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Modern Agriculture Practices and Associated Health Risks: An Indian Study

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SUMMARY

High inputs of agrochemicals and water, and widespread practice of monoculture are believed to be the major reasons for India's success in modern agriculture practice. However, there are very few comprehensive analyses of potential adverse health outcomes that may be related to these changes. This study aims to compare high-input and low-input agricultural practices in the southern Indian state of Karnataka and the consequences for health of people in these communities. The study identified four major visible impacts: mosquito borne diseases, changing nutritional status, occupational hazards, and inequity in development. Ecological changes on account of widespread cultivation of rice have further augmented mosquito breeding, and thus there has been a surge in the incidence of Japanese encephalitis and malaria. The traditional coarse cereals have been replaced by mill-polished rice. The prevalence of overweight has emerged as a new public health challenge. In the high-input area, mechanization has resulted in more occurrences of serious accidents and injuries. Output-driven and market-oriented modern agricultural practices have changed the ecology and disease pattern in this area in India, and our survey indicated significant health effects associated with these changes.

Keywords: Ecological changes, Food safety, Occupational hazards, Communicable diseases, Nutritional status.

1. INTRODUCTION

India has undergone a major shift in agriculture, by embracing new technologies including high yielding seeds, intensive irrigation, agrochemicals and mechanization. As a consequence, the nation has shown impressive progress in terms of securing food for the masses and bringing millions of people out of poverty. One of the noteworthy policy shifts has been a change from traditional multi-crop to mono-crop cultivation (Swaminathan 2010). Currently, rice, wheat and plantation crops are the major crops in terms of area of cultivation, production and yield; lagging behind, however, is cultivation of traditional coarse cereals and pulses which continue to perform very poorly (Bhalla *et al.* 2009).

With the success of modern agriculture soon there have also been negative consequences including reduced biodiversity, soil salinity due to improper and excessive use of water, decline in the water table, erosion of soil nutrients, growing pest resistance to insecticides and dependency of farmers on all types of inputs (Swaminathan 2006). In several instances these changes have led to declining yields and with the need for augmented fertilizer and pesticide inputs in subsequent cropping cycles (Kesavan *et al*. 2008, Ladha *et al*. 2003). Toxic industrial effluents often contaminate the agriculture lands and eventually accumulate in the produces (Kisku *et al.* 2011). Furthermore, there can be negative consequences on agricultural producers, systems and outputs are associated with human health through a complex set of factors including

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environmental change, exposure to a variety of natural and human-origin stressors, social position, changing behavior, occupation, and access to services (Hawkes *et al*., 2006). In India, however, existing evidence linking agriculture to human health has been scattered and disconnected; for example there is no comprehensive information on multiple health risks attributable to modern agriculture practices in any specific rural community.

2. METHODS

We conducted a study to explore multiple health risks associated with changing agriculture practices in one region of rural India. The survey was carried out in Karnataka, one of the southern Indian states and compared the health risks of older and modern agricultural practices. The state has experienced several decades of adoption of new systems of agriculture within and adjacent to a large river-based irrigation system known as the Tungabhadra Project (TBP). The TBP was commissioned in the early fifties and high-input agricultural practices have been increasingly implemented in areas that have access to an abundant water supply. The assured irrigation changed the cropping pattern of the command area, putting almost exclusive emphasis on water and chemical-intensive crops, especially rice, which have replaced sorghum, maize, and millets and other traditional dryland crops (CADA 2008, vanLoon *et al*. 2005). At the same time, there continues to be co-existence of more traditional systems (low-input and organic) in the adjoining areas not benefitted by the TBP, providing an opportunity for us to undertake a comparative study. We selected six closely- related villages of Gangavati *taluka* in Koppal district (one of the major beneficiaries of TBP) (See Fig. 1 and 2). Gangavati was selected for this study as it encompassed three agro-ecological areas: (a) high input irrigated agriculture at the head end of the command area of TBP, (b) dryland traditional agriculture in the area northwest of the canal and, (c) the centuries-old irrigated 'ancient' area [The ancient area is a historical region known for the famous Vijayanagar Kingdom. The kingdom was established in 1336 AD and this area was the centre of major economic and political activities of the kingdom. One

