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CHAPTER 12

Collective Action on Improving Environmental and Economic Performance of Vegetable Production: Exploring Pesticides Safety in India

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Abstract: From the chemical input-intensive yield-enhancement practices of the Green Revolution era, agricultural research and development focus is gradually shifting towards establishing Good Agricultural Practices (GAP) in fruits and vegetable sector. The dominant problems affecting fruits and vegetables in terms of safety is presence of pesticide residues. Globally, authorities have long highlighted this risk and imposed appropriate maximal limits of residues (MLRs). In spite of imposing MLRs in fresh vegetables, negative health effects of pesticides residue in consumers have been increasingly reported from states of India like Kerala. Along with other factors, food quality and safety declination resulting from inappropriate chemicals and pesticide use during crop production is widely documented as one of the root-causes of the health issues. The weak quality assurance schemes in developing countries impede smallholders' inclusion in high value chains due to imperfect institutional and governance arrangements throughout the system. Apparently, erstwhile studies have emphasized the significance of collective action among smallholders as a solution to the above constraints. However, past studies on vegetable production in India are either from a horticultural and entomological perspective on increasing production and productivity, pest management or on cost of cultivation and those solely from an econometric, institutional and collective action perspective have been hardly studied. Still lesser are studies understanding the inter-linkages between smallholders' collective action and pesticides risk reduction in vegetable production of India. In this backdrop, the current study examines various econometric models and suggests suitable models to assess the institutional mechanisms on improving environmental and economic performance of vegetable production in India under collective action.

Keywords: Agricultural practices, bio-control agents, crop rotation, data envelopment, ecological conditions, food safety, insecticides, organic farming, pathogenic, pesticide safety, pest management, poverty reduction, quality assurance, smallholders, vegetable production.

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1. INTRODUCTION

From the chemical input-intensive yield-enhancement practices of the Green Revolution era, agricultural research and development focus are gradually shifting to establishing Good Agricultural Practices (GAP) in fruits and vegetable sector. The dominant problems affecting fruits and vegetables in terms of safety do not concern pathogenic contamination but pesticide residues [1]. Globally, authorities have long highlighted this risk and imposed appropriate maximal limits of residues (MLRs) [1, 2], and promoted integrated pest management (IPM) [3] and organic farming practices. In spite of imposing MLRs in fresh fruits and vegetables, negative health effects of pesticides residue in consumers, have been increasingly reported [4] (for example recent cases of endosulphan victims in Northern Kerala). Along with other factors, food quality and safety declination resulting from inappropriate chemicals and pesticide use during crop production is widely documented as one of the root-causes of the health issues [5-8].

The role of both public agencies and private actors in pesticide risk reduction have been widely discussed in the academic literature [9, 10]. In fact, there is a common consensus between the private and public food safety regulations in developed countries, where both these regulatory standards increasingly wreathe together to manage and ensure food safety. On the other hand, the institutional frameworks on food safety regulations in developing countries are significantly weaker, and controlled by government bodies [10, 11]. Besides, with private voluntary standards still in the state of emergence, there is a lack of clarity in the structure and functioning of food safety regulations in developing countries [3].Such weak quality assurance schemes impede smallholders' inclusion in high value chains due to imperfect institutional and governance arrangements throughout the system. Apparently, erstwhile studies have emphasized the significance of collective action among smallholders as a solution to the above constraints [12, 13]. However, past studies on fruits and vegetable production in South Asian countries like India are either from an agronomic perspective on increasing production and productivity [14, 15] or on cost of cultivation [16] and those solely from an econometric, institutional and collective action perspective have been hardly studied. Still, the studies about understanding the inter-linkages between smallholders' collective action and pesticides risk reduction in vegetable production of South Asia are few.

1.1. Pesticide Safety in Indian Scenario

In South Asia, with an annual production of approximately 81 million tonnes of fruits and 162 million tonnes of vegetables during 2012-2013; India is regarded as the leading horticultural producer of the world [17]. The country has witnessed excessive pesticide use in case of both fruits and vegetables [18, 19]. Because of varying socio-economic conditions and lack of knowledge, farmers in India tend to misuse or overuse pesticides that are illegal, banned, and acutely toxic or in most cases not fit for horticultural crops [20].

