

Alternatives to Slash-and-Burn

Working Group on Economic and Social Indicators: Report on Methods for the ASB Matrix

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INTRODUCTION{tc \l1 "INTRODUCTION}

A technical workshop was convened in Rio Branco, Acre, Brazil over the period March 18th through March 25th, 1997, in order to more clearly define the objectives of socioeconomic or social science and policy research associated with Phase II of the GEF-funded Alternatives to Slash-and-Burn Agriculture (ASB) research program, and to discuss in detail the analytical methods and fieldwork required to meet these objectives, both within and across the three ASB sites represented at the meeting — Brazil, Indonesia, and Cameroon.

More specifically, there were two primary and two secondary objectives proposed for this workshop. The primary objectives were:

- 1) Fill in the socioeconomic 'cells' (socioeconomic issue X best bet technology) of the ASB Best Bets matrix (as identified at the most recent GSG meeting, with columns pertaining to international externalities as well as small farmer adoptability) for Brazil, Cameroon, and Indonesia, which implies, in the context (socioeconomic/biophysical reality X work to date) of each site.^{1, 2} This would involve:
 - 1) clarifying the meaning of each of the rows and columns (and the cells) of the ASB best bet matrix, making modifications to all, as needed;
 - b) evaluating the analytical methods proposed for filling in the cells of the matrix;
 - 3) reviewing the results of preliminary empirical research (if any) aimed at filling in the cells; and
 - d) checking for cross 'row' (best bet), within-site comparability.
- 2) Synthesize across ASB sites, which implies:
 - 1) assessing the extent to which the methods and expected results will allow for comparability across sites as regards the role of socioeconomic factors (individually, or in groups) in influencing farmers' adoptions of (and consequently the selection by ASB of) best bet technologies; and
 - 2) establishing and setting in motion a plan for improving cross-site synthesis on this issue.

¹For a discussion of policy analysis matrices and their usefulness in policy research see: Monke, E. A. and S. R. Pearson, 1989. *The policy analysis matrix for agricultural development*. Cornell Univ Press, Ithaca, NY.

²For a general discussion of the ASB Best Bet matrix see: Tomich, T., M. van Noordwijk, S. A. Vosti, and J. Witcover. 1998. Agricultural development *with* rainforest conservation: Methods for seeking *best bet* alternatives to slash-and-burn, with applications to Brazil and Indonesia. *Agricultural Economics* 1315 (1998).

Secondary objectives were:

- 1) discuss the links between the socioeconomic rows and cells in the ASB matrix with the biophysical rows and cells (GEF priorities and agricultural sustainability), in the context of each site; and
- 2) discuss the possible policy implications of our findings.

A follow-up meeting was held on February 9-13, 1998 in Mombasa, Kenya, at which the issues raised in the first workshop were reviewed, and changes to the matrices were made.

**MATRICES FOR BEST BET EVALUATION AND TECHNICAL NOTES:
SOCIOECONOMIC ISSUES**

General Best Bet Matrix for Evaluating Land Use Systems
as Potential Best Bets for
Alternatives to Slash-and-Burn Agriculture at Forest Margins

This matrix is derived from the matrix adopted by ASB at the 1996 Global Steering Group meeting, and contains modifications to that original matrix, all relevant for social science and policy research. In some cases, the decisions taken here on the format of the matrix to answer the socioeconomic issues may have implications for how the global environmental concerns and agronomic concerns cells are measured and reported. Efforts to lay out all those implications and resolve them, though, lie beyond the scope of this document.

First, the title here does not reflect that this conceptual framework is flexible enough to be applied to both land use systems and production activities (which are seen as parts of land use systems, and the focus of much of ASB technology development efforts). Rather, it reflects the focus of the ASB Best Bet evaluation exercise on land use systems, and highlights that many of its intended by-products for the measurement of global environmental concerns as well as adoption stand out most clearly in this context. Moreover, the framework is set up to evaluate any land use system described by the user (there may be some land use systems that aren't potential Best Bets, but may be useful to compare against potential Best Bets).^{3, 4}

Second, the scale of operation of each system (that is, the scale at which farmers would normally deploy such systems) has been added as a descriptive column to highlight differences across potential ASB Best Bets as regards scale (and hence, perhaps, adoptability by small-scale farmers). Moreover, as will be seen in the explanatory notes, issues linked to the scale of operation at which given systems can be evaluated for the purposes of the ASB matrix are paramount. While scale of operation can differ by land use system, scale of reporting needs to be constant within sites (for all systems evaluated). Differences across sites in scale of reporting are possible, but less desirable than a common scale of reporting. The relevant time period for evaluation of each system is another important problem. Conclusions regarding ways of

³For a discussion of land use systems in tropical areas, see Ruthenberg, H. 1980. *Farming systems in the tropics*. Oxford: Clarendon Press.

⁴For a general discussion of agricultural production systems in developing countries see: Timmer, C. Peter, W. P. Falcon, S. R. Pearson. *Food policy analysis*. 1983. Published for the World Bank [by] The Johns Hopkins University Press, Baltimore, MD

'normalizing' for within-site, across system differences in scale of operation and length of system 'cycle', depending on the parameter under evaluation, appear in the technical notes to the matrices.

Third, the perspective towards agronomic sustainability, socioeconomic concerns, and institutional requirements vis-a-vis technology adoption was generally taken to be that of small farmers.⁵ For some sites, such as Cameroon, this was not perceived to be an important narrowing of actors. For other sites, such as Brazil with its three key sets of actors responsible for land use and forest conversion decisions — small farmers, large farm enterprises, and extractivists — and Indonesia, with logging companies and large scale plantations as "actors" alongside the small farmer, this narrowing of focus would be quite important. In Indonesia, in particular, the actors implied in the description of some land use systems go beyond the smallholder, even though effects on smallholders may be highlighted in text and/or gleaned from institutional matrices.

Fourth, agronomic sustainability is assessed at plot level, thereby precluding any research on local externalities (positive or negative) generated by ASB *Best Bet* alternatives. (Note that key international externalities are captured by the Global Environmental Concerns.)

Next, a final column was added to capture institutional requirements associated with land use systems under evaluation, and the extent to which these are already or easily met at the sites, as well as some potential impacts of *Best Bets*. The exact content of this column, and the various institutional needs/availability assessments required to fill it, would be made on the basis of expert interviews.

⁵For discussions of household decisionmaking in rural areas see: Singh, I. J., L. Squire and J. Strauss, eds. 1986. *Agricultural household models: Extensions, applications, and policy*. Washington, D. C.: World Bank; Sadoulet, E., and A. de Janvry. 1994. *Quantitative Development Policy Analysis*. Johns Hopkins University Press, Baltimore, MD.; and Vosti, S. A., and J. Witcover. 1996. Slash-and-burn agriculture — Household perspectives. *Agriculture Ecosystems & Environment* 58 (1996): 23-38;

Finally, there may be some essential elements that, described at each site, lend some important insights into the socioeconomic context that will run through the evaluation of all land use systems evaluated. A list of those essential elements and site-specific descriptions based on them are still pending.

Matrix 1 — Matrix For Evaluating Land Use Systems as Potential *Best Bets* for Alternatives to Slash-and-Burn at Forest Margins (General *Best Bet Matrix*) {tc \11 "Matrix 1 — Matrix For Evaluating Land Use Systems as Potential *Best Bets* for Alternatives to Slash-and-Burn at Forest Margins (General *Best Bet Matrix*) }

Land Use Systems		Global Environmental Concerns				Smallholders' Agronomic Concerns	Smallholders' Socio-Economic Concerns			Institutional Requirements
Description of System	Scale of Operation/ Evaluation	Carbon Stocks	GHG Emissions	Biodiversity		Sustainability (at the plot level)	Profitability	Labor Requirements	Food Security	Institutional Endowments
				Above-ground	Below-ground					

Technical Notes on the General *Best Bet* Matrix{tc \l1 "Technical Notes on the General *Best Bet* Matrix}

I. Rows — Land Use Systems

A. A description of land use systems for evaluation

1. land use systems are understood as well-defined trajectories of land use from a defined point of departure to some end use (perhaps passing through other land uses along the way — the amount of time in each land use is part of the system description)⁶
2. land use systems evaluated initially will have a common land use 'point of departure' in all sites — forest⁷
3. where many *best bets* are not commonly found in farmers' fields (such as in Brazil), or if they are, have not been there long enough to define a complete cycle of definitive land use, more land use systems may need to be evaluated to examine the results of different potential paths; under these circumstances, since direct measurement of the system may be impossible, careful examination of how production activity analysis can be used to generate relevant evaluations must be made
4. actual land use systems to be evaluated will vary across sites
5. the description of the land use system for evaluation implies more than a sequence of land covers over time, but includes:
 - i. a defined scale of operation (and a defined scale of evaluation)
 1. the appropriate scale of operation for land use systems that include rotations within a given plot area will be the entire plot area — for example, for annuals planted on a different 1/4 hectare

⁶For a detailed discussion of definitions of land use systems, agricultural investments and analytical tools for evaluating them see: Gittinger, J. P. 1982. Second Edition. *Economic analysis of agricultural projects*. Johns Hopkins University Press, Baltimore, MD.