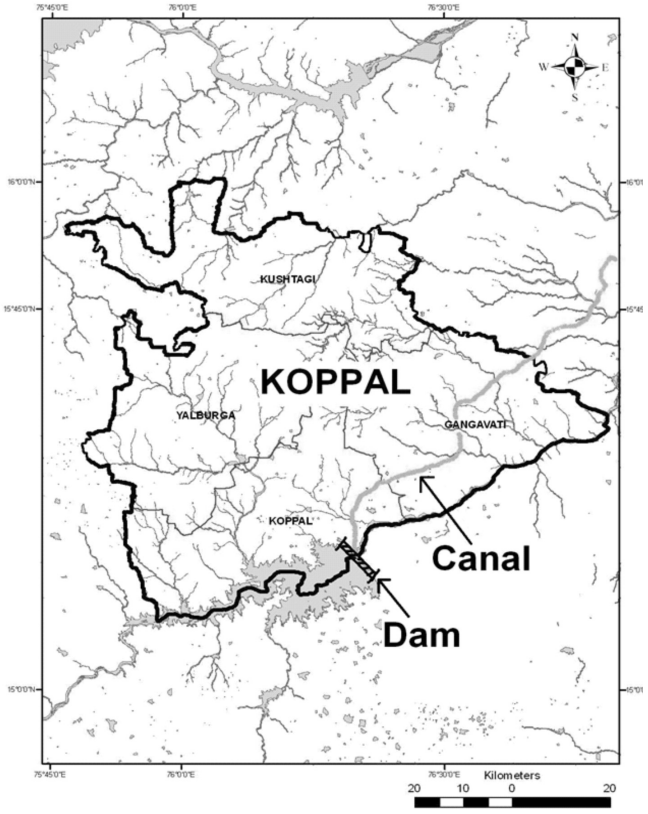

Fig. 1. Location of TBP (dam) and Gangavati taluka

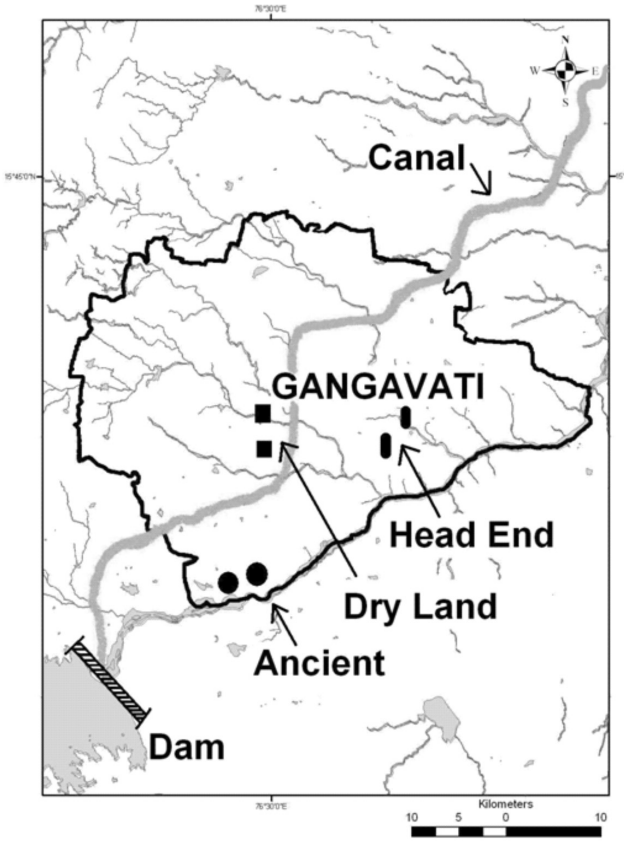

Fig. 2. Location of study villages in Gangavati taluka

of the kings built a canal system for irrigation and security reasons. The water from the Tungabhadra River still flows in this canal and continues to be used for irrigation.] known for some measure of 'organic' methods of farming and a conscious decision to avoid overuse of chemical inputs (vanLoon *et al*. 2005). The existence of three major agriculture practice areas in a single *taluka* has helped us to eliminate the effects of some confounders, such as diversity with regard to local culture, topography, soil characteristics, and climate. A structured schedule was developed for household interviews (N_{total} = 240) and pretested prior to the actual field survey which took place from May to August, 2009. As a part of data collection, government officials (health, agriculture, and teachers), private practice physicians, pesticide traders, village leaders (*panchayat* officials), and preschool child caregivers (*anganwadi* workers) were also interviewed. Participants' observations as well as information from secondary sources such as government documents were incorporated in the analysis.

