

Chapter 3: Methods

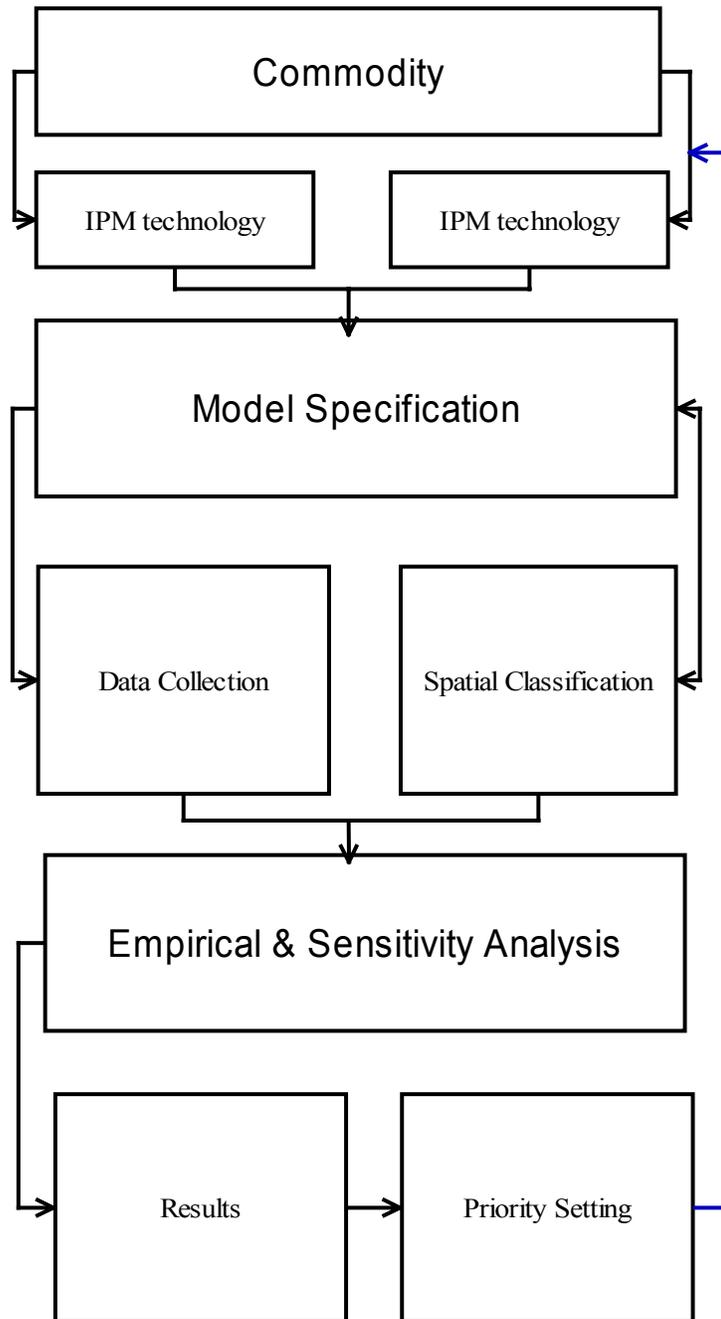
3.1 Introduction

The aim of this chapter is to provide a strategic framework for assessing the economic impact of IPM strategies. This study applies an economic surplus approach for evaluating the economic impacts of some of the IPM CRSP's research activities in Bangladesh and Uganda. In so doing, it develops a general framework capable of change from area to area and over time so that it can be useful in assessing the economic impacts of IPM research activities throughout the world. This chapter consists of four main components. First, it traces, step by step, the general structure of the framework, then it articulates the theoretical justification behind some of the methods used, and it details the structure of the economic surplus model. Second, the discussion focuses on the computing methods used to perform the economic surplus model. It points out each method's merits and shortcomings. Third, an introduction to sensitivity analysis is presented to address uncertainties in the results. The final section discusses communication of results, and also briefly charts the course followed in Chapter four.

3.2 Analytical framework

This section integrates the definitions and concepts discussed in the first two chapters into a framework for analyzing linkages among generation, dissemination, and adoption of IPM technologies. It shows how important or critical it is to assess “economic benefits” of technologies in order to justify research costs. The exercise of building this framework provides the opportunity to review some common approaches to impact assessment and the different methods used in conducting economic evaluations of IPM technologies. Variations in approaches and methods are related to differences in research objectives and outputs. The framework is designed to provide a structured system for monitoring the progress of IPM CRSP research activities. Figure 3.1 illustrates the process of the framework and lays out the interconnection among each step of the analysis. The first task in the framework is to define the objective of the assessment and to select a commodity and its related IPM technology. Second, the methodology needs to be specified to proceed with data collection and spatial classification. Once these steps are completed, the empirical analysis can be performed using available computational methods. The findings can then be used to prioritize research agendas and facilitate sound decision-making. The following sections will discuss each step in detail.

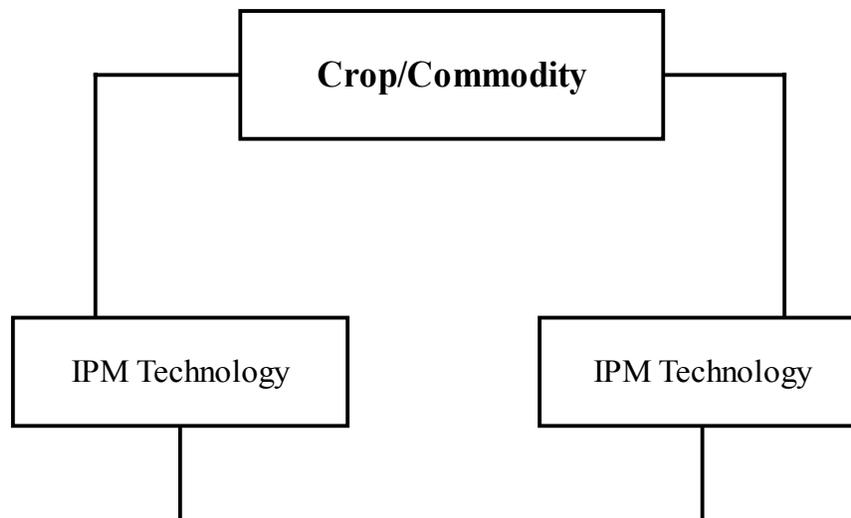
Figure 3.1. Flowchart of the Framework



3.2.1. Identification and Definition of Commodities and Technologies

The first requirement is to identify the commodity in question and establish the objectives of the proposed technology to be evaluated on the basis of location and time. This requires discussions among researchers, extension agents, decision makers and socio-economists. The discussions serve to define, at least as a first approximation, the relevant kinds of IPM technologies available for a given commodity. Figure 3.2 lays the framework on how a commodity is defined as it relates to its respective IPM technology. The aim at this level is to establish the cornerstone of the whole analysis by providing a concise statement about the commodity and the technology in question.