⁷There is interest, particularly in some sites, in looking next at degraded lands (such as, in the case of Brazil, degraded pastures) as a point of departure for potential *Best Bet* land use systems.

portion each year within the same one hectare plot (so the same 1/4 hectare is used in year 5 as in year 1), the scale of operation would be one hectare (one way to account for the 3/4 ha. in fallow each year that composes an essential part of the land use system)

2. in all cases, the appropriate unit of reporting is the average hectare in each system. In the example above, then, output in the 1/4 ha. of annual crop production would be 'divided by' the entire 1 ha. plot (1/4 ha. of annual crop land plus 3/4 ha. of fallow land).
1. defined management techniques
 2. a set of "initial conditions" associated with the system and needed for its evaluation, such as land 'type', access to infrastructure, institutional context, basic household characteristics (for example, household labor composition and food security needs)⁸
 3. shifting some initial conditions may drastically alter the measured parameter, others less so; at each site, the effect of variation in some of these initial conditions to the evaluation of land use system may be extremely important to highlight. Reporting techniques to reflect this and precise array of relevant initial conditions may vary by site (and are commented on briefly below)
1. One or more 'best guesses' for likely 'bad bets' will be included as rows in the matrix as a basis for comparison (for example, unsustainable shifting cultivation or degraded grasslands). An advantage of the filled out matrix is that it gives the user flexibility to compare land use systems as relevant for policy action, technology research, or other purpose, and doesn't lock in a comparison vis-a-vis either 'bad bets' or 'pristine forest'.
 - C. Some rows may not be relevant for certain communities or ecological conditions within each ASB benchmark site. For example, in Brazil, the set of candidate *best bets* for Rondônia may not overlap completely with the set for Acre.
 4. Differences across sites (and perhaps especially within sites) in management techniques need to be identified and carefully documented. For example, cacao production in Brazil is not very similar (in terms of management) to cacao production in Cameroon. In some cases, particularly where management practices are known to vary substantially within sites, inclusion of more than one 'row'

⁸Note that a subset of these initial conditions might hold for all the land use systems evaluated in a given site, and as such are really context setters for the matrix as a whole, and need to be identified as such.

(variations on a given system) might be advisable. For example, many definitions of improved pastures in Brazil might exist. If so, multiple 'rows' for improved pasture might be needed in the Brazil matrix.

- E. In all cases, once the 'rows' have been defined, "average" production coefficients will need to be determined and used for evaluating each cell of that row. For example, financial evaluation will require an estimate of the amount of hired labor used for a particular system. This estimate will have to be provided and justified, knowing that use of hired labor can vary due to household characteristics that are independent of the system being evaluated. In a sense, an "archetypical household" will need to be identified, and can vary across systems.

II. Columns — Socioeconomic Concerns

- A. The indicators chosen stem from a micro-based approach to understanding *Best Bets* from smallholders' perspectives; therefore, some of the measures chosen may be irrelevant for largeholder land use systems (for example, large-scale logging or tree crop estates in Indonesia, or large farm enterprises in Brazil).
- 2. Scale of operation differs from one system to another, and needs to be noted in a separate column. Note also that the scale of evaluation need not be equivalent across sites or across systems within sites, but that for reporting purposes the data included in the tables must be 'normalized' in terms of spatial units of observation. For some parameters, the data in the table must also be temporally normalized to allow for cross-row comparisons. That issue is taken up again below.
- C. The agreed-upon unit of spatial observation for reporting will be the hectare. Where possible, units should be reported directly in the matrices to avoid confusion or need to refer extensively to background documentation to interpret matrix figures.
- D. The time scale for assessment used for reporting in the adoption columns will be standardized by replicating 'shorter cycle' systems (where 't' is the length of the system cycle) to make them comparable with 'longer cycle' systems, within a given observation period (labeled "T" from now on).
 - 1. Note that 't' may vary across systems, even within sites.
 - 2. Note that some multiple of 't' must equal "T," which may require adjusting "T."
 - 3. Note that "T" should be the same for all systems at a given site, but may vary across systems.
 - 4. To take an example, "T" (the time frame for system evaluation) will be determined for each site. For systems with cycles (that is, 't's) less than the

site's "T," say, 20 years, replications of system cycles will be done until the sum total of years (multiples of 't's) is equal to "T" (20 years in this example).⁹ So, reaching a 20-year time frame may require replicating system cycles.

5. This need to replicate systems with 't' less than "T" to make some calculations comparable has important implications, especially taking into consideration agronomic knowledge about systems to be "replicated."

⁹For Brazil, T=20 years for all land use systems, except for the cafe/bandarra system for which T=21. For Indonesia, T=25 years for all systems.

- a. If the "agronomic sustainability" column = 1 (given the land 'type' under study) systems will simply be repeated until the multiples of 't' equal "T," the complete evaluation period, with no assumed loss in productivity over time.¹⁰ For example, pasture cycles may run 15 years, but agroforestry systems may run 20 years. In this case, we need to 'replicate' the pasture system 4 times (calculating, for example, NPV for each cycle) and replicate the agroforestry system 3 times in order to get temporally comparable systems. Note that discounting will 'erase' most differences after about year 15. Note also that some statistics do not lend themselves to replication, for example, years to positive cash flow. In this particular case, the first cycle of 't' will be the temporal basis for assessing cash flow patterns, regardless of whether or not these patterns are expected to change with replications of 't.' In other cases, similar judgment calls will have to be made, and documented.
 - b. If the "sustainability" column = 0, data are required on the effects of successive cycles on output and inputs, and these changes will be incorporated into the relevant calculations.
 3. In the absence of such data (referred to directly above), there may be variations of the land use system (with added inputs or longer fallow periods) that would be sustainable that would be useful to evaluate.
- F. There may be substantial range within cells. Where relevant/important, this range can be included in the cells, with footnotes identifying explicitly the sources of this variation.
7. The Profitability, Labor Requirements, Foods Security, and Institutional Issues columns themselves were each 'broken out' into separate matrices, to be described below. The extent to which evaluations made in each of those sub-matrices can be "summarized" and captured in the general *best-bet* matrix was discussed case-by-

¹⁰The algorithm for replicating land use systems for which $t < T$ may require revisions based on updated information and revised methods emerging from the ASB working group dealing with agricultural sustainability issues.

case, and deserves further consideration. (This is briefly taken up in the Linger-
ing Issues section that follows.)

**Profitability, Labor Requirements, Food Security, and Institutional Issues
(Matrices 2, 3, 4, 5, and 6)**

To better define and allow for a description of the essential elements for system adoption, each of the columns of the general ASB *Best Bets* matrix linked to technology adoption (profitability, labor use, food security, and institutional issues) was 'broken out' into a separate matrix. The sub-matrices and technical notes (primarily) about measurement issues associated with particular columns within each sub-matrix follow.

Note that the land use systems under evaluation refer to specific plots of land that can but do not necessarily encompass an entire operational holding of a given actor. As noted in the previous section, some priors about the actors controlling these plots of land, and some ideas of the other activities involved in their operational holding — the "archetypical household" — will be necessary for some of the calculations described here.