As an integrative measure of nutritional status of the adult male and female respondents of the households, Body Mass Index [BMI = Weight (kg)/ {Height (m)}^{2}] was used and thus, during the household surveys, height (m) and weight (kg) of all respondents were measured in the field and BMI was calculated during data analysis.

In order to analyze for a range of insecticides/ herbicides/fungicides and mercury, 15 rice samples and 1 straw sample were collected from the head end area and the ancient areas. The pesticides were measured by standard methods using gas chromatography-mass spectrometry (GC-MS) and liquid chromatography-mass spectrometry (LC-MS), and mercury by cold vapor atomic absorption spectroscopy (CV-AAS).

3. RESULTS

The results are classified into the following categories: (1) ecological changes affecting the disease patterns in the study area, (2) diet, nutritional status, and food safety, (3) inequity in development and changing behavior and (4) occupational hazards during farm activities.

3.1 Ecological Changes and Mosquito-borne Diseases

The major mosquito-borne diseases in Gangavati were malaria and Japanese encephalitis (JE). These diseases were clearly connected to agriculture practices as the vectors breed in flooded rice fields, open ditches, and distribution canals (distributaries). In the head end area, we found several damaged distributaries (due to lack of maintenance) that had created several artificial water bodies which were full of thick vegetation and a high population of young adult mosquitoes. The health records (unpublished) of Gangavati *taluka* health facility showed that incidence of JE was essentially confined to irrigated rice field areas due to a significant presence of *Culex* mosquitos. Standing-water in rice fields enhances the growth of crustaceans and other insects which, in turn, attract herons and egrets. These birds are known to be reservoirs for the JE virus. Thus, the combination of change of landscape, ecology, and land use pattern along with human behavior has contributed to the occurrence of JE. Between the two irrigated areas, the malaria problem was greater in the ancient area. There the land use and the landscape patterns, such as standing of water in rice fields and vegetation in the water, were very similar to the head end area. In addition, there were numerous small water bodies in depressions in the undulating landscape and along the bank of the Tungabhadra River that provided further favorable mosquito breeding grounds. The delicate ecological balance was also disrupted if frogs, the natural predators of mosquitoes, were removed from the ecosystem. Due to rapid expansion of modern agriculture, the population of frogs has declined rapidly with a corresponding rise in the mosquito population (Agoramoorthy 2009, Mann *et al*. 2009). In fact, around 90% of the farmers of the study areas noted a decline in the frog population and associated this with extensive pesticide use.

3.2 Diet, Nutritional Status and Food Safety

There has been a significant change in the regular diet of the population within and around the TBP area. Before the construction of the canal system, the diet involved traditional coarse cereals such as sorghum, millet, and maize as staple foods. The new irrigation

system has encouraged farmers to grow rice and in the last several decades it has become the principal crop among farmers living in the head end of the command area. High demand and assured profit have encouraged farmers to shift almost totally to rice cultivation. In contrast, coarse cereals have lost patronage in terms of equivalent types of private and public institutional support. Cultivation of these grains has declined and in large part they have gradually disappeared from the regular diet of the local people. It was found that the nature of local agriculture significantly influenced the consumption pattern. Rice consumption was the highest in the head end area (80%), followed by the ancient area (70%). In the dryland area, where cultivation of traditional cereals is still widespread, rice consumption was lower (53%).

