolchildren (of illiterate parents) and 4 literate farmers, and these numbers will increase substantially.

The project will benefit poor smallholders in the area in several ways beyond the

supplemental income for input analysis households. The research explicitly addresses the information gap, and effects of GM crops on that gap, characterizing some of the poorest farmers whose situation is underrepresented in policy discussions. Many of the subjects in the input analysis agricultural ethnography will be Tribal Lambadas; these farmers have particularly severe problems with IMS due to illiteracy and lack of experience in cotton cultivation (they have also been overrepresented in the farmer suicides documented by Sudarshan Reddy and Rao [1998]). The project is committed to bringing these farmers' experiences to the attention of policy-makers, and its budget includes funds to support publication of such results. Data collected in the inputs analysis will have a more immediate benefit: in December 2002 farmers participating in the preliminary version of the inputs analysis asked Stone for summaries of the data for their own farms so they could better track their expenditures. These summaries are now being prepared, and will be updated regularly for any farmer who wishes them, for the duration of the study.

The project will be involved in disseminating other findings to the local populace and Indian scholarly community, remedying what has been a persistent problem. For instance, the research team led by Sudarshan Reddy had no outlet for disseminating its important findings on the causes of the 1998 suicides until their report was posted on GDS's website. This project will establish a website (accessible by the rapidly growing internet infrastructure in Andhra Pradesh), publish notices in local publications read by farmers, and publish articles in publications read by policy-makers on direct and indirect effects of the new technologies on smallholders.

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i. Professional Preparation

Northwestern Univ., Anthropology, B.A. 1977
Univ. of Arizona, Anthropology, M.A. 1982
Univ. of Arizona, Anthropology, Ph.D. 1988

ii. Academic Appointments

1995- Assoc. Professor, Anthropology, Washington Univ.
1993-95 Assoc. Professor, Anthropology, Columbia Univ.
1988-93 Asst. Professor, Anthropology, Columbia Univ.
1987-88 Weatherhead Fellow, School of American Research

iii-a. Publications (related to proposal)

G.D.Stone (2003) Neomalthusian ethics and genetically modified agriculture. To appear in **Anthropology and Ethics**, edited by P.Pels and L.Meskill.
G.D.Stone (2002) Both Sides Now: Fallacies in the Genetic-modification Wars, Implications for Developing Countries, and Anthropological Perspectives (with CA* commentary). **Current Anthropology** 43(5):611-630. Online enhancements including "Biotech Backgrounder" at www.journals.uchicago.edu/CA/journal/issues/v43n4/024005/024005.html
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Stone, G.D. and C.E.Downum (1999) Non-Boserupian Ecology and Agricultural Risk: Ethnic Politics and Land Control in the Arid Southwest. **American Anthropologist** 101:113-128.
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iv. Synergistic Activities

Developed interdisciplinary course, "Brave New Crops: Ecology and Politics of Genetic Modification." Featured molecular biologists, Monsanto executives, green activists from India and US, journalists, IP lawyer, public-sector biotechnologist, environmental philosopher, and a

farmer. Website at www.artsci.wustl.edu/~anthro/bnc; written up at http://magazine.wustl.edu/Fall01/glennstone.html

Collaborated with political & environmental scientists in developing multidisciplinary freshman program, "Land Dynamics & Environment: Scientific-Cultural-Policy-Ethical Perspectives" (1997-2000). Topics included population, agricultural change, scientific policy; exercises on remote sensing, Stella simulations.

Numerous contributions to development of new forms of web-based anthropological scholarship, including several publications on the topic; service as Current Anthropology's Associate Editor for Internet as it was going online and pioneering enhanced articles; developing various anthropology-related websites; training students to develop scholarly websites; also posting scholarship by Indian researchers.

Numerous op-ed pieces on agriculture in developing countries.

v. Collaborators & Other Affiliations

COLLABORATORS LAST 48 MONTHS : G. Barkin (Washington U)

GRADUATE ADVISORS: R.M. Netting (dissertation chair, deceased), M. Schiffer (U. Ariz.), C. Kramer (deceased), W. Longacre (U. Ariz.).

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1983 PhD, Agricultural Economics, Osmania University, Hyderabad A.P.

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iii-a. Publications (related to proposal)

A. Sudarshan Reddy (2000) Growing Informal Agricultural Credit Markets, in Mohd. Iqbal Ali et.al (Ed) Credit policy and Rural Development, Quality Publishers, Bhopal.
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A. Sudarshan Reddy (2001) Rural Transition in Khammam District – An Inter-temporal Analysis – The Experience of Banigandlapadu. Published by the XIX Annual Conference of Economic Association.
A. Sudarshan Reddy (2000) Rural Youth Employment : A Village Experience from Andhra Pradesh". Indian Journal of Labour Economics, vol.43, No.4.
A. Sudarshan Reddy. Rural Economics (for B.A. course sponsored by Telugu Academy, Andhra Pradesh).
A. Sudarshan Reddy. Indian Economic Problems (for B.A. course sponsored by Telugu Academy, Andhra Pradesh).

iv. Synergistic Activities

30 years activity in Warangal District: Rural electrification, agrarian relations, womens' participation, child labour, common property resources.

Long-term study of cotton-growing communities in Warangal District (being prepared for publication).

Co-founder & President, Centre for Environmental Studies. Examples of research projects include Environmental Impact Assessment of Singareni Coal Mine at Venkatpoor (1998); Environmental Impact Assessment of Hasanparthy Power Plant (1997); Report on Maleria Incidence in Mangapet Mandal (1997); Report on Godavari Floods – Causes and Consequences (1990); Farmers' Awareness Camps (50) during 1997-99; Coordinated 160 Radio talks on environment with All India Radio (1992-93)

Co-founder and President, Warangal Consumers Council.