Matrix 2 — Profitability

Description of System	RETURNS TO LAND		RETURNS TO LABOR		ESTABLISHMENT COSTS	
	Net Present Value — Private Prices	Net Present Value — Social Prices	Wage to set PDV to Zero		Net Present Value of Establishment Costs — Private Prices	Years to Positive Cash Flow
			Family Labor	Total Labor		

Technical Notes on the Profitability Matrix

Note that, depending on relative factor scarcity, returns to land, returns to labor, or capital needed for establishment may be the most relevant for whether farmer's will adopt a given technology. The Profitability Matrix contains sections with indicators for each concern.

RETURNS TO LAND

I. Net Present Value — Private Prices

- A. Definition — net present value of each system
 1. reporting is on a per hectare basis, giving returns to land
 2. including all out-of-pocket costs
 3. including rental rates on all family-owned assets (tools, machines, barns, etc.) used in production (depreciation is discussed in the next section)
 4. including imputed value for opportunity cost of family labor
 5. excluding any imputed costs for family land and family management
- B. Farm gate or other prices relevant to farmer decisions will be used.
- C. All prices and values will be reported as end 1996 \$US.
- D. Discount rate
 1. real rate of return (opportunity cost) of capital, which varies by country
 2. farmer's discount rate may in part be determined by size of operational holding. Sensitivity analysis can be used to assess the implications that such differences might have on the profitability of particular activities.
- E. Results of sensitivity analysis focusing on discount rate, wage rates, and output prices will be reported in supporting documents to the matrix.
- F. Cross-row comparisons using NPV (mutual exclusivity assumption needs to be noted, as discussed more in the next section) — this implies that systems are examined individually, and not in the whole farm context. Whole farm analyses (with or without whole farm models) will be useful to assess what is 'lost' using a systems-based approach.

II. Net Present Value — Social Prices

It is hoped that juxtaposing NPVs using market and social prices will identify policy (and other) distortions to markets, and signal the potential gains to particular types of policy interventions for promoting *best bet* technology adoption.

1. Definitions and technical notes — same as above, but with a different set of prices (shadow prices, border prices, world prices), where the set of prices used will be made explicit. The most relevant set of prices may vary by country context; comparability issues across sites will be examined *ex post*.
 2. Use international prices for traded goods, adjusted as needed to reflect transport costs from study area.
 3. Try to identify market imperfections/policy distortions for non-traded goods and services. Explicitly distinguishing the price effects of market vs. policy distortions is desirable for traded and non-traded goods and services.
- D. Same discount rates as above.
- E. Same comments on 't' and "T" hold.
- F. Use Monke and Pearson, 1989 as a reference.

RETURNS TO LABOR

- III. Wage that sets PDV for Activity/System to Zero — Partial productivity ratios such as the return to labor *per se* (revenue or yield divided by labor input) can be misleading, but many disciplines are more accustomed to comparing land uses in these terms than the total factor productivity concepts employed by economists. The problems of partial labor productivity measures are complicated further for perennials and other systems where costs and returns span a number of years. Particularly when several years of "establishment" are required before output begins, an annual partial productivity ratio of "returns to labor" has little meaning.

However, there is an alternative: the wage rate that sets the present discounted value (PDV) of cash flows to zero for a given discount rate gives a measure of the "surplus" that accrues to labor (and management embodied therein). In the common situation where the discount rate itself is subject to uncertainty, it is possible to calculate (and graph) pair-wise combinations of discount rates and wage rates that set PDV equal to zero. This measure answers the question (for a given discount rate): what is the maximum wage level (paid to hired *and* family labor alike) at which this activity will be profitable? This figure would appear in the Total Labor sub-column. The Family Labor sub-column is optional, and can be used if analysts wish to distinguish returns to *family* labor from the wage bill for *hired* labor; since it will be necessary in any case to disaggregate these labor categories if they have different opportunity costs, the basis for calculating the wage (paid only to family labor, this time) that sets PDV to zero is there. The question of human capital, or skills base, of household labor, vis-a-vis the systems' requirements, is taken up in the Institutional Issues matrices, and again in the next section.

Several caveats to this measure are in order. First, as usual, handling seasonality and gender differences can be tricky, but the Labor Requirements Matrix that follows should help flag when and how those issues should be considered. Second, just like partial productivity measures, this measure attributes all the "surplus" to a single factor (labor). Depending how land and other fixed factors are handled, this may seriously overstate returns to labor.

ESTABLISHMENT COSTS

IV. Net Present Value of Establishment Costs

- A. Definition — Net present value of all inputs used to establish systems, including imputed value of family labor and family-owned implements, but excluding any imputed costs for family land and management.
2. "Establishment" is defined to be years to positive cash flow, regardless of whether or not the positive cash flow emanates from the primary or other production activities (or combinations of these) associated with a given land use system. We will compile both NPV of establishment costs and years to positive cash flow, and delete one if the two turn out to be redundant.

V. Years to Positive Cash Flow

1. Definition — Number of years to positive cash flow — revenues from sales minus out-of-pocket expenses (including hired labor, but excluding family labor) for establishment and operations.
- B. Add an asterisk in the column to indicate 'post-establishment' negative cash flow periods. Footnotes/supporting documents can describe the size of the negative cash flow, its length, or its timing in relation to establishment, if relevant.

Matrix 3 — Labor Requirements

Description of System	Establishment Phase		Operation Phase	
	Total Labor	Intensity	Total Labor	Intensity

Technical Notes on the Labor Requirements Matrix

Note that returns to labor are explored in the context of the Profitability Matrix.

I. Establishment of System

A. Total labor required to establish a system

1. Definition — total labor in person-days used in the initial phase of system establishment, expressed as an annual average. (This period is the years to positive cash flow indicated above in the Profitability matrix; the units are then person-days per hectare per year.)
 - a. investments occurring after the initial establishment period (such as maintenance investments) that require labor will not be included here.
 - b. this cell will contain an asterisk if gender issues arise (for example, if primarily female labor is required for establishment).
Footnotes/supporting documents can elaborate on gender-specific tasks, and potential gender-specific impacts will be flagged in the Institutional Issues matrices (below).
3. this cell can also contain an asterisk if other specific types of labor (hired vs. family, skilled vs. unskilled) are required for the activity system. The Institutional Issues matrices take up these topics in the context of labor markets.

B. Intensity

1. This column will only be relevant for some systems. The intention of this column is to highlight potential bottlenecks if labor needs of new land use systems (not widely adopted already) overlap with other household activities (where the benchmark is the typical household, both in terms of available household labor and in terms of typical production activities besides the activity being evaluated).
2. Definition — the column should identify the activity and the season (for example, livestock production, fence building in the dry season) foreseen as creating bottlenecks that might prevent the system under evaluation from fitting in with existing household activities given their labor needs. Footnotes and/or supporting documents can be used to further describe the source and severity of identified bottlenecks.

II. Operation of System

A. Total Labor for Operating System

1. Definition — total labor used to operate/maintain system once the establishment stage is finished, expressed in person-days per hectare per year (averaged over the relevant period).
2. This cell will contain an asterisk if gender issues arise (for example, if female labor will be used exclusively), or if a known reliance on hired or skilled labor exists. As noted above, both these issues are taken up again in the context of the Institutional Issues matrices.

B. Intensity

1. This column will only be relevant for some system. The intention of this column is to highlight potential bottlenecks if labor needs of new land use systems (not widely adopted) overlap with other household activities (where the benchmark is the typical household, both in terms of available household labor and in terms of typical production activities besides the activity being evaluated).
2. Definition — the column should identify the activity and the season (for example, coffee production, harvesting) foreseen as creating bottlenecks that might prevent the system under evaluation fitting into existing household activities. Footnotes and/or supporting documents can be used to further describe the source and severity of identified bottlenecks.