Inspite of India's status as the second largest producer of fresh fruits and vegetables, export of horticultural products is less [21]. For a long time, India has aspired to export its fruits and vegetables to European markets. This was in accordance to the country's rural development strategy aimed to promote exports of agricultural goods [22]. Since early 1990's, India has achieved short term success in export of horticultural products to Northern European countries like the UK, Netherlands and Germany [23]. Apparently, there are success stories in fruits and vegetables export involving cooperatives and collective action. For example: grapes' export to UK, Germany and Netherlands by *'Mahagrapes'* in the Indian state of Maharashtra [21], and vegetable farming by *'Kudumbashree'* women collective groups in Kerala state [24].

Moreover, it is often reported that smallholders limited by resources may not be able to cope up with the safety standards of the global and domestic markets [13, 25]. Inability to comply with the various standards acts as an exclusion barrier for smallholder production systems to enter high value chains [3]. As such there is an on-going debate around the rise of food safety standards, especially private agri-food standards – whether these act as a barrier or benefit to the smallholder producer at the downstream of the agri-food chains in developing countries like India and impede poverty alleviation [26, 27].

2. ENSURING PESTICIDE SAFETY FOR HIGH VALUE CHAINS

Under the realms of food safety in pest management, actions by individual farmers alone in case of vegetable production could cause new problems. One of the often observed problems in vegetable production of India is the extensive use of pesticides on individual farms neglecting pesticide translocation effects to nearby plots, water resources or soil. This could also trigger pest movement to fields not treated with pesticides, or pests developing localized resistance. Another problem may arise when predator population is below viable size in fields that uses biological means of control. Furthermore, in organic vegetable production, there are other issues with respect to pest management. Primarily, translocation effect of pesticides from non-organic farms could damage the positive effects of organic farming and secondarily, there is the issue of non-uniformity in practices between the organic farms.

Collective action in agriculture is identified as providing several benefits to small and marginal farmers such as reducing transaction costs while increasing bargaining opportunities, alongside better access to inputs, credit, and market [28-30].

Most importantly, the impact of collective action in managing pesticide safety standards occur when farmers in a particular area or village take decisions jointly and share operations and costs to implement integrated pest management practices. For *e.g.* joint decisions on, and the collective use of organic management techniques, bio-control agents, inorganic less toxic remedial measures, or the use of recommended crop and pest specific pesticides in combination with sequential/companion cropping with "*pest push and pull techniques*", as per requirement.

Forming farmer collectives in pest management for participation in high value chains could be challenging in developing countries due to farmers' heterogeneity in social and economic status, belief systems, attitudes, behavior and values towards the society and the environment *etc*. Farmers behave rationally and often try their best to produce more from limited land, and often venture into extensive pesticide application or compete with neighboring farmers for markets and better prices. Therefore, it is important to convince all the farmers in an area to adopt integrated pest management practices in a coordinated fashion.

Three things have received less attention during a collective action process for integrated pest management especially in the context of high value agri-food chains. Although a collective effort of integrated pest management approach allows certain crop losses; the effect is synergistic in the sense that it increases overall production and profits alongside reduced environmental pollution and human health risks. Secondly, localized adoption of integrated pest management among small group of farmers without considering the spatial dimension limits the success of the process since the pest can move to those non-adopted fields. Finally, pest management is not a static process controlling a single pest in a single season but it is a constant effort across temporal scales that require sustained collective action in a coordinated fashion.

Apart from the above, many other factors including socio-economic, institutional and cultural aspects and processes drive collective pest management action in farmers. Collective action (i) increase farmers' ability for joint investments and public-private partnership (ii) provide farmers with necessary information (iii) make possible vertical integration or contract farming [13, 21, 31-33].

Hence, future research should address the following issues:

- Characterization of public and private pesticides safety requirements of vegetables in national and international high value chains.
- Assessing the economic impact of pesticides safety standards of vegetables on smallholders in India.
- Estimating the impact of Indian vegetable producing smallholders' collective action on institutional and economic performance linked to pesticides safety.
- Comparing the pesticides safety performance among organic/GAP certified and noncertified vegetable growers of India.