Figure 3.2. Step one: Identification of Crop and Technology

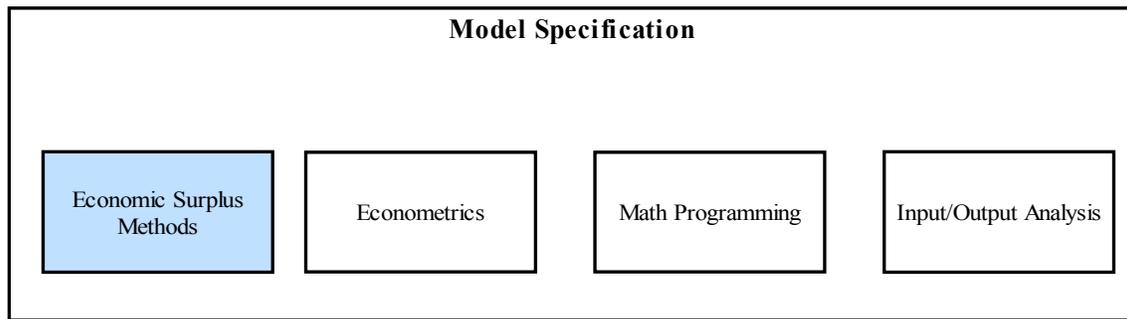


3.2.2. Model Specification

Selection of a methodology is made on the basis of the objectives, scale and intensity of the evaluation. Chapter 2 has already mentioned the different methodologies used in assessing research benefits. Figure 3.3 illustrates the available methodologies that can be used alone or in combination to perform the

impact assessment activity: economic surplus methods, econometrics, math programming, and input-output analysis. Now we can specify models or procedures that can meet the objectives set in conducting the evaluation. The specified model will evaluate the economic feasibility of IPM CRSP induced IPM technologies. Economic Surplus method, briefly discussed in the previous section, will be used to assess selected IPM strategies.

Figure 3.3. Step three: Model Specification

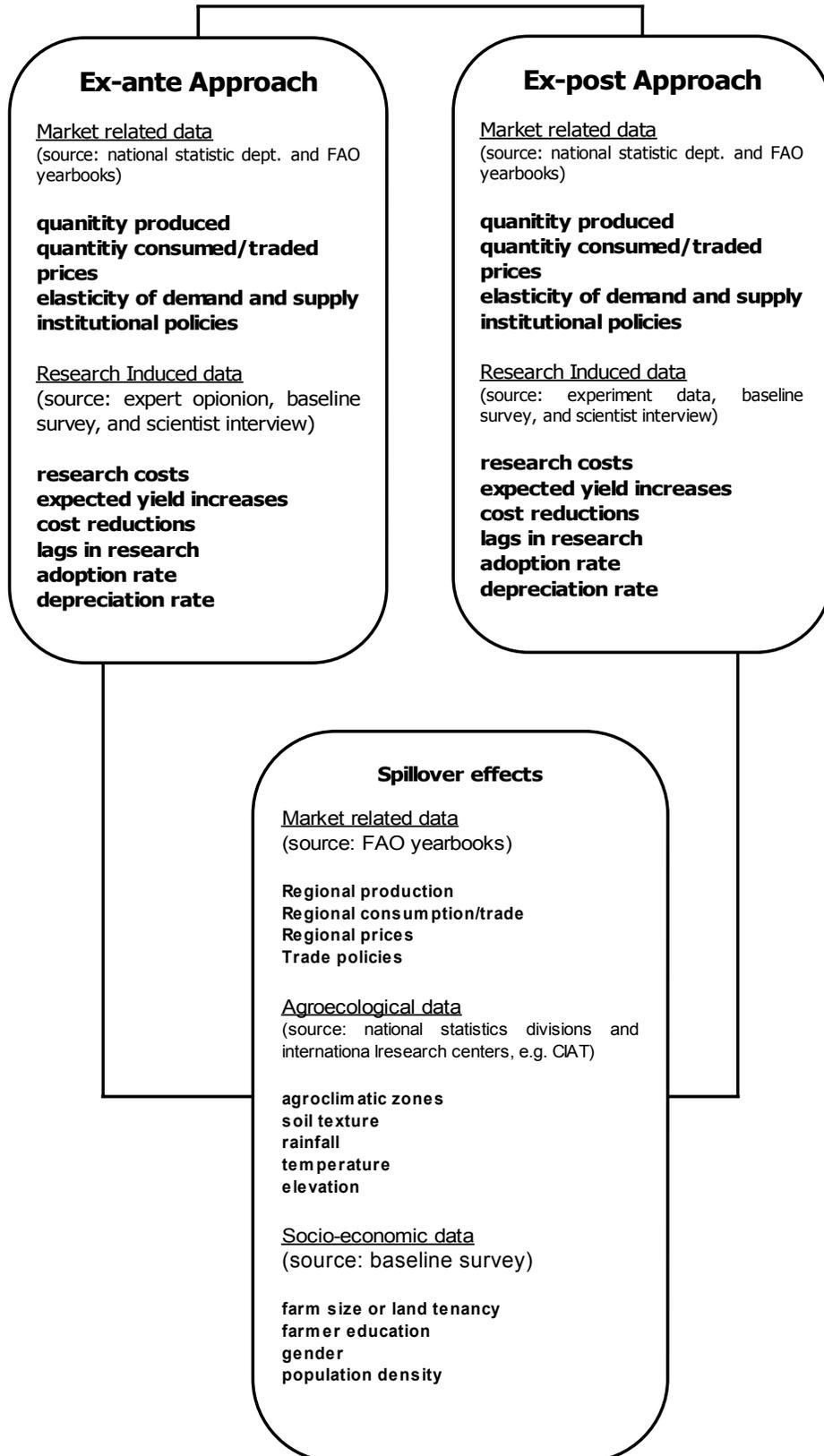


3.2.3. Collection of Data and Information

This section briefly explains how quantitative data from various sources and the subjective opinions of IPM program scientists were used in estimating benefits. Most of the studies mentioned in the literature review used ex-post data to evaluate the impact of IPM programs. Such data are not available to evaluate IPM CRSP activities in view of the fact that most of the technologies developed are at the experiment level (with the exception of Longe-1 variety in Uganda), that is the farmers have not adopted them yet. Since the research is an aggregate level ex ante study, the researcher, therefore, has resorted to the use of secondary and experiment data as well as expert opinions on potential

technology adoption. Figure 3.4 outlines the specific data requirements for ex-ante and ex-post approaches. The next four sections define each set of data requirements and their respective sources.