The risk of having low BMI was greater in the dryland area than in either of the two irrigated areas. On the other hand, people in both irrigated regions had a greater tendency to be overweight than in the dryland area. In the head end and ancient areas, more than half of men (51-52%) had a BMI in the normal range, with lower proportions falling in both the high (25-26%) and low categories (24-25%). In the dry land area, half (51%) had a low BMI while only about one-tenth had a high value. For females, the distribution pattern showed a larger number of underweight than for men. However, in the head end area, there was a somewhat higher number of overweight women than men (31% against 24%). Overall, compared to males, the numbers of both low and high BMI among females were higher. Of particular concern is the significant proportion of the population that was overweight. Less physical work combined with high fat intake were believed to be the causes of the rising trend of obesity. Introduction of modern farm machines, modern household gadgets, and availability of servants in the large landowners' homes were suspected to be the principal reasons for the reduced physical activity of the well-to-do men and women. Interviews with the local physicians revealed that there has been increasing incidence of diabetes, hypertension, and ischemic heart diseases in the head end and ancient areas. Our study has identified overweight and obesity as the emerging risk factor in the modern agriculture practice areas; however, there is no epidemiological data in the district. Therefore, we had to rely upon the anecdotal evidences. In fact, several interviewees of our study at the head end had open heart surgery and angioplasty, but not a single such case we found in the dryland area. A population based study on these emerging health risks in rural communities is necessary.

Two out of eight rice samples from the head end area had detectable levels (35, 100, 13 and 28, 45, 29 µg/kg respectively) of insecticides (buprofezine, chlorpyrifos) and fungicide (propiconazole). It is worth noting that all the samples were analyzed at least four months after harvest; during that time volatilization would contribute to some loss of the residues. Seven rice samples and 1 straw sample were also analyzed for the currently-banned pesticide endosulfan and mercury. Measureable levels of endosulfan were found in all samples. Comparing the recommended value of the Agency for Toxic Substances and Disease Registry (ATSDR), results of the rice and straw sample analysis (again, 4 months after harvest) were considerably lower (ATSDR, 2000). However, its presence in rice and straw residues remains a serious environmental health concern, because of heavy consumption of rice in the study areas and use of straw as fodder for cattle, indicating the vulnerability of livestock, and humans as well through the food chain. Lower concentrations of endosulfan could still pose a serious threat to children's health due to bioaccumulation, its placental transfer affecting fetal development, and through secretion of breast milk affecting early childhood growth. It is important to note that irrational use of agrochemicals has been rampant in the study areas. Most of the chemicals are being used either lower or higher than the recommended doses. Lack of knowledge and economic factor (cost of agrochemicals) are believed to be the main reasons.

The typical dryland local varieties of coarse grains and pulses are less subject to pest problems; therefore farmers in those areas used a lesser quantity of insecticides. Higher rates of insecticide use were observed in the head end area than in the ancient area, and especially among the large-landholders. Buprofezin, endosulfan, phorate, monocrotophos and imidacloprid were the most widely used pesticides in rice cultivation. Average application rates of buprofezin and imidacloprid were 71% and 73% higher respectively than their recommended doses prescribed by the University of Agriculture Sciences, Dharwad, Karnataka. Except phorate, the remaining pesticides were used at lower levels than the recommended doses. Around 90% of the farmers considered yield as the most

important criterion for successful agriculture practice and, in an attempt to protect the crop against any loss, used agrochemical extensively. Widespread irrational use of pesticides was essentially due to a communication gap between the community and agriculture officials.

We identified mercury in all rice and straw samples (21-58mg/kg). The probable sources of mercury in the rice samples were two coal-based power plants located within 120 km of the field area and/or a number of brick kilns close to the study villages. A study in China has also shown the presence of mercury in rice as its uptake by this plant was higher than several other crop species (Zhang *et al*. 2010). This was due to the fact that its growth occurred in submerged soils, a reducing environment, in which the mercury is present in forms that can be readily assimilated by the plant. Moreover, in rice approximately one-fifth of total mercury is present in methyl form which is more toxic than its ionic form.

3.3 Inequity in Development

Modern agriculture has improved the overall quality of life in terms of income, nutritional status, housing, education, water, energy, and health status. Several villagers attributed improvements in childhood nutrition to the school nutrition program, improved sanitation and general health awareness. Now the villages are relatively cleaner, most children have proper clothing, and parents are more aware of requirements for adequate health care, resulting in fewer illnesses. However, the continuing presence of high childhood malnutrition at Gangavati reflected that the situation currently remains far from satisfactory and further improvements in diet and general health care are still required. An unpublished local record (2008-2009) of the Integrated Child Development Scheme, Gangavati (Govt. of Karnataka), shows that 67% of the children from 0 to 6 years are still malnourished.