Matrix 4 — Household Food Security

Description of System	Nutritional Value of Food Produced by the System			Food Entitlement Via: Own Production or Exchange		Risk of Food Entitlement Failure		
	Calories: avg kcal /ha/yr	Protein: avg. kg /ha/yr	Micro-nutrients	Establishment	Operation	Production Risk		Terms of Trade Risk
						Food	Non-food	

Technical Notes on the Household Food Security Matrix{tc \l1 "Technical Notes on the Household Food Security Matrix} ¹¹

I. Food Produced by System

1. "Food" refers to the amount of food produced by a particular system, which is then converted into calories, protein, and dichotomous indicators of the presence of key micro nutrients (where 'key' will be determined by site-specific, endemic shortfalls of micro nutrients — vitamin A and iron are strong candidates). Note also that foods that are produced by particular systems but not normally consumed by rural inhabitants (that is, foods that are not already part of established food habits) will receive 'zero' values for the calorie, protein, and micro nutrient categories. Note also that 'foods' includes not only staples like rice, beans, cassava, etc., but also meats, milk, fruits, etc. (when they are included in the typical food basket). Our task (here) is to demonstrate increases in food availability regardless of the likelihood of it being consumed, so long as the form in which the calories/protein/micro nutrients are becoming available 'matches' food consumption habits generally.

- B. Evaluation will be done over period of the system, "T," and may include several cycles of 't', and will be averaged (but not discounted) over that period to arrive at an annual figure. That is, the average number of calories produced per year over the evaluation period "T" — for example, rice production occurs during the first year of establishing coffee production systems (and for simplicity, 't' is equal to "T"), so average annual calorie production from rice over the entire coffee cycle will be total rice produced divided by the number of years in the coffee system cycle ('t'="T"). This number might be quite small.

- C. Calories — defined as the average annual amount of calories produced by the system in the form of foods normally consumed

¹¹For discussions and applied assessments of poverty, food security and livelihood security see: Lipton, Michael and J. van der Gaag, eds. 1993. *Including the Poor*. (Part I) The World Bank. Washington, D. C.; and *Urban Livelihoods and Food and Nutrition Security in Greater Accra, Ghana*. 2000. Dan Maxwell, Carol Levin, Margaret Armar-Klemesu, Clement Ahiadeke, Marie Ruel, and Saul Morris. International Food Policy Research Institute. Research Report 112. Washington, DC

1. total calories produced divided by the total number of years in the system.
 2. see the discussions in I.A. and I.B. above for guidance in selecting relevant foods and time periods for evaluation.
- D. Protein — defined as the average annual amount of protein produced by the system in the form of foods normally consumed.
1. Total grams of protein produced divided by the total number of years in the system.
 2. See the discussions in (I.A and I.B) above for guidance in selecting relevant foods and time periods for evaluation.
- E. Micro nutrients — cells will contain simple Y/N, referring to the presence/absence in the food produced by the system of one or more micro nutrients deemed to be important for site inhabitants. Footnotes can be used to identify micro nutrients, which should be related to some known micro nutrient problem at each site (that is, fruit-based systems may help address vitamin A deficiencies).
- II. Food Entitlement via Own Production or Exchange¹²
- A. Definition — label OP (Own Production) = system provides additional food production on farm; label PI (Produced Income) = system only provides additional income for food purchases; label BO = both, regardless of the proportions.
2. This assessment will be made for each system twice: once for the establishment phase, and a second time during the operational phase. This will add clarity and avoid a large number of cells containing "BO" due to food production during the establishment phase only.
 3. Benchmark — The 'traditional' cultivation system as practiced by the "archetypical household" at each site will be the benchmark for this assessment.
 4. OP/PI paths may not be mutually exclusive (depending upon issues of timing).
- III. Risk of Food Entitlement Failure¹³

¹²For a discussion of entitlement-based assessments of food security see: Sen, A. 1982. *Poverty and famines: an essay on entitlement and deprivation*. Oxford University Press, NY, NY.

¹³For discussions of the multiple sources of risk in rural areas of developing countries see:

A. Production Risk

1. Food production risk (to capture yield variability)
 - a. The intention is for the measure to capture risk. Sources of risk include weather shocks, pest shocks, and others, all of which will be explained in supplementary documents.
 - b. This statistic may have to be calculated at a fairly high level of aggregation (for example, municipal level), and therefore may include geographic areas and (more importantly) and households that are not in the ASB samples, as strictly defined. The length and quality of time series data on production and area cropped is likely to vary considerably by site. "Noise" in secondary data may make it difficult to disentangle production risk from other sources of risk (for example, price) that affect off-take. In some cases (especially those involving systems not yet firmly established in farmers' fields) expert assessments of production risk may have to be relied upon to generate risk statistics. Judgment calls and interpretations will be needed in all cases, and cross-site discussions aimed at improving comparability at that level are essential.
3. Definition — A weighted standard deviation (or coefficient of variation) of yields of the food products of the system, where the weights are kcals of energy provided by a given unit of that product, prepared in keeping with local food consumption and preparation habits.
2. Non-food production risk (to capture yield variability) — The same statistic(s) (standard deviation or coefficient of variation of yield) will be generated for each non-food product, following the method outlined in the case of food production risk. For systems with multiple non-food products, the yield variance for each component will be reported separately (given that data gaps prevent calculation of covariances that would be needed to use

von Braun, J., P. Webb, and T. Teklu. 1998. *Famine in Africa*. (Chapter 2) Johns Hopkins University Press, Baltimore, MD; and Hardaker, Brian J., R. B. M. Huirne, and J. R. Anderson. 1997. *Coping with Risk in Agriculture*. CAB International. Wallingford, U.K.

prices as weights). Issues of level and time frame for which the statistic(s) may be calculated apply as in the case of food production risk.

2. Terms of Trade Risk — The form of this measure elaborated below takes into consideration gaps in price series that prevent calculation of covariances. For some sites, this gap may not apply, and more informative summary statistics on terms of trade risk may be calculated.
 1. This cell would report:
 - a. the standard deviation (coefficient of variation) of price for *each* product sold (P_{sold} for each product);
 2. the standard deviation (coefficient of variation) of price of food for consumption (can be a single product, or a basket)(P_{purchase});
 3. the standard deviation (coefficient of variation) of ($P_{\text{sold}}/P_{\text{purchase}}$); a different ratio for each product sold, that product's P_{sold} as the numerator, and the P_{purchase} as the denominator.
 - d. where data allow, covariances across multiple products sold and purchased will be calculated.
 2. In all cases, "purchases" refer to food; and "sold" refers to food and/or other products generated by an system.

- C. Emerging Products/New Markets — The term "emerging market" or "new product" can be placed in one or more of the risk columns/cells to indicate our current inability to assess terms of trade or production risk. Alternatively, a best guess at these statistics could be accompanied by an asterisk indicating new product of emerging market status, or both, and hence the lack of information to reliably calculate risk measures. The issue of output markets, flagged here, is taken up again in the Institutional Issues matrices (below).

Matrix 5 — Institutional Capacity Vis-A-Vis System-Specific Institutional Needs — A Checklist for Markets

Land Use System & Aggregate Assessment	Input Supply Markets			Output Markets			Labor Markets						Capital Markets			
	Degree of dependence on input markets L/M/H	Current degree of 'development' of input markets L/M/H	Current ability of the social system to compensate for market imperfections L/M/H	Degree of dependence on output markets L/M/H	Current degree of development of output markets L/M/H	Current ability of the social system to compensate for market imperfections L/M/H	Unskilled Labor			Skilled Labor			Degree of dependence on borrowed money L/M/H	Current degree of 'development' of capital markets L/M/H	Current ability of the social system to compensate for market imperfections L/M/H	
							Degree of dependence on unskilled labor L/M/H	Current degree of 'development' of unskilled labor market L/M/H	Current ability of the social system to compensate for market imperfections L/M/H	Degree of dependence on skilled labor L/M/H	Current degree of 'development' of skilled labor market L/M/H	Current ability of the social system to compensate for market imperfections L/M/H				
Land Use #1																
Aggregate Assessment of #1																
Land Use #2																
Aggregate Assessment of #2																

Matrix 6 — Institutional Capacity Vis-A-Vis System-Specific Institutional Needs — A Checklist for Other Institutional Issues