Figure 3.4. Step four: Data Collection



3.2.2.1 Market Related Data

The economic surplus model outlined in this study requires data on production and consumption, prices, and the price elasticities of supply and demand. Price elasticities influence whether the flow of benefits from a given technical change will be realized as a producer surplus or consumer surplus. Due to the ex-ante nature of this study, production and price data for only a few years back are needed as a benchmark. Though detailed market-related data are needed for most studies employing the ESA model, data on exports and imports, and exchange rates are ignored because most of the commodities in this study are not traded across national boundaries except maize. However, inter-regional trade within the country is taken into consideration to assess the technology spillover effects across agro ecological zones. Also, a discount rate is needed for calculating benefits and cost over time.

3.2.2.2. Research-Induced Data

Economic surplus and benefit-cost analyses of research requires information related to production costs that change due to research. Although historical data on these costs are fundamental for doing an ex-post analysis, they are also useful in establishing a benchmark for an ex-ante analysis (Alston et al, 1995). Scientists conducting the research provided detailed cost of production data from partial budget analysis of their experiments. Research cost data are also needed such as labor and material costs collected from IPM CRSP annual budget allocation and working plans. Researchers' salary was also incorporated.

3.2.2.3.Spatial Data

Spatial data such as agro-ecological zones, soil topography, land elevation, climate, and socio-economic characteristics were collected from the GIS section of the Bangladesh Agricultural Research Council (BARC) in Bangladesh, and from the CIAT office in Uganda. Some of the data needed to perform the spatial analysis did not come in a format suitable for our objectives. Though GIS analysis is not recent phenomenon, Bangladesh and Uganda still lack reliable digital data sets. Therefore, the study is expected to complement the growing usage of GIS for conducting socio-economic research in pest management in these countries.

3.2.2.4.Adoption Questionnaires

Questionnaires were formulated to project patterns of the adoption of a technology in question where no previous information is available. The questionnaires also were aimed at eliciting specific information on changes in production and in cost due to the introduction of longe-1 maize variety and seed dressing for bean in Uganda, and the use of hand weeding for cabbage and Neem Leaf powder for Brinjal cultivation in Bangladesh. Data such as expected yield increase, percentage reduction in cost, success rate of research, when the technology will be available and expected adoption and depreciation rates were collected. The sets of questionnaires asked five basic questions: research lag, expected yield or cost change, success, technology adoption, and research depreciation.

3.2.3. Spatial Analysis: GIS

IPM technologies have a measurable impact when the beneficiaries gain from the outputs generated from a research project. It is important to recognize that farmers will only adopt technologies that suit their needs and circumstances, be they technical, social, economic, and agro-ecological (Mack, 1997). Past research on adoption has given considerable importance to these factors, which are outlined in greater detail below. These factors have been crucial to the development of analytical techniques for studying adoption at the farm and aggregate level. To fully realize the economic impact of IPM CRSP research activities, a way to map adoption patterns of a given technology on a regional basis, and a way to correlate these patterns with the economic impact results is needed. The power of a GIS resides in its ability to associate locations and characteristics, and its ability to cross-reference different types of spatial information (Gerland, 1996). The researcher needs both of these abilities in this endeavor. Figure 3.5 outlines the three main factors (agro-ecological, socioeconomic, and institutional) in mapping out spatial dimension of adoption patterns. Below, these factors are discussed in brief. Note that not all of the factors discussed are included in this study's analysis. Some of them are given for informational purposes only.

Agro-ecological Factors

Effective agricultural research and development requires good delineation and definition of zones according to agricultural, as well as climatic characteristics.

This section describes the AEZ maps of Bangladesh and Uganda that were built by superimposing successive layers of information about the environment, which are relevant to assessment of agricultural potentials and land management. The following four-layer information was used for defining and delineating the agro-ecological regions: physiography, soil, inundation information, and agro climate. A total of 30 agro-ecological zones were recognized in Bangladesh on the basis of physiography, 88 sub regions on the basis of soil and inundation status of land, and 535 agro-ecological units on the basis of agro-climatic subdivisions (FAO, 1997). A total of 33 agro-ecological zones were delineated and defined for Uganda (Wortmann and Eledu, 1999).

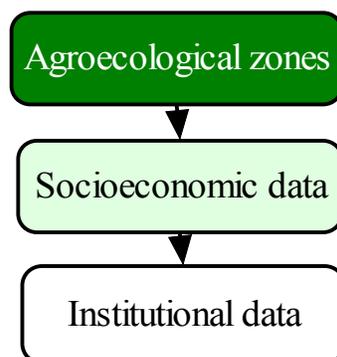
Socio-economic Factors

Aside from agro-ecological factors, socioeconomic factors play a vital role in targeting farmers who are most likely to adopt new technologies. First, a farmer, with age, can become more risk-averse to new technology. Second, large households will be able to provide the labor that might be required by improved technologies. Third, exposure to education will increase the farmer's ability to obtain, process, and use information relevant to the adoption of new technologies. Fourth, farm size is an indicator of wealth and perhaps a proxy for social status and influence within a community. The relationship of farm size and technology adoption is conditioned by such factors as fixed adoption cost, risk preferences, human capital, credit constraints, labor requirements, and land tenure arrangements (Feder et al., 1985)

Institutional factors

Awareness of the profitability or potential preferential benefits of new technologies is necessary to trigger the diffusion of an agricultural innovation. However, for the adoption process to be sustained, the new technology must be compatible with farmers' economic resources and supported by institutions responsible for providing inputs and technical advice. For instance, farmers who have access to credit can relax their financial constraints, and in some cases, access to credit is tied to a particular technological package. Also, agricultural extension services are the major source of agricultural information. Extension visits, attendance at on-farm demonstrations, exposure to mass media are some proxies of awareness of new innovations (Mack, 1997). Therefore, institutions need to facilitate policies that are sound and viable in order for technologies to be fully adopted.