The government reports showed that the infant mortality rate (IMR, total number of deaths of infants per year per 1000 live births), one of the sensitive indicators of quality of health, was consistently higher in the dryland area (43, 53, and 44 in 2006, 2007 and 2008 respectively) compared with the head end area (36, 36, and 31 in the same corresponding years). According to the health workers and the local physicians, lack of work opportunities for women in their own villages played a negative role in terms of getting access to public health services, including antenatal care and child care, particularly immunization. Due to lack of agricultural activities during much of the year in the dryland area, poor people were compelled to migrate to other districts, resulting in interruption of regular health check-ups for the children. The unfamiliar environment was another barrier to seeking prompt medical care (including routine immunization) for the migrant workers. Therefore the children remain unimmunized and eventually became vulnerable to various infectious diseases, with resulting high morbidity and even fatality.

3.4 Occupational Hazards

According to the farmers the major farm-related occupational hazards were: cut injuries (85%), heat stroke (51%), eye injuries (24%), animal bites (19%), pesticide exposure (14%) and accidents (2%). Cut injuries usually occurred during the use of hand tools or machines and most were relatively minor. According to the farmers in the head end area, introduction of heavier machines have resulted in increasing numbers of major injuries, including some fatal accidents. The serious injuries are most often due to being struck by, pinned by, or caught in the mechanism of tractors, threshers and other machines. There have been reports of several cases of genital mutilation in the recent past due to farm machine related accidents. The traditional loose-fitting clothing, are not appropriate for operating most machines as the loose ends of the clothes are easily caught in the fast moving mechanisms and the sudden forceful pulling takes away the skin of the scrotum and penis. Even though machine-based agriculture is becoming increasingly common, traditional harvesting methods are still widely used, especially in the ancient and dryland areas and the hand tools are the source of usually minor cuts. Minor eye injuries due to foreign bodies like straw fibers or small husks of grain are common at the time of harvesting.

Several farmers shared a number of adverse impacts that they experienced due to exposure to insecticides during their application in the field. The common symptoms of direct exposure were itching and irritation of skin (78%), weakness and giddiness (36%), breathing problems (23%), and vomiting (10%).

4. DISCUSSION

Since the TBP became operational in 1953, there has been a rapid transformation in agricultural practice, landscape and society as a whole, as well. Rice production has almost completely altered the traditional diet, and this change along with lack of physical activities has taken its toll by increasing the prevalence of overweight and obesity among both men and women. Rice cultivation has also changed the landscape from a semi-arid dryland, modified by seasonal rains to land having year-round moisture. This change along with overuse of fertilizers and stagnation of water in old and dilapidated distributaries of the canal has augmented mosquito breeding and eventually the risks of communicable diseases. The positive laboratory results for pesticide residues, including one that has been banned, in rice grain samples, even several months after harvesting, confirmed their extensive use. The presence of pesticide residues in straw showed that livestock and wild animals can also be exposed. Analysis of a small number of rice samples has indicated the presence of mercury at levels that could be a potential threat for neurological and intellectual development for the rice eating population, particularly children. Introduction of new types of agricultural machinery has clearly posed some new and unprecedented public health challenges by causing serious injuries and even fatalities. Probably the most startling finding of the study was the growing evidence of overweight/obesity among the India's rural population, commonly been portrayed as chronic sufferers of nutrition deficiency. At the same time, undernutrition remains as a serious problem.

The association between modern agriculture and emerging health risks is very complex and therefore an interdisciplinary perspective is deemed necessary for generating a comprehensive picture. This research initiated such a comprehensive study through collection of data on agriculture practices, ecosystem, food and water contamination, nutrition, human behavior, and adverse health impacts. In this paper we have given brief account of our research and for detail information, the readers are requested to refer our two previous publications, mentioned in the references (Sarkar *et al*. 2011, Sarkar *et al*. 2012).