Land Use System & Aggregate Assessment	Non-Market Information			Regulatory Issues			Local Environmental Impact	Property Rights	Equity Biases		Social Cooperation		
	Degree of dependence on non-market information L/M/H	Current availability to households of non-market information L/M/H	Current ability of the system to generate and deliver non-market information L/M/H	Degree of dependence on regulations L/M/H	Current ability of households to deal with regulations L/M/H	Current ability of system to deal with regulations L/M/H	Importance of local environmental impacts beyond the farm itself L/M/H	The degree to which the rights to access, use, and bequeath land and land investments are secure L/M/H	Possible concentration of wealth/land L/M/H	Possible intra-household changes in roles or in the distribution of returns L/M/H	Degree of dependence on social cooperation L/M/H	Current degree of social cooperation L/M/H	Current ability of the system to generate and deliver social cooperation L/M/H
Land Use #1													
Aggregate Assessment of #1													
Land Use #2													
Aggregate Assessment of #2													

General Notes for the Institutional Issues Matrices{tc \l1 "General Notes for the Institutional Issues Matrices}

1. Contextual "behind-the-matrix" descriptions. In the case of institutional issues, the need for at least brief descriptions of salient site-specific features and trends that affect the interpretation of institutional issues as regards each of the land use systems under evaluation was thought to be important.^{14, 15}
2. The objective of these institutional matrices is to identify potential institutional bottlenecks and address equity issues associated with systems linked to *best bet* technologies. In addition, several columns of matrix 6 focuses on the potential for social cooperation in response to one or more of the institutional problems raised in these matrices. (Note that responses by other actors or groups of actors, for example, government or the private sector, are not dealt with explicitly; the focus on local social cooperation stems from common perception that these other actors have not been, and are unlikely to soon become, effective in dealing with many of the institutional weaknesses facing smallholders in these areas — for example, local environmental impacts.)

¹⁴For a review of institutional and other factors influencing technology adoption in agriculture see: Feder, Gershon and D. L. Umali. 1993. The Adoption of Agricultural Innovations: A Review. *Technological Forecasting and Social Change*: 43, 215-239 (1993).

¹⁵For discussions of the importance of markets and other institutions in agricultural systems in developing countries see: Abbott, J. Ed. 1993. *Agricultural and Food Marketing in Developing Countries: Selected Readings*. CAB International, Wallingford, U. K.

- A. In the cells examining each institutional issues in detail (i.e., the first row in each of the pair of rows dedicated to each system, we employ a 'low/medium/high' (L/M/H) approach to signal if and to what degree an institutional bottleneck or equity problem is likely to exist, and the extent to which the system can respond.¹⁶ Almost all institutional issues, then, have three sub-columns dedicated to them — dependence, current situation, and ability of the system to respond. This matrix shows a 'traffic light' approach as follows: L indicates no problem is anticipated or that the issue is not relevant for a particular land use system; M indicates that some problems may exist; and H indicates that a severe bottleneck or equity problem is likely to exist. It is possible for any given land use system to have different combinations of 'signals,' but some will not convey important information and therefore should be excluded. For example, a land use system might not be dependent on purchased inputs (hence, a 'L' in that cell) and the relevant geographic area might have very underdeveloped input markets (hence, in theory, a 'L'). Since the 'L' has no real meaning in this case, we suggest it be dropped. Note that there might be site-specific adaptations that supplement this approach.
- B. An aggregate assessment row is located beneath each land use system row, and its purpose (this time using a 'traffic light' approach) is to signal the extent to which one or more of the possible institutional bottlenecks, equity, or other problems is likely to limit the adoption and spread of a particular land use system (an 'R' — red light— indicating a serious problem; a 'Y' indicating some problems; and a 'G' indicating no serious problems).
- C. Note that there is no intention anywhere in this matrix to identify sufficient conditions for technology adoption and/or system change. Agricultural and resource use changes are known to occur in the absence of many of the institutional bottlenecks detailed below.

Technical Notes for the Institutional Issues Matrix 5 — A Checklist for Markets

Matrix 5 assesses market dependence, market performance, and possible social system responses to market imperfections in the context of purchased inputs, marketed outputs, hired labor, and formal credit. The sections below highlight how to fill out the top row, associated

¹⁶Some sites may choose to use a 'traffic light' approach (G=green, no problem; Y=yellow, possibly a problem; R=red, an important problem) for the detailed examination of institutional constraints rather than the L/M/H approach.

with each land use system. Aggregate assessments are then made based on this information (see above).

I. Input Supply Markets

A. Objective — assess the extent to which purchased inputs are important components in land use systems, and the extent to which input markets perform the basic functions required to make adoption of the system feasible, and the extent to which social systems can compensate for input market imperfections (including actually improving market functions). (Other factor markets are dealt with below in separate sections for skilled and unskilled labor and capital markets; land markets are discussed under Equity Biases.)

1. Input markets are assessed as regards:

- a. the degree of dependence of a particular land use system on purchased inputs — 'L' = not dependent, or not an issue; 'M' = an issue, and some dependence on purchased inputs; and 'H' = an issue, and heavily dependent on purchased inputs.
- b. the current degree of development of input markets, where 'development' can range from non-existent, to existing but functioning only partially or seasonally, to well-functioning markets — 'L' = well developed; 'M' = somewhat developed; and 'H' = underdeveloped.
- c. the current ability of the social system (taken as a whole) to respond to or compensate for input market imperfections. For example, can/will existing farmers' cooperatives take on the challenge of providing needed inputs for new land use systems? — 'L' = social system can respond; 'M' = social system will have difficulty responding; and 'H' = social system cannot respond, or can respond only with great difficulty or at high cost.

II. Product Output Markets

A. Objective — assess the extent to which output markets are required for land use systems, and the extent to which these markets perform the basic functions required for technology adoption, and the extent to which social systems compensate for output market imperfections.

1. Output markets are assessed as regards:

- a. the degree of dependence of a particular land use system on output markets — 'L' = not dependent, or not an issue; 'M' = an issue, and some dependence on output markets; and 'H' = an issue, and heavily dependent on output markets.

- b. the current degree of development of output markets (where 'development' connotes the same range described as regards input supply markets above)— 'H' = well developed; 'M' = somewhat developed; and 'L' = underdeveloped.
- c. the current ability of the social system (taken as a whole) to respond to or compensate for output market imperfections (where 'social system' has the same meaning as described as regards input supply markets above). For example, can/will existing farmers' cooperatives take on the challenge of marketing the outputs from new land use systems? — 'H' = social system can respond; 'M' = social system will have difficulty responding; and 'L' = social system cannot respond, or can respond only with great difficulty or at high cost.

III. Labor Markets

- A. Objective — assess the extent to which unskilled and skilled labor are required for land use systems, and the extent to which markets for these categories of hired labor perform the basic functions required for technology adoption, and the extent to which social systems compensate for labor market imperfections. (Market for skilled and unskilled labor are handled separately in the matrix.)
 - 1. Unskilled and skilled labor markets are assessed as regards:
 - a. the degree of dependence of a particular land use system on hired labor — 'L' = not dependent, or not an issue; 'M' = an issue, and some dependence on hired labor; and 'H' = an issue, and heavily dependent on hired labor.
 - b. the current degree of development of output markets (where 'development' connotes the same range described as regards input supply markets above)— 'H' = well developed; 'M' = somewhat developed; and 'L' = underdeveloped.
 - c. the current ability of the social system (taken as a whole) to respond to or compensate for labor market imperfections (where 'social system' has the same meaning as described as regards input supply markets above). For example, are there labor sharing arrangements among households that compensates for the absence of or imperfections in hired labor markets? — 'H' = social system can respond; 'M' = social system will have difficulty responding; and 'L' = social system cannot respond, or can respond only with great difficulty or at high cost.
- B. Special attention needs to be paid to seasonal failures in labor markets.

3. Some further clarification is needed regarding how to differentiate the dependence on skilled markets, from dependence on non-market information about the technology (see Matrix 6, below) under certain circumstances.

VII. Capital Markets

1. Objective — assess the extent to which borrowed money is required for land use systems, and the extent to which capital markets perform the basic functions required for technology adoption, and the extent to which social systems compensate for capital market imperfections.
 1. Capital markets are assessed as regards:
 - a. the degree of dependence of a particular land use system on borrowed money — 'L' = not dependent, or not an issue; 'M' = an issue, and some dependence on borrowed money; and 'H' = an issue, and heavily dependent on borrowed money.
 - b. the current degree of development of capital markets (where 'development' connotes the same range described as regards input supply markets above) — 'H' = well developed; 'M' = somewhat developed; and 'L' = underdeveloped.
 - c. the current ability of the social system (taken as a whole) to respond to or compensate for capital market imperfections (where 'social system' has the same meaning as described as regards input supply markets above). For example, are there local money lenders and/or farmers' cooperatives that can substitute for private or public banking systems in providing credit? — 'H' = social system can respond; 'M' = social system will have difficulty responding; and 'L' = social system cannot respond, or can respond only with great difficulty or at high cost.