Co-founder, Society for Development Alternatives

Co-Founder & Secretary, A.K.V.R. Rural Development Society

Participant, Peoples Participatory Mulkanoor Programmes on "Green your Colony" and "Arogya Mitra, Slum Area Development."

JOHN DALVI AWARD, 1992, Leslie Sawhny Programme of Training for Democracy, Bombay: for outstanding social work as a crusader in creating awareness in hundreds of students and citizens about the rights and duties of consumers and threats to ecology, and for setting up consumer councils in Andhra Pradesh.

v. Collaborators & Other Affiliations

Doctoral Thesis Supervisor: Prof.K.S.Surya Narayana (emeritus, A.P. Agricultural University).

Doctoral Theses supervised:

P.Rajesham 8-6-1990 'Agrarian unrest in A.P.-A Micro-level study in Telangana Region'.

H.Girija Rani 25-9-1990 'Pattern of Female Labour Force Participation and Utilisation -A Case Study in A.P'.

G.Raji Reddy 21-5-1991 'Pattern of Population Change in A.P.- A Micro-level Study in Telangana'.

K.Kondal Reddy 4-6-1991 'Child Labour in Agriculture-A Case Study in Telangana.

B.Venkateshwar Rao 27-1-1992 'Pattern of Agrarian Change in Telangana'

B.Sudhakar 8-1-1993 'Price Spread of Agricultural Products'

Y.Venkat Reddy 12-5-2000 'Role of Common Property Resources in Rural Economy'.

BIOGRAPHICAL SKETCH: Robert B. Tripp

i. Professional preparation

Univ. of Michigan. B.S. with High Honors in Chemistry, 1966.
Columbia Univ., College of Physicians and Surgeons, M.S. in Human Nutrition, 1972.
Columbia Univ., Graduate Faculties, Ph.D. in Social Anthropology, 1978.
International Maize and Wheat Improvement Center (CIMMYT), Rockefeller Foundation Postdoctoral Fellow, 1978-1981.

ii. Appointments

1994-present. Research Fellow, Rural Policy and Environment Group, Overseas Development Institute, London.
1989-1994. Assistant Director, Economics Program, International Maize and Wheat Improvement Center (CIMMYT), Mexico.
1982-1989. International staff, Economics Program, CIMMYT, Mexico.

iii-a. Publications related to proposal

R. Tripp (2001) *Seed Provision and Agricultural Development. The Institutions of Rural Change* Oxford and Portsmouth NH: James Currey and Heinemann.
R. Tripp (2001) 'Can biotechnology reach the poor? The adequacy of information and seed delivery' *Food Policy* 26: 249-264.
R. Tripp and S. Pal (2001) 'The private delivery of public crop varieties. Rice in Andhra Pradesh' *World Development* 29: 103-117.
R. Tripp and A. Ali (2001) 'Farmers' access to natural pest control products: Experience from an IPM project in India' AgREN *Network Paper No. 113* London: ODI. (www.odi.org.uk/agren)
R. Tripp and S. Pal (2000) 'Information and agricultural input markets. Pearl millet seed in Rajasthan' *Journal of International Development* 12: 133-144.

iii-b. Other Publications

R. Tripp (2001) 'Twixt cup and lip—biotechnology and resource-poor farmers' Nature Biotechnology 19(2):23
R. Tripp (2000) 'GMOs and NGOs. Biotechnology, the policy process and the presentation of evidence' *Natural Resource Perspectives* No.57. London: ODI. (www.odi.org.uk/nrp)
R. Tripp (ed.) (1997) New Seed and Old Laws. *Regulatory Reform and the Diversification of National Seed Systems.* London: Intermediate Technology Publications.
R. Tripp (ed. (1991) *Planned Change in Farming Systems. Progress in On-Farm Research*. Chichester: John Wiley.
R. Tripp (1996) 'Biodiversity and modern crop varieties: Sharpening the debate' *Agriculture and Human Values* 13(4): 48-63.

iv. Synergistic Activities

a. Present work for the UK Department for International Development (DFID) on the enabling environment for agricultural technology generation. Developing background material for DFID and other donors on how to promote the nexus among public agricultural research, regulatory frameworks and indigenous agricultural enterprise.
b. Work on seed policy in Africa. Several projects, including a multi-country effort with ICRISAT, has led to developing articles and working papers that are used as references in national and regional efforts at regulatory reform, including USAID-led project on regional regulatory harmonization for Eastern Africa. Member of scientific advisory committee for Rockefeller Foundation Biotechnology, Breeding and Seed Systems for Africa Program.
c. Work on seed policy in India. Several projects in collaboration with NCAP (National Center for Agricultural Economics and Policy Research) have made contributions to the debate on Indian seed policy. A workshop to present project findings chaired by the head of government's project to write a white paper on seed policy reform.
d. Adaptive on-farm research. More than a decade with CIMMYT organising and teaching courses for developing country agricultural scientists on adaptive on-farm research. Lead author of three widely-used manuals (on the economic analysis of on-farm trials, setting priorities for on-farm research, and the conduct of technology adoption studies). Developed and presented field-level courses in 15 countries in Africa, Asia and Latin America.

v. Collaborators and other affiliations

a. Collaborators in past 48 months. None in the USA.

Others: Dr. David Rohrbach, ICRISAT, Bulawayo; Dr. Richard Jones, ICRISAT, Nairobi; Dr Suresh Pal, NCAP, New Delhi; Mr. Niels Louwaars, Wageningen, The Netherlands.

b. Graduate advisors: Prof. Lambros Comitas, Prof. George C. Bond, Prof. Alexander Alland (Columbia University).

c. Thesis advisor. (Not in academic post)