Figure 3.5. Step five: Spatial classification



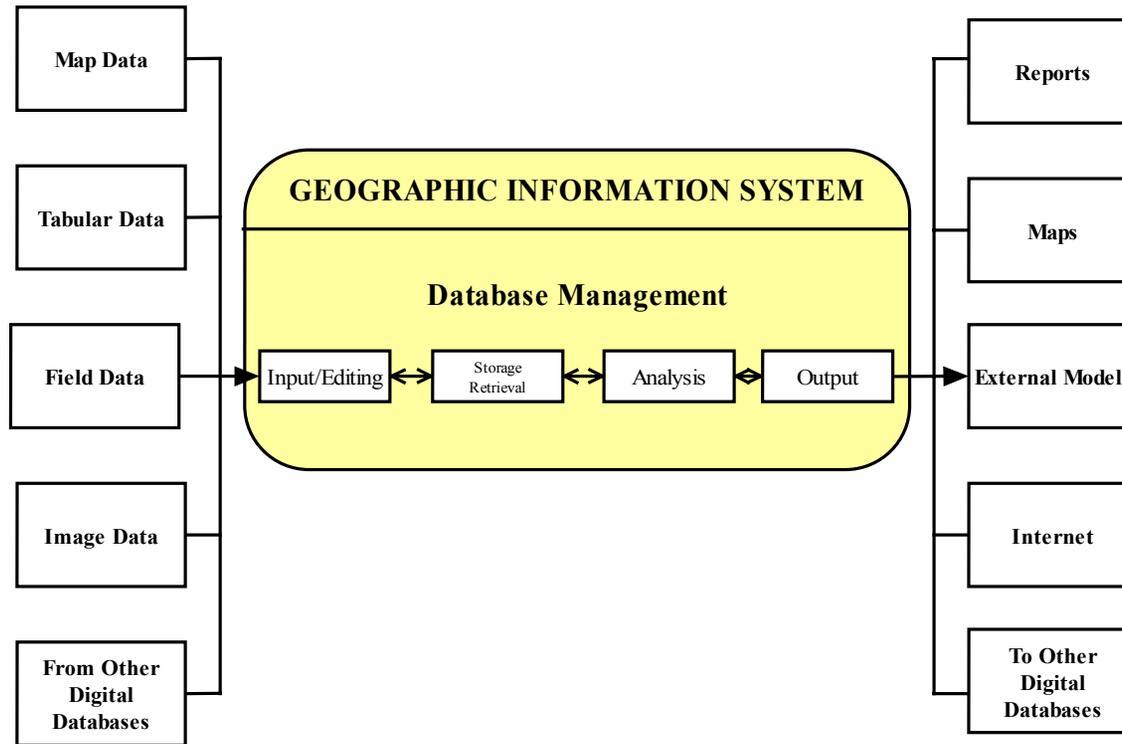
GIS Procedures

The approach presented here is adopted from Hassen et al (1997). It emphasizes the importance of socio-economic factors to the spatial framework.

GIS is defined as an organized collection of computer hardware, software, geographic data, and personnel designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information (ESRI, 1994). GIS procedures should be viewed as a complementary methodology capable of extending and enhancing current economic analysis and findings.

Different forms of analysis are available to correlate spatial and socio-economic analysis. There are also numerous computer software packages that handle such kinds of analysis. The GIS software packages used in this study are the basic Arc View GIS and A.C.T. (Almanac Characterization Tool). Figure 3.6 outlines the GIS process from data tabulation to map outputs.