Technical Notes for the Institutional Issues Matrix 6 — A Checklist for Other Institutional Issues

Matrix 6 examines possible constraints to land use change posed by non-market information, regulatory issues, local environmental impacts, and property rights. The final two sets of columns address possible equity biases inherent in land uses, and the need for and likely availability of social cooperation in the context of adoptability of particular land use systems.

I. Non-Market Information

1. Objective — assess the extent to which non-market information (for example, technical information) is required for land use systems, the extent to which this

information is currently available to farm households, and the extent to which social systems can fill non-market information gaps. (Note that market information would be covered in the context of Matrix 5, as part of the level of development of markets of various types.)

1. Non-market information is assessed as regards:
 - a. the degree of dependence of a particular land use system on non-market information — 'L' = not dependent, or not an issue; 'M' = an issue, and some dependence on non-market information; and 'H' = an issue, and heavily dependent on non-market information.
 - b. the current degree of availability to farm households of non-market information — 'H' = well developed; 'M' = somewhat developed; and 'L' = underdeveloped.
 - c. the current ability of the social system (taken as a whole) to respond to or compensate for gaps in non-market information (where 'social system' has the same meaning as described as regards input supply markets in Matrix 5 above). — 'H' = social system can respond; 'M' = social system will have difficulty responding; and 'L' = social system cannot respond, or can respond only with great difficulty or at high cost.

2. See note above under skilled labor market dependence regarding need for clarification on how to differentiate that from dependence on non-market information.

II. Regulatory Issues

1. Objective — assess the extent to which information on and the ability to deal with regulatory issues is required for adoption of land use systems, the extent to which this information/ability is currently available to farm households, and the extent to which social systems can respond to assist farmers in becoming aware of and dealing with regulatory issues.
 1. Regulatory issues are assessed as regards:
 - a. the degree of dependence of a particular land use system on regulations — 'L' = not dependent, or not an issue; 'M' = an issue, and some dependence on regulations; and 'H' = an issue, and heavily dependent on regulations.
 - b. the current degree of availability to farm households of information on regulations and the ability of farm households to deal with them — 'H' = well informed/able; 'M' = somewhat informed/able; and 'L' = uninformed/unable.

- c. the current ability of the social system (taken as a whole) to respond to or compensate for gaps in information on regulations, or gaps in the ability to deal with them (where 'social system' has the same meaning as described as regards input supply markets in above) — 'H' = social system can respond; 'M' = social system will have difficulty responding; and 'L' = social system cannot respond, or can respond only with great difficulty or at high cost.

III. Local Environmental Impacts Beyond the Operational Holding

1. Objective — assess the extent to which local environmental impacts beyond the operational holding (that is, local environmental externalities) affect the adoption of particular land use systems. For example, will the actions of non-adopting neighbors affect a farmer's decision to adopt a particular land use system? As a more specific example, what would be the effect of annual pasture burning by one's neighbors on the likelihood of adopting a coffee production system?
 1. Local environmental impacts (externalities) are assessed as regards the degree to which actions by others locally (especially neighbors) will influence land use system adoption — 'L' = will not influence adoption decisions, or not an issue; 'M' = may influence adoption decisions; and 'H' = likely to heavily influence adoption decisions.
 2. Note that this column does NOT measure the land use system's Q effect on the local environment, except insofar as this influences adoption of the system.

IV. Property Rights

- A. Objective — assess the extent to which the ability to own, use, derive income from, sell, and/or bequeath real property or the improvements made to real property influence the adoption of a given land use system. Refers to land, water, trees (all factors of production), and the products derived from these.
 1. Property rights (taken together) are assessed as regards:
 - a. the degree to which property rights rules and/or uncertainty regarding these rules affect land use system adoption — 'L' = will not influence adoption decisions, or not an issue; 'M' = may influence adoption decisions; and 'H' = likely to heavily influence adoption decisions.
 2. Supporting text will detail shortfalls in property rights, if any, and how they influence adoptability of the system under evaluation.

22. Equity Biases

- A. Objective — assess the potential *impact* of a given land use system on the concentration of land and wealth, and on gender roles currently in place.
1. The impact on land concentration and wealth is assessed as regards:
 - a. the extent to which a particular system will lead to the concentration of land and/or other forms of wealth in rural areas due to economies of scale in some aspect(s) of production, including harvesting — 'L' = will not lead to the concentration of land/wealth, or not an issue; 'M' = may lead to the concentration of land/wealth; and 'H' = will almost surely lead to the concentration of land/wealth.
 - b. The organizational/institutional checks to land/wealth concentration need to be absent, or at least unlikely to function well. For example, if technological change leads to an increase in the optimal scale of operation and land rental/leasing markets do not function properly, then land concentration might be expected.
 - c. Divisibility of land holdings linked to technology adoption, although not explicitly discussed at the workshop, is another dimension tied to functioning of local land markets that may be relevant to evaluation of particular systems.
 2. The impact on gender roles is assessed as regards:
 1. the extent to which a particular land use system modifies existing gender-specific production activities and/or the gender-specific distribution of the returns to those activities— 'L' = will not lead to changes in gender-specific activities or returns, or not an issue; 'M' = may lead to changes in gender-specific activities or returns; and 'H' = will almost surely lead to changes in gender-specific activities or returns.
 3. Supporting text will detail changes in gender-specific activities and/or gender-specific returns, if any, and how they influence adoptability of the system under evaluation.

VI. Social Cooperation

- A. Objective — assess the extent to which social cooperation is required for the adoption of a particular land use system, the extent to which existing types and amounts of social cooperation might meet these needs, and the potential for social change to meet these needs.
1. Social cooperation is assessed as regards:

- a. the degree of dependence of a particular land use system on social cooperation — 'L' = not dependent, or not an issue; 'M' = an issue, and some dependence on social cooperation; and 'H' = an issue, and heavily dependent on social cooperation.
 - b. the current degree of availability of social cooperation to meet the needs posed by a new land use system — 'H' = available/willing; 'M' = somewhat available/willing; and 'L' = not available/unwilling.
 - c. the current ability of the social system (taken as a whole) to respond to or compensate for the absence of social cooperation linked to the particular needs of a land use system (where 'social system' has the same meaning as described as regards input supply markets above)— 'H' = social system can respond; 'M' = social system will have difficulty responding; and 'L' = social system cannot respond, or can respond only with great difficulty or at high cost.
3. Supporting documentation can outline the source of the need for social cooperation as appropriate.

From the Sub-Matrices to the General Best Bet Matrix{tc \l1 "From the Sub-Matrices to the General Best Bet Matrix}

The following information (cell contents, generally) was taken from the sub-matrices detailed above for placement into the general *best bet* matrix (Matrix 1).