3. MEASURING COLLECTIVE ACTION IN SMALL HOLDERS' VEGETABLE PRODUCTION

Depending on the empirical information, two approaches for performance analysis of smallholders' collectives are proposed here: (a) Ordinary Least Square (OLS) regression model [3] and (b) Data Envelopment analysis [34].

a. OLS Regression Model

$$Y = \alpha + \beta(group\ characteristics) + \gamma(institutional\ arrangements) + \delta(institutional\ \&\ economic\ environment) + \eta(ecological\ conditions) + \varepsilon, \varepsilon \sim N(0, \sigma^2) \quad (1)$$

Where *Y* is the dependent variable denoted by quantity of pesticides used by the individual farmers or farmers in the group, and other exploratory variables in the model are given in parenthesis.

b. Data Envelopment Analysis

Performance analysis or efficiency is a relative notion [35] and has its roots in production analysis. The efficiency concepts and its measurement can be applied to various fields including farm level production. Data Envelopment Analysis

(DEA) [34] is one such performance evaluation approach that identifies inefficiencies and also suggests possible improvements. This is also applicable to micro level decision management units (DMUs) [36] such as smallholders' collective or organisations [37]. Hence, the BCC-DEA[1] model under variable returns to scale which is proposed as [38]:

$$\min_{\Delta\lambda} \Delta j \ (2)$$

subject to

$$\sum_{j=1}^{n} y_j \lambda_j - y_j \geq 0; \lambda_j \geq 0 \ for \forall_j,$$

$$x_{ij}\Delta_j - \sum_{j=1}^{m} x_{ij}\lambda_j \geq 0,$$

$$\sum_{j=1}^{n} \lambda_j = 1, \ 0 \leq \Delta \leq 1$$

The assumptions of this model are as follows:

- Farm $j(j = 1,2, \ldots, n)$ produces a single output (y_j) using a combination of inputs

$$x_{ij}, where\ i = group\ charecteristics, institutional\ arrangements, ecological\ conditions, labor, machinery, seed, feretilisers\ etc.$$

- Input-oriented production frontier under variable returns to scale (VRS)

where (Δ_j) is a scalar which indicates the technical efficiency scores of the j^{th} farm $(if\ \Delta_{j=}1$, then the farm is on the frontier and is technically efficient under variable returns to scale, but $if\ \Delta_{j=}\ 0$, then the farm lies below the frontier and is technical inefficient); (y_j) is a$(1 * n)$ vector of single output produced by the n farms; x_{ij}, x_{ij} is a $(m * n)$ input matrix; λ_j, λ is a $(n * 1)$ vector of weight value, $j\forall$ denotes for all j.

[1]Banker, Charnes and Cooper - Data Envelopment Analysis

From the Linear programing problem, assuming that the observed activities (x_j, y_j) (belong to production possibility set (P). Then minimize (Δ)that reduces the input vector (x) radically to (Δx)while remaining in P. The (Δ) is scalar representation of BCC- technical efficiency value, which varies in range of zero and one [36].

4. MEASURING ECONOMIC IMPACT OF PESTICIDES SAFETY

Along with production function analysis, damage control function approach is proposed for assessing the economic impact of production standards on farm revenue and pesticide usage [39]. 'Total revenue on sales of vegetables per acre per cropping season' is taken as the dependent variable, then the Cobb-Douglas production function with logistic damage control can be represented as:

$$ln(Q) = ln\,(\alpha) + \sum_{i=1}^{n} \beta_i ln(w_i) + \gamma G_i + ln[1 - \exp\left(\lambda - \alpha x_p\right)]^{-1} + v \quad (3)$$

where Q denotes total revenue per unit land received on sale of vegetables, the vector iW includes labor, fertilizer, seed, number of vegetable crops grown, other farm specific factors that affect total revenue such as, age of the household head and location-specific factors and iG denote adoption of Organic/IPM/GAP standards. The $i\beta's$ are the corresponding coefficients to be estimated; λ is constant and α is the parameter to be estimated for pesticides in logistic damage function framework.

CONCLUSION

The present paper has attempted to delineate briefly the pesticide safety issues in vegetable production in India. The collective action effort in food safety to increase environmental and economic performance of vegetable production by minimising pesticide risk is an emerging concept. In spite of the several advantages of collective action outlined above, methods of its measurement for ensuring food safety or pesticide risk reduction in high value chains in vegetable production of India has been hardly discussed. Hence, the methods presented above could be considered as a pioneering effort in this regard. Nevertheless, the absence of empirical evidence from India to test the presented models delimits importance of this paper. Yet, the paper could be a way forward for future empirical studies in this direction since these may augment the decision-making of all involved stakeholders minimizing welfare loss among smallholder vegetable production because currently little is known about most of the above issues which largely impede inclusion of India's smallholder vegetable farmers in global high value chains.

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CONFLICT OF INTEREST

The author(s) confirm that this chapter contents have no conflict of interest.

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