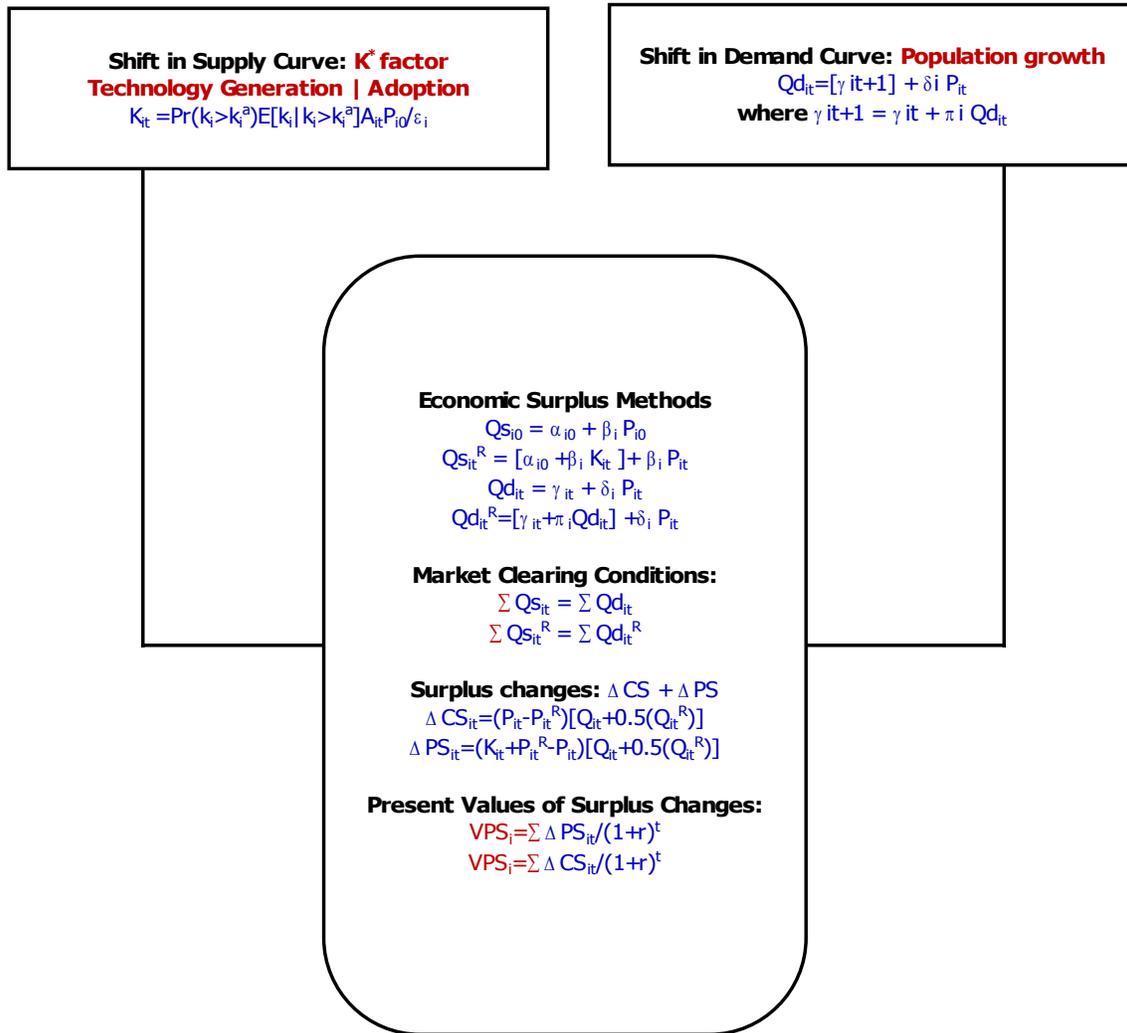
Figure 3.6: Step six: Spatial analysis



3.2.4. Estimation Procedure

Most economic impact assessment studies use an ex-post analysis in conducting such research. In this study, however, an ex-ante approach of economic surplus method will be adopted to project future benefits of IPM CRSP research activities in Bangladesh's vegetable system and Uganda's bean and maize production. Questionnaires were developed to elicit information on changes in production and in cost due to the introduction of new technologies and also to assess patterns of adoption for these technologies. The study relies on mostly secondary data, which were provided by the Bangladesh Bureau of Statistics and Bangladesh Agricultural Research Council in Bangladesh; and by the National Agricultural Research Organization and the Department of Statistics and Planning of the Ministry of Agriculture in Uganda. The primary information/data collected on site help supplement the theoretical model. Figure 3.7 presents the sequential empirical formulas used to perform the analysis.

Figure 3.7. Step Seven: Empirical analysis



The Basic Model

The study examines the benefits of selected IPM CRSP strategies to Bangladesh's vegetable farming system and Uganda's bean/maize production system using the ex-ante economic surplus technique. The basic model can be used for any commodity and for any locality. The model (technique) comprises three components: (1) *the capacity of IPM technologies to shift the supply curve*, (2) *the change in consumer and producer surplus due to the supply shift*, and (3) *the transferability of these IPM technologies inter- and intra-regionally*. Prior to spelling out the details of the model, it is essential to point out the underlying assumptions in the model.

The model assumes that the supply and demand curves are linear and shift in a parallel fashion as a result of research-induced technical changes. Dynamic modeling is ignored and instead a succession of single-period models is used. Moreover, competitive market clearing is imposed and welfare changes are manifested through consumer/producer surplus measures. Figure 3.8 illustrates the basic model used as a foundation for this study.

The linear demand and supply curves are expressed:

$$\text{Supply: } Q_s = \beta + \beta(P + K)$$

$$\text{Demand } Q_d = \alpha + \alpha P$$

S_0 and D_0 depict the supply and demand curves prior to the technological change. The original price and quantity are P_0 and Q_0 . As the technology change is adopted, the supply curve shifts to S_1 , inducing changes in price and quantity:

P_1 and Q_1 . Due to adoption of the technological change, there is also a welfare change. The area P_0CDP_1 depicts the change in consumers' surplus, and the area $BDP_1 - ABP_0$, represents the change in producer surplus. Calculating consumer and producer surplus provides an assessment of economic benefits. The surplus models taken from Alston *et al.* (1995) are as follows:

1. $\Delta CS_t = P_0 Q_0 Z (1+0.5Z\eta)$
2. $\Delta PS_t = P_0 Q_0 (K-Z)(1+0.5Z\eta)$
3. $\Delta TS_t = P_0 Q_0 K (1+0.5Z\eta)$

Where, ΔCS =change in consumer surplus in time period t

ΔPS =change in producer surplus in time period t

ΔTS =change in total surplus in time period t

K =per unit cost reduction due to technological change

$Z = \epsilon\eta / (\epsilon + \eta)$ where ϵ and η are price elasticity of demand and supply.

Net Present Value (NPV) will be estimated using the total surplus and the research expenditure to assess the benefits.

$$NPV = \sum (\Delta TS_t - RC_t) / (1 + r)^t$$

Various refinements can be made to the model to take into account different factors affecting supply and demand depending on the commodity or technology being analyzed.