I. Profitability

- A0 Two sub-columns can be presented under the profitability column. (NB — 'Social' and 'private' were agreed on as terms, as opposed to 'economic' and 'farmer.')
- 1 Returns to land at social prices, providing an estimate of international comparative advantage
- 2 Returns to labor at private prices, providing a good indicator of attractiveness for adoption

II. Labor Requirements

- A. Total labor requirements (person days/ha./year) over the evaluation period will be reported.
 - 1. Asterisks/footnotes can be included to reflect competition with other ('traditional") H.H. activities

III. Food Security

- A. Food acquisition routes will be reported, but only for the operational phase of each land use system.
 - 1. Asterisks/footnotes can report caloric value of food component, when the acquisition route involves own consumption

IV. Institutional Endowments/Requirements

- A. A series of upper and/or lower case letters indicating the presence and severity of particular institutional impediments to the spread of each LUS would be included in this cell. More than one letter (separated by commas) can appear; order does not matter. Upper case letters suggest major problems; lower case letters imply substantial problems; the absence of a letter indicates no problem is known to exist. There can be separate 'sub-columns' corresponding to market and non-market institutional issues.
 - 2. Letters are:
 - 1. for the market columns
 - 1. I,i = input markets
 - b. O,o = output markets

3. L,l = labor markets
- d. K,k = capital markets
2. for the non-market columns
 1. N,n = technical information
 2. R, r = regulatory issues
 - c. E,e = local environmental impacts
 4. P,p = property rights
 - e. B,b = equity bias (concentration of wealth or intra-H.H. issues)
 6. S, s = social cooperation

Lingering Issues for Discussion and Future Research

The following issues have not been fully resolved even for the purposes of filling in the *Best Bet* matrices. Many of these issues (and some others) have already been flagged in the preceding technical notes. The lingering issues fell roughly into several broad categories (although some spanned categories, and others fell neatly into none) — a) import of factors held constant within the ‘*best-bet*’ matrices (or held constant for each row/land use system, throughout its evaluation in the various matrices); b) challenges of filling cells of the ‘*best-bet*’ matrices (measurement and reporting, with a particular emphasis on measurement difficulties arising out of the time scale for evaluation proposed); c) problems in, and suggestions for, defining the rows of the ‘*best-bet*’ matrices; and d) a look at what evaluations using the ‘*best-bet*’ matrices must, or should not, entail. This last category itself includes comparing information across rows, summarizing ‘row’ information, and looking across matrices. A final category highlights critical gaps in the analytical framework presented here, most notably its need to bring in the perspective of the national or regional policymaker in interpreting or expanding on the matrix information. These groups of issues are listed here (in no particular order) to prompt more thought by ASB as we attempt to complete the matrices presented above, and more generally. The section concludes with a brief word on gains made in cross-site comparison, particularly vis-a-vis socioeconomic research and policy analysis.

1. Factors Held Constant Within the *Best-Bet* Matrices, or for Evaluation of Particular Rows of the Matrices
 - A. Constant for the Matrices vs. Constant for the Rows — While cross-row comparability argues for some elements being held constant across the rows of the matrices (described below), some of these are impractical to implement for some sites, due to the different elements that normally are implied by the land use systems under evaluation themselves. In those cases, the elements are understood as important to define carefully for the land use system under evaluation.
 - B. Archetypical households — The need for deciding on an archetypical household to perform needed calculations was agreed upon, including such elements as household gender and age composition, access to infrastructure, resource 'base' (financial and human capital, as well as natural). The dangers associated with this necessary evil were also discussed. Where the characteristics of rural households vary substantially, sensitivity analysis might be used to assess the impact of changes in these on system performance. This might be particularly important when estimating the use of hired (versus household) labor, and assessing the impact on system costs of this key cost.
 - C. Homogeneous ‘Land Type’ — Similarly, the need to compare systems across rows necessitated a focus, for a given matrix, of a particular land type, on which

all systems would be evaluated. For each site, this means strategically choosing one among several land types for the initial evaluation, justifying this choice, and documenting, where possible and thought to be important, the actual or expected effects of a shift in land use type for a given system. Natural resource elements other than soil type might be included under this heading, for example, access to water and forest resources 'built into' the site.

- C. Sensitivity Analyses — Many candidates (too many to be practical) for sensitivity analyses were discussed. In addition to soil types/qualities and characteristics of archetypical households, parameters needed to characterize systems for evaluation in one or more matrices included technical coefficients, market prices, social prices, discount rates, institutional contexts. Doing sensitivity analysis on discount rates, price changes, and some key technical coefficients would probably be wise for all sites. The results could either be presented as footnotes to the tables, or in supporting documents.

2. Filling in the Cells of the *Best-Bet* Matrices

- A. Measurement Error — Questions regarding the precision with which we might expect to measure key inputs and outputs linked to systems containing *best bet* technologies arose constantly. In some cases, available measurement instruments will be quite blunt — for example, county-level prices for particular products would be used in calculations, knowing that substantial within-county price variation existed due to differences in access to markets and product quality. In other cases, no measurement instruments exist at all — for example, the definitions and relative importance of skilled versus unskilled labor in particular activities of emerging systems is not known, and therefore cannot be currently measured. Finally, in most cases it was not clear what proportion of within-cell variation might be due to measurement error versus other sources of variation, such as unobserved differences in key underlying inputs (for example, management practices).
- B. Ranges of Values within Cells — With the exception of cells containing dichotomous entries, ranges of values within cells arose as an issue. Where ranges are large and researchers are confident of the dispersion, ranges themselves (rather than means or some other statistical measure of centrality) might be entered in a cell. In all cases, discovering and reporting (perhaps as footnotes to tables) the source(s) of the ranges of values was deemed to be critical, and probably more important than the ranges themselves. For example, if a wide range of profitability numbers were discovered for improved pastures in Brazil, the challenge would lie in figuring out the source of this variation (for example, management practices).

- C. **Thresholds** — Thresholds were discussed at length in the context of several columns of the sub-matrices presented above. Poverty thresholds were discussed in the context of the food security matrix — how close to being food insecure a household is should influence our assessment of the importance of (for example) shifting from own production to purchasing food. Likewise, key information would be lost by noting only the number of years to positive cash flows for systems, since huge losses in the post-establishment period would be given the same weight as trivial losses. These issues need to be addressed in almost all columns; their relevance might vary across systems, too. To some extent the identification of such thresholds can inform both sensitivity analyses, and when, where, and how to report ranges.
- D. **Time Scale** — Implications
1. **Discount Rates** — A perennial problem for all evaluations over time, this problem is generally handled by replicating evaluations at different discount rates and reviewing the outcomes. That can be done here, too. However, this is a particularly difficult issue for our task due to possible differences among actors in discount rates. For example, large plantation operations in Indonesia with direct links to capital markets might have very different discount rates than small farmers without access to formal credit. We may have to use different discount rates for different systems if such cross-actor differences are confirmed, and if we can make reliable matches between groups of actors and particular systems.
 2. **Depreciation and other Over Time Changes** — The depreciation of family-owned assets in the production process needs to be explicitly incorporated into all relevant evaluations. Reductions in expected productivity of these inputs needs to be noted, too. Finally, and perhaps most difficult, the changes in the productivity of labor of the sometimes long evaluation periods needs to be dealt with — a 20-year time frame will mean that half a generation will pass during the evaluation period for some systems. We also need to assess the impact of likely changes in (for example) household composition on technology performance over that period, at least subjectively.
 3. **Replication versus Multiplication** — As indicated earlier, short-cycle systems will have to be ‘replicated’ so that the time frame for evaluation will be the same for all systems, at least for some measures. In the (probably rare) cases in which the actual replication of an system leaves the natural resource base (sustainability exactly equal to 1) and the archetypical household unchanged, this method is fine. However, if agronomic conditions are improved (sustainability greater than 1), our measures of performance/adoptability will only capture improvements that enhance yields for the systems being evaluated. Productivity improvements that might go to other crops, or increases in wealth not linked to productivity increases will not be captured. Perhaps more

worrisome, if the natural resource base is degraded (sustainability = 0) much more information will be needed on the impact of activity/system replication on the resource base in order to generate reliable evaluations.

4. **Biophysical Measurements Over Time** — Methods for taking into consideration systems/activities with different cycle lengths, and making evaluations for longer temporal scales for the socioeconomic ‘side’ of the matrix are detailed above. However, this issue needs to be addressed in the rest of the general *Best Bet* matrix, and methods deployed in the biophysical ‘side’ of the matrix need to jibe with our treatment. This might be especially critical for the agronomic sustainability column (as one of the adoptability columns), now treated (by us) as dichotomous.
5. **Risk** — While there is some uncertainty regarding the agronomic performance of some systems, we often know virtually nothing about the several types of risk (production, market, etc.) the producers of these new systems will face. This is particularly true in Brazil, where new products in settlement areas are neither stable nor well integrated into regional markets. Innovative measures of risk will be needed in these cases.