The purpose of this shorter communication, focussed on modern agriculture practices and the associated health risks vis-a-vis traditional agriculture, is to bring home some important issues that need to be investigated in more detail with sufficient quality data. At places certain claims have been based on anecdotal evidence instead of a study with adequate power. For instance, there is no government epidemiological data on hypertension obesity in rural population. However, there are anecdotal evidences from the local medical practitioners at the Gangavati town. In fact, several interviewees of this study in the irrigated areas had open heart surgery, angioplasty, but not a single such case was found in dry area. In the absence of data availability on many important environmental health issues that emerge because of the modern agricultural practices, it may be difficult to make any strong recommendations. In that sense the present study has its own limitations. The authors also strongly feel that there is a need to analyze nutritional quality data. The use of pesticides and insecticides, coupled with irrigation water, contamination of agriculture product due to industrial effluence, etc., are other important environmental health hazards that need to be probed further.

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REFERENCES

Agoramoorthy, G. (2009). Reviving frogs in India's freshwater environment to control mosquito-borne diseases. *Ind. J. Med. Res*., **129**, 201-202.

ATSDR (2000). Public Health Statement – Endosulfan (CAS#: 115-29-7). Agency for Toxic Substances and Disease Registry/Center for Disease Control, Atlanta. [Online] Available at: http://www.atsdr.cdc.gov/toxprofiles/tp41-c1-b.pdf [Accessed 20 July 2011].

Bhalla, G.S. and Singh, G. (2009). Economic liberalisation and Indian agriculture: a statewise analysis. *Econ. Pol. Wkly*., **44**, 34-44.

CADA (2008). Tungabhadra, project Munirabad. Annual Report 2007-08, Command Area Development Authority, Munirabad. **1**, 11-13.

Hawkes, C., Ruel and M.T. (eds.) (2006). Understanding the links between agriculture and health. International Food Policy Research Institute (IFPRI), Consultative Group on

International Agricultural Research (CGIAR), IFPRI, Washington, DC, 1-36.

Kesavan, P.C. and Swaminathan, M.S. (2008). Strategies and models for agricultural sustainability in developing Asian countries. *Philos. Trans. R. Soc. Lond. B Biol. Sci*., **363(1492)**, 877-891.

Kisku, G.C., Pandey, P., Negi, M.P. and Misra, V. (2011). Uptake and accumulation of potentially toxic metals (Zn, Cu and Pb) in soils and plants of Durgapur industrial belt. *J. Environ. Biol*., **32(6)**, 831-838.

Ladha, J.K., Dawe, D., Pathak, H., Padre, A.T., Yadav, R.L., Singh, B., Singh, Y., Singh, Y., Singh, P., Kundu, A.L., Sakal, R., Ram N., Regmi, A.P., Gami, S.K., Bhandari, A.L., Amin, R., Yadav, C.R., Bhattarai, E.M., Das, S., Aggarwal, H.P., Gupta, R.K. and Hobbs, P.R., (2003). How extensive are yield declines in long-term rice-wheat experiments in Asia? *Field Crops Res.,* **81(2-3)**, 159-180.

Manna, R.M., Hyne, R.V., Choung, C.B. and Wilson, S.P. (2009). Amphibians and agricultural chemicals: review of the risks in a complex environment. *Environ. Pollut*., **157**, 2903-2927.

Sarkar, A., Aronson, K.J., Patil, S.G., Hugar, L.B. and vanLoon, G. (2012). Emerging health risks associated with modern agriculture practices: A comprehensive study in India. *Environ. Res.* http://dx.doi.org/10.1016/j.envres.2012.03.005

Sarkar, A., Patil, S.G., Hugar, L.B. and vanLoon, G. (2011). Sustainability of current agriculture practices, community perception and implications for ecosystem health: an Indian study EcoHealth, **8(4)**. DOI: 10.1007/s10393-011-0723-9

Swaminathan, M.S. (2010). Achieving food security in times of crisis. *New Biotech.,* **27**, 453-460.

Swaminathan, M.S., (2006). An evergreen revolution. *Crop Sci.,* **46**, 2293-2303.

vanLoon, G.W., Patil, S.G. and Hugar, L.B. (2005). *Agricultural sustainability-Strategies for Assessment.* Sage Publication, New Delhi, 259-266.

Zhang, H., Feng, X., Larssen, T., Shang, L. and Li, P. (2010). Bioaccumulation of methylmercury versus inorganic mercury in rice (Oryza sativa L.) grain. *Environ. Sci. Tech*., **44**, 4499-4504.