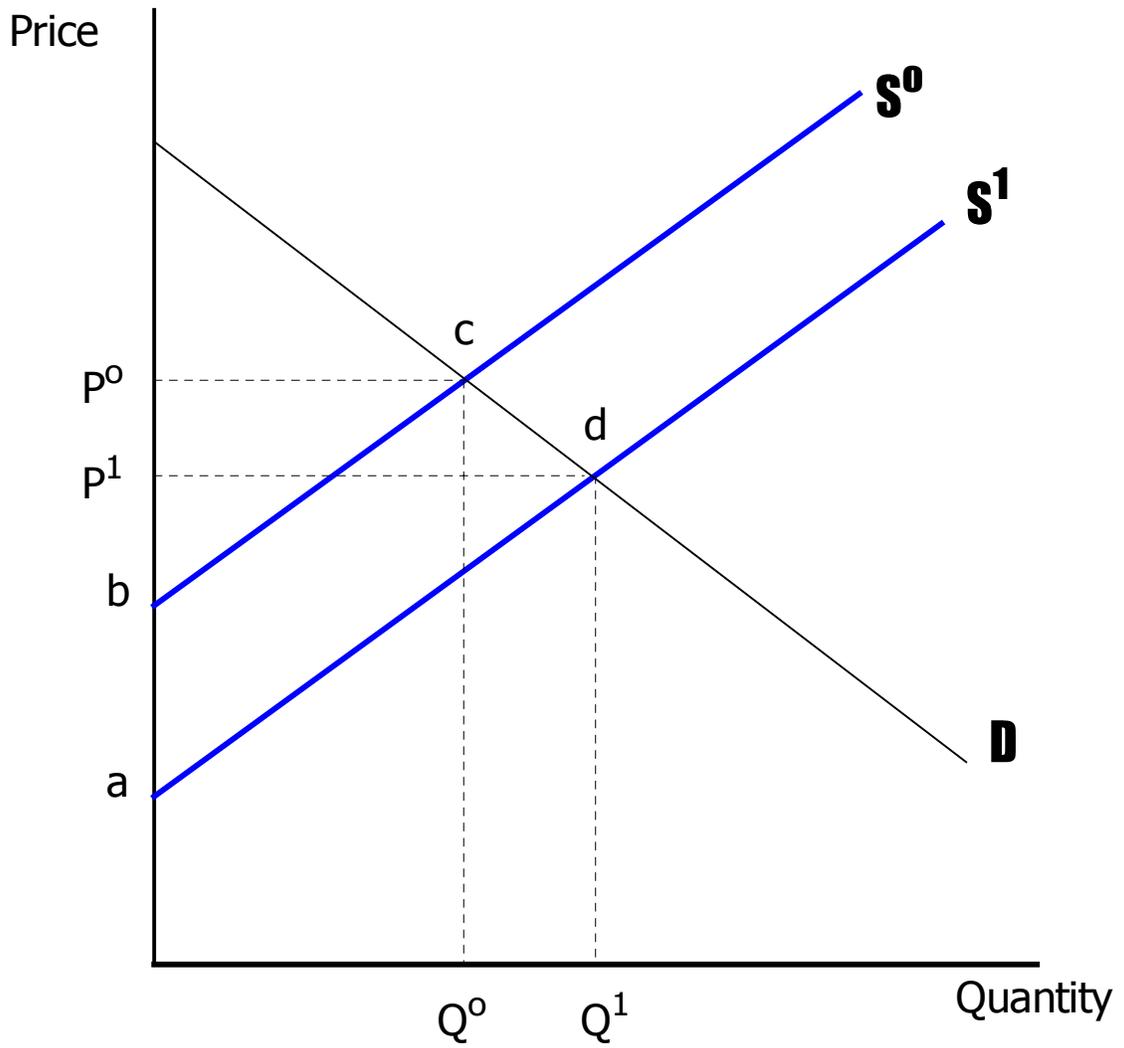


Figure 3.8: Basic Economic Surplus Model for Non-traded commodity

Research Model

The closed economy model represented in the previous section can be modified in several aspects in order to fit the actual realities of our study areas: Bangladesh and Uganda. A refinement can be added to the basic closed economy model to incorporate exogenous shifts in the demand curve and the possibility of technology spillovers across regions.

$$\text{Supply: } Q_s = \alpha_{it} + \beta_i P_{i,t}^s$$

$$\text{Demand } Q_d = \gamma_{it} + \delta_i P_{i,t}^d$$

Where P^s and P^d is the producer (supply) and the consumer (demand) prices in each region, i at a given year, t , respectively. The slopes are assumed to be constant for each region for all time periods. For our analysis, we use an aggregated demand function for each country, instead of each region within the country. This assumption was due to lack of sufficient consumption data for each given agro-production region.

$$\text{Demand } Q_d = \gamma_t + \delta_i P_t^d$$

The production effects of agricultural research are generally realized over several years. Thus, changes in demand, which occurs due to changes in population and income over time, would substantially affect the market of non-traded commodities (Mills, 1998). Economic indicators show that both Bangladesh (5.7%) and Uganda (5.6%) has been experiencing a moderate rate of

GDP growth over the past five years (1994-1999). Furthermore, population growth is another important factor that needs much scrutiny.

$$\alpha_{it} = \alpha_{it-1} + V^s_i Q^s_{i,t} \text{ for } t > 0$$

$$\gamma_{it} = \gamma_{it-1} + V^d_i Q^d_{i,t} \text{ for } t > 0$$

where V^s_i and V^d_i are the growth rate of supply (productivity) and the growth of demand (population and income growth) in each region, i , respectively.

Furthermore, the basic model refers strictly to the case of a homogenous product being sold in a single market. As it is one of the purposes of this study to investigate the possibility of technology spillovers over regional (agro-ecological) areas, we need to consider a multiple markets model to capture the benefits of IPM technology beyond the primary (experiment) sites. In that case, the refined model is outlined below. The refinement of the basic model is adopted from Mills (1997) and Alston *et al.* (1995):

Let zone i be the innovator of the technology in question. The zone specific expected unit cost reduction from the technology, K_{it} :

$$K_{it} = \Pr(k_i > k_i^a) E[k_i | k_i > k_i^a] A_{it} P_{i0} / \varepsilon_i$$

Where;

$\Pr(k_i > k_i^a)$ = probability of success if the research is successful and the results are fully adopted;

$E[k_i | k_i > k_i^a]$ = the expected net yield gain (conditional upon the dissemination threshold being exceeded);

A_{it} = the expected adoption rate for the period

P_{s10} = the initial unit price of the commodity; and

ϵ_I = supply elasticity for the zone.

Information pertaining to the adoption and depreciation of the given technology lies in the heart of determining the actual supply shift in each zone. Therefore, it is essential to include an assessment of the probable zone-specific adoption pattern. Figure 3.9 shows a generic adoption profile. Several basic characteristics of the profile are identified in the figure:

λ_R = research development lag in years

λ_A = adoption lag (the initially increasing adoption rate to maximum adoption)

λ_M = maximum lag (the adoption plateau)

λ_D = depreciation lag (declining adoption as the technology becomes obsolete)

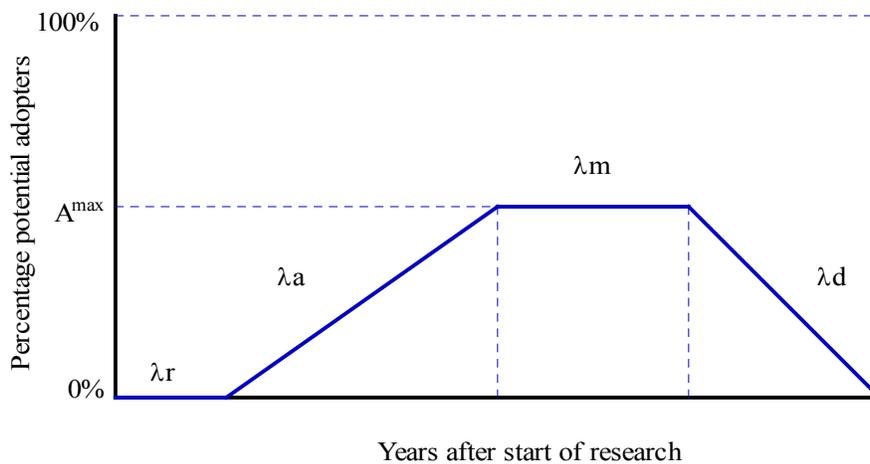


Figure 3.9 Basic Trapezoidal adoption profile

Research-induced changes in producer and consumer surplus are easily calculated from equilibrium quantities and prices for the “with” and “without”

research scenarios. The change in consumer and producer surpluses in zone i at time t are calculated as:

$$\Delta PS_{it} = (K_{it} + P^{s'it} - P^{s_{it}}) [Q^{s'it} + 0.5(Q^{s'it} - Q^{s_{it}})]$$

$$\Delta CS_{it} = (P^{d_{it}} - P^{d'it})[Q^{d_{it}} + 0.5(Q^{d'it} - Q^{d_{it}})]$$

$$\Delta TS_{it} = \sum_i \Delta PS_{it} + \sum_i \Delta CS_{it}$$

Now we need to consider spillover of technologies across regions where we defined them using information on agro-ecological zones. In our analysis, we assume that spillover coefficients are one among agro-production zones within a country. The spillover effects from zone i to other zones, j , are parameterized in relation to the supply shifts in region i .