III. Defining the Rows (Systems) of the ‘*Best-Bet*’ Matrices

- A. **Land Use Systems versus Production Activities** — From the outset, the notions of land use systems and production activities, and where *best bet* technologies fit into both, presented some difficulty for both identification of “rows” and cross-site analysis. At some sites, such as Indonesia, where systems and the activities that make them up have had sufficient time to ‘settle down’ into general patterns, the notions were easy to separate. In other sites, such as Brazil, where smallholder production systems, and the economic and biophysical environments shaping them are still in substantial flux, stable systems in particular, but also production activities, were difficult to define in the precise manner needed. Clarity in defining both the system/activity and the scale of evaluation were deemed critical. Interaction among researchers during the periods of system definition will increase the value and reliability of cross-site comparisons. The need to have some cross-site comparability in terms of what rows represent was deemed essential: for the purpose of this initial ASB exercise, rows under evaluation will be land use systems (with their various component activities over well-defined time scales), and the ‘point of departure’ for the system will be forest.
- B. **“Close Cousins” to Potential *Best Bet* Technologies** — Defining *best bet* technologies, and in many instances the systems/activities that contained them, was a non-trivial task. In some cases, within-cell variations may well be due to the lack of precision with which we define systems containing *best bets* (thus

leading to measurements being taken on what are actually different systems). As we move forward in filling out the proposed matrices, due thought needs to be given to the impact of imprecise definitions to system evaluation, reporting, and cross-row comparison. The group underlined the importance of capturing the ‘trade-off’ in critical biophysical and socioeconomic parameters, as well as farmer know-how (vis-a-vis the *best bet* itself) associated with particularly likely or prevalent *best bet* ‘close cousins.’

- C. Variations in Key Factors of Production — As indicated earlier, variation at farm level in key agricultural inputs and/or management practices can dramatically alter the ‘performance’ — both biophysical and socioeconomic — of systems. Some method needs to be introduced to control for such variation, and to measure its impact.
- D. Scale Issues — More thought needs to be given to the spatial scale at which systems are evaluated, and the scale at which the results of these evaluations are reported in the *best bet* matrix. At a minimum, this information has to be contained in all tables, and some discussion of the potential for realistically scaling up or down at farm level must be addressed. This is critical in cases where economies of scale in some aspects of production/processing change the costs associated with production/processing as the scale of operation changes. For example, the results of our evaluation of pastures in Brazil will be reported on a per hectare basis, but the likelihood of owners of one-hectare plots to adopt this technology is low. Some scope for addressing this topic already exists within the institutional issues matrix. How socioeconomic 'scaling up' issues will or need to jibe with those presented for the other (non-socioeconomic) columns of the matrix is still to be explored.

IV. System Evaluations within ASB Sites

- A. Cross-Row Comparisons, Mutually Exclusive Activities, and NPV — Within the profitability matrix, one reason for choosing NPV as a measure was to allow a ranking of rows. However, one of the notions embedded into NPV evaluations is that activities are somehow mutually exclusive — farmers chose between one system or another, but do not do both. We know this is not true in many cases, and some assessment of the potential for combinations of systems involving *best bet* and/or other technologies needs to be done. Formal modeling at household level would be ideal, but other acceptable methods are available. Other 'cross-row' comparisons within particular columns deemed of use should be similarly scrutinized for methodological pitfalls or caveats.
- B. "Summing Up" Across (or Distilling Information in) Columns for Given Systems — Given the diversity of measurement tools and analytical methods deployed

across the different cells of the *Best Bet* matrices for given rows, it will be extremely difficult (indeed probably impossible) to quantitatively distill for each row a single measure capturing the information, for example (in the case of the General *Best Bet* Matrix), on international externalities, agronomic sustainability, and technology adoption concerns. Moreover, trying to create such summary statistics might be unwise for several reasons. First, a uniform summary statistic might not reflect the ‘weights’ needed in specific cases for a realistic evaluation. For example, ‘fatal doses’ noted in a particular column might ‘kill’ a particular technology, regardless of how well it ‘scores’ in other cells. The problem can compound itself if the effort to generate summary statistics within matrices should expand to generating summary statistics across matrices. Second, units of measure vary widely across columns, and no "common denominators" were identified. At the end of the day, we will need to make broad assessments of technologies, and make comparisons among them. More thought as to how this process should be carried out, for the disciplinary 'blocks' within the matrix (for example, the columns representing socioeconomic issues), then across blocks, is needed.

- C. Linking the *Best Bet* Matrices — Although it may be misguided at this point to attempt to create uniform summary statistics that link the *best bet* matrices one to another (and particularly the sub-matrices to the General *Best Bet* Matrix), it would be equally misguided to ignore that the issues raised in each matrix are meant to be considered in a broader, cross-matrix context, and that specific column-to-column links across matrices may yield fruitful insights (for example, labor intensity in the labor requirements matrix, in the light of whether markets for skilled and unskilled labor function in the region, from the institutional issues matrix). As noted above, how the information is processed to reach overall evaluations on systems/activities deserves more consideration.

- D. Links between Biophysical and Social Science Aspects of *Best Bet* Matrices — These links were discussed, with particular focus on the agronomic sustainability column. More needs to be done, particularly assessing the impact of some of the global change variables on technology adoption potential. The below-ground biodiversity work would seem to offer an excellent opportunity in this regard. Such links imply getting a handle on how temporal and spatial measurement and reporting issues might vary for the biophysical, vis-a-vis the social science, columns, and the implications of those differences for how the biophysical/social science links may be perceived.

22. Gaps to be Filled

- A. Policy-focused View of *Best Bets* — There are two interest groups explicitly ‘targeted’ in the general *Best Bet* matrix: the international community concerned

with global externalities, and small farmers who might eventually adopt *Best Bet* technologies. A key interest group not explicitly mentioned in the matrices are policymakers, who may place different weights on the information contained in the matrix, or who may find our matrices lacking key information. Therefore, we need to find ways to inject regional and national policymakers' concerns into the *Best Bet* matrices, and distill from the matrices messages relevant to policymakers. One entry point already devised in the profitability matrix is the use of different sets of prices to highlight effects of existing policy distortions or potential policy action.

2. **Meso Issues** — Related to the above, in the process of tackling very macro (GHG emissions) and very micro (farm household) issues, this analytical framework does not explicitly address on important meso issues, such as labor absorption and employment generation, the impact of increased output supply and/or input demand in regional markets, etc. These are probably among the most important issues developing country policymakers need to deal with, and information contained in the matrices (including that about labor requirements, institutional frameworks, and local market function failures) is vital input into addressing them. At a minimum, supporting documents to the matrices should elaborate on the implications of matrix information to such meso-level concerns, wherever possible.
 3. **Local Externalities** — ASB is collecting lots of data on international externalities — GHG emissions, biodiversity, and carbon stocks. However, local externalities (the spill-overs across farms or groups of farms) linked to activities/systems are rarely addressed. Ironically, these spill-overs may be of most interest to policymakers in the developing world. Ways to incorporate them or other frameworks to address them need to be devised. Note that information gathered for the "social cooperation" column in the institutional issues matrix is a start in this regard.
- VI. **Eyeing Cross-Site Comparisons** — The initial aim of the *best bet* matrices is within-site evaluation, as a necessary but insufficient step towards the ASB broader aim of getting at the roots of similarities and differences in tropical forest margin zones throughout the world. The emphasis placed here on measurements that enable cross-site comparability without compromising within-site evaluation is a step toward that broader aim. Another was agreement that careful looks across rows for the technology adoption columns, less with a view towards ranking systems, and more with one towards gleaning common policy levers that might affect local land use systems more broadly, would, especially in cross-site analysis, yield important insights (and discussions in the workshop and in the field touched frequently on cross-site differences and similarities in this regard). Variation in the degree to which land use systems of interest were found 'on the landscape' and were stable came up repeatedly, not unrelated (as mentioned earlier) to the degree to which the study site was clearly a frontier area, or already a stable settlement.

This theme arose in conjunction with other important topics, some already touched upon in this report (for example, the need for the framework to handle both land use systems and activities, the challenges in defining best-bet technologies, etc.), others unmentioned but important, such as the nature of agricultural research vis-a-vis what is found in farmers' fields (and the interchange among agricultural research and farmer practices). The ASB analyses will need to devise ways to more clearly formulate and test hypotheses stemming from these observations; the site-specific descriptions of 'essential elements' as regards socioeconomic evaluation described in this document are a first step in that direction.