Thus, $K_{j,t} = \pi_{ji} K_{i,t}$ for all i and j

Where

π_{ji} = supply shift in j due to technology-induced supply shift in i ($\pi_{ji} = 1$) and, hence, $K_{j,t} = K_j A_{j,t}$, where $A_{j,t}$ is the adoption rate in region j in year t .

The welfare distribution in zones, j , due to the spillover of technology from zone, i , is similar to the corresponding effects to zones, i . Thus far, the research has described the working model to assess the economic impact of IPM research on a nation's economy and to project the potential spillover effects across agro-ecological zones within a nation. Figure 3.10 illustrates the spillover effects of IPM technologies given inter-regional trade. Notice that the research-induced supply shift in the innovating region (AEZ i) causes the regional price to fall.

Measures of Benefit

The only remaining task is to aggregate those surplus estimates into summary measures of IPM research benefits. Two important factors need to be defined in order to perform such a task. The real discount rate must be obtained, and a relevant span of time needs to be defined. For this study, a real discount rate of 5% and a span of 30 years are selected as parameters to calculate present values of surplus changes. The zone-specific present values for the stream of changes in producer and consumer surplus (VPS and VCS) are:

$$VPS_i = \sum_{t=0}^{30} \Delta PS_{it} / (1+r)^t$$

$$VCS_i = \sum_{t=0}^{30} \Delta CS_{it} / (1+r)^t$$

All the information on benefits and costs must be collected and aggregated on an annual basis over the lifetime of the technology to determine the annual streams of costs and benefits. Then, a project's economic benefit can be assessed and a comparison made between alternative projects.

Two types of decision rules are commonly used: the net present value (NPV) and the internal rate of return (IRR). Both depend on similar information - the generation of benefits and costs associated with the technology over the appropriate time horizon.

Net present value (NPV) is the general formula used to determine the viability of a project. It computes present value by discounting a set of benefits and costs that occur through time back to the beginning of the base year ($t=0$).

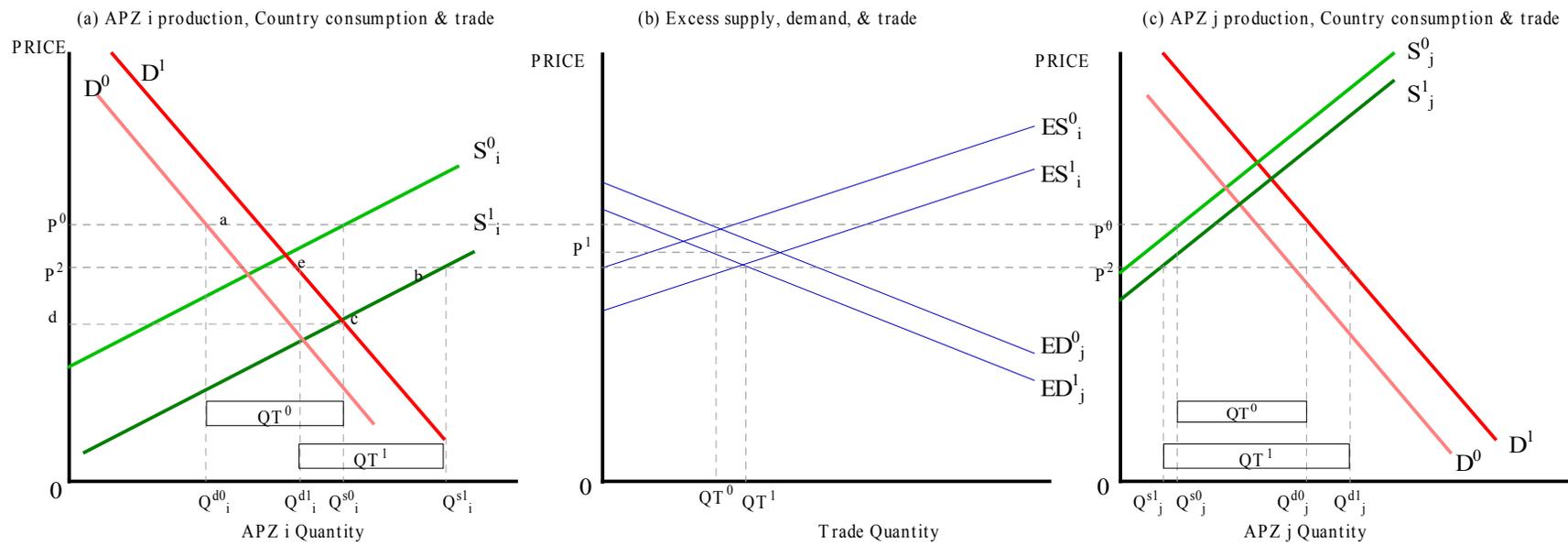
Two equivalent formulas may be used:

$$NPV = \sum_{t=1}^n \frac{(B_t - C_t)}{(1+r)^t} \quad \text{or} \quad NPV = \sum_{t=1}^n \frac{B_t}{(1+r)^t} \div \sum_{t=1}^n \frac{C_t}{(1+r)^t}$$

The internal rate of return (IRR) is defined as the rate of return that equates the present value of the expected flow of expenditures in the development, implementation, and maintenance of technology and the present value of the expected flow of benefits. These measures of benefit were calculated for each research and commodity and aggregated by agro production zones.

$$IRR = \sum_{t=1}^n \frac{(B_t - C_t)}{(1+r)^t} = 0 \quad \text{or} \quad IRR = \sum_{t=1}^n \frac{B_t}{(1+r)^t} = \sum_{t=1}^n \frac{C_t}{(1+r)^t}$$

Figure 3.10 Size and distribution of research benefits for internally traded goods across agro-production zones (exporter innovates, with technology spillovers, exogenous demand shift)



3.3 Computing Methods

This section discusses the computer programs that can be used to conduct economic surplus analysis. It provides an overview of the various methodologies incorporated in the programs, their strengths and weaknesses, as well as shows the site-specific information that was used to simulate typical farming conditions in Bangladesh and Uganda. The economic analysis is the core component of the framework. It seeks to provide some measure of the potential economic impact of the IPM strategies that maximize net returns (economic surplus) to the farmer and consumer. The analysis will accomplish this task by evaluating selected IPM technologies and providing a quantitative assessment of the potential impact that each strategy has on the local economy. Two approaches can be taken in computing the research benefits of the IPM CRSP: spreadsheet or Dynamic Research EvaluAtion Management (DREAM).

An EXCEL spreadsheet approach: The spreadsheet approach is useful for relatively simple analysis. A basic model on EXCEL has been set up for this thesis that can be adopted to do other assessments. The model is borrowed from a similar study done by Mills (1998). Anyone with limited computer knowledge can construct a spreadsheet model. Some limitations of this approach should also be kept in mind. It is difficult with this approach to incorporate multimarket spillovers. Nevertheless, while specific IPM impact studies could obtain potentially more precise results from comprehensive and dynamic models, overall the spreadsheet approach offers a good estimate of economic surplus

induced by IPM research. Furthermore, this approach constitutes a good starting point, especially considering the lack of empirical data for the IPM technologies and crops evaluated in this study.

The *Dream*© approach: *Dream*© is a computer program that was developed by the International Food Policy Research Institute (IFPRI) for research on priority setting and evaluation. The program was designed in parallel to the publication of *Science Under Scarcity* (Alston et. al., 1995), which is this study's core modeling reference. Thus, the program utilizes approaches that are fairly well established in the book. Unlike a spreadsheet, *Dream*© easily incorporates research spillover effects. As a result the *Dream*© approach gives a more comprehensive illustration in determining benefits of research or technology when multiple markets are involved (Alston et al., 1995).

As with a spreadsheet approach, *Dream*© also poses some limitations regarding the accuracy and specificity of measurements. *Dream*© is an unconfigurable computer program that is designed for general purposes. Such paradigms tend to generalize conditions and may force unwarranted assumptions into the procedure (IFPRI, 2000). For example, the program does not include transportation costs (Alston et al., 1995). The program has undergone several modifications since its inception. Despite its drawbacks, *Dream*©, relative to the spreadsheet, does a good job of giving comprehensive results when multiple markets are involved. A copy of the latest program can be obtained on IFPRI's website at www.ifpri.org/dream.htm.

3.4. Sensitivity Analysis

Because economic evaluation is a predictive tool, it is difficult to determine accurately what a technology's benefits and costs will be in the future. Sometimes, due to time and money constraints, it will not be possible to gather sufficient data and evaluations will be based on data not directly applicable to the technology or on information rooted in judgments. Alternatively, there simply may not be enough knowledge to make an accurate predictive assessment. Future values are difficult to predict and there will always be some uncertainty about the analysis results (Qaim, 1999). The effects of different values should be investigated. One useful and simple way of gaining insight into the impact of uncertain outcomes is a sensitivity analysis.

A Sensitivity Analysis is the comparison of outputs from a model, given certain changes in model structure or model input. It aims to ascertain how the model depends upon the information fed into it, upon its structure and upon the framing assumptions made to build it (Qaim, 1999). This information can be invaluable, as

- Different level of acceptance (by the decision-makers and stakeholders) may be attached to different types of uncertainty.
- Different uncertainties impact differently on the reliability, the robustness and the efficiency of the model and the overall framework.

Sensitivity analysis involves changing the value of one or more selected variables and calculating the resulting change in the NPV or IRR. The extent of

change in the selected variable to test can be derived from post evaluation and other studies of similar projects. Changes in variables can be assessed one at a time to identify the key variables. Possible combinations can also be assessed. Sensitivity analysis should be applied to project items that are numerically large or for which there is considerable uncertainty. To facilitate mitigating action, variation should be applied separately to underlying variables, not just to aggregate values.

Where the results are shown to be sensitive to the value of a variable that is uncertain, mitigating actions should be considered. This can include more investment in reliable information or redesigning questionnaire formats and methods to obtain accurate responses from researchers. Where there is exceptional uncertainty, the model itself may have to be redesigned or implemented.

3.5. Communication of Findings

Economic impact assessment plays an important role in both identifying the highest payoff pest management practices and in the creation of a consensus on research priorities. Communicating the economic implications of management practices under consideration is important throughout the planning process. In the early stages of research planning, preliminary partial budget assessment of proposed IPM technologies will assist planners and researchers in developing feasible management practices. Once the management scenarios

have been defined, more in-depth economic assessment is carried out to assist decision makers reach a consensus in priority setting of research. Once a consensus has been determined, further economic assessment will help to identify expected impacts and implications for the planning area and the country as a whole.

To be useful to the planning process, the economic implications of pest management practices must be clearly communicated. The documentation and evaluation of IPM strategies will generate considerable information for prioritizing IPM CRSP future research agenda. To communicate this information in a form meaningful for comparison, a matrix summarizing the findings of the assessment can be used. The matrix should include the benefits, costs, and key trade-offs of each pest management practices. This information will indicate how scenarios could be modified to mitigate their costs relative to other practice. Moreover, the uncertainty associated with the findings should also be documented using sensitivity analysis, as it may indicate the need for caution in the selection of a preferred pest management technology, or the need for further analysis of the strategies before a decision can properly be reached.

3.6. Conclusions

In such a complex area as the development of programs to promote generation and dissemination of IPM technologies, it is essential to have a sound conceptual framework to use as the basis for evaluation and planning. This framework has been absent in the IPM CRSP. This study has attempted to fill

this gap, basing the framework on the view that economic impact assessments are primary sources of information and that this information has value primarily as an input to decision making. The next chapter provides a detailed discussion of the results generated by the economic impact analysis. At present the link between these two parts will be briefly outlined. The economic surplus model will be used to evaluate the aggregate economic impacts of IPM CRSP induced IPM technologies in Bangladesh and Uganda. Four case studies - Neem leaf powder to control soil-borne disease in Brinjal cultivation & altered hand weeding for weed control in cabbage production from Bangladesh, and Seed dressing for beans and maize streak virus resistant Longe-1 variety for maize from Uganda - will be evaluated.