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IMPACT SYNERGIES, INSTITUTIONS, AND FOOD SECURITY: An Evaluation Methodology with Empirical Results*

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Content

ABSTRACT

With increasing investments on development programs, there are obvious concerns on their actual impacts. But, two key factors that influence the extent and sustainability of these impacts, though well known, continue to lack proper treatment both in the economic literature and in development policy. They are the roles that institutions play in impact generation and transmission and the impact synergies that a development intervention derives from the past, ongoing, and planned interventions. Exclusion of these factors is a serious problem, particularly in achieving *meta* development goals such as food security, where the realization of the final goal is linked with the progress of several intermediate but related goals of a hierarchy of programs spanning over sectors.

This paper develops and applies a methodology that explicitly captures the effects of institutions and development synergies within a unified framework and quantitative context. The framework is developed by (a) taking three development interventions (system rehabilitation, bulk water delivery, and crop diversification), (b) tracing their impact pathways and interaction points, (c) locating relevant institutions in these points and pathways, and (d) linking them all with the final goal of food security. This framework is, then, translated into a system of 21 sequentially linked equations using a set of development, institutional, and impact variables. The methodology is illustrated by taking the Kala Oya Basin in Sri Lanka as the empirical context and using perception-based qualitative information from 67 experts as the data source.

The estimation of the model provides considerable insights on the nature of both the roles that different institutions play at various points of the impact pathways as well as the synergies that a given development intervention derives from others. The derivatives of the reduced form equation with respect to different interventions and institutions are, then, used to numerically evaluate the development synergies and institutional impacts. The analysis shows that the synergies from bulk water delivery are relatively more than those of the other two. In terms of the marginal effects on food security, market institution has the highest effect, followed by others such as price regulation and trade policy. Unlike these institutions with a positive effect, there are others with a negative contribution such as land tenure and rural development policy. Although the results are based on the learned judgment of the experts, they still have qualitative significance and policy relevance as an indication of prevailing consensus on institutional roles and development impacts.

The paper adds significantly to existing understanding on institutional analysis, development planning, evaluation methodologies, and even, empirical procedures. From the perspective of practical policy, this paper has two main contributions. First, it demonstrates why and how it is important is to account for the development synergies and institutional impacts, which are possible from the past, ongoing, and future interventions when planning and implementation a new development in any given region. Second, it also provides a diagnostic tool both for locating the weak spots and slack links in various impact pathways as well as for identifying the institutions and impact chains that are to be strengthened to improve the impact flows of development programs.

Keywords: *Development Interventions, Food Security, Impact Pathways, Impact Synergy, Institutional Analysis, Institution-Impact Matrix, Kala Oya Basin, Millennium Development Goals, Perception Data, Sri Lanka, Stakeholder Evaluation.*

1. MOTIVATION AND CONTEXT

The motivation for this paper comes from two major gaps persisting both in the theory and practice related to the critical subjects of development impact and institutional analysis. First, there is a lack of proper treatment of the synergies inherent among development interventions (i.e., projects, programs, or policies) with closely related goals.[1] These synergies not just occur among ongoing interventions but even flow from those completed in the immediate past and planned for the near future. Accounting for these synergies is particularly important for realizing composite or *meta* development goals (e.g., Millennium Development Goals,[2] combating climatic change, and governance reforms), where the realization of the final goal is critically linked with the realization of several intermediate but related goals of a hierarchy of development interventions. Second, while the general development roles of institutions are being evaluated in various degrees, there is an insufficient attention on their roles in the specific context of impact generation and transmission. These two gaps are obviously serious in view of the error they could cause in development planning and impact assessment.

Ironically, the issue of the lack of or insufficient treatment of impact synergies and the institutional roles in development impact is not entirely new as are its consequences to development planning, impact assessment, and institutional analysis. But, the problem persist essentially due to the absence of an empirically applicable methodological framework that can bring together the multiple impacts pathways[3] of two or more development intervention within a

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[1] Note that the development synergies can be both positive and negative, depending on the nature of the development interventions considered together. These synergies relate only to the enhanced or reduced welfare effects of one intervention due to the externalities from the other interventions. Thus, these synergies capture the difference between the sums of their individual impacts when implemented in isolation and their joint impacts when implemented and evaluated together.

[2] The MDGs came from the Millennium Declaration adopted in 2000 by all 189 member states of the United Nations. As they set targets for countries to reduce poverty, hunger, disease, illiteracy, and gender bias and improve environmental sustainability and global governance by 2015, they are now accepted by the international development and donor agencies as a framework for monitoring development progress (*http://www.un.org/millenniumgoals/index.html*).

[3] The impact pathways capture the various routes through which an intervention affects its final goal. These routes can be characterized by a chain of sequentially and functionally related development, outcome/impact, and institutional variables. For instance, in the case of the food security role of an irrigation project, one pathway can be the chain of variables, i.e., irrigation—productivity—food output—food availability—food prices—food security. Besides this output pathway, there is also an income pathway, i.e., irrigation—cropping intensity—employment—wages—income—food security. Other similar paths can also be visualized and constructed. IN

common analytical framework and single evaluation context. Existing impact assessment approaches are of no or little help in view of their inherent analytical limitations.[4] Since they do not elaborate the impact process to capture the entire set of impact pathways, they also miss the opportunity to locate and evaluate the impact role of institutions in the specific contexts of different pathways. In view of their *ex-post* orientation and reliance on objective data, the existing approaches are also inherently unsuitable for contexts with multiple and time-lagged projects with continuing, lagged, and uncertain flow of impacts, where *ex-ante* approach and subjective information remain indispensable.[5]

This paper aims to develop and empirically illustrate a methodology that can directly capture both the development synergies and the institutional roles within a unified framework and quantitative context. The methodology is based on an analytical framework that traces the major impact pathways linking the interventions with the final development goal and characterizes these pathways in terms of sequential and functional linkages among the development, institutional, and impact variables. Since these linkages can be mathematically translated into a system of structurally linked equations, each capturing different impact pathways, the framework can be empirically applicable and quantitatively assessable. The practical application of this methodology is also demonstrated by taking (a) the Kala Oya Basin in Sri Lanka as the empirical context, (b) food security related to the first MDG as the development goal, (c) system rehabilitation, bulk water delivery, and crop diversification as the development interventions,[6] and (d) ex-ante qualitative information from a sample 67 stakeholders of the region as the data source.

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each of these paths, we can also include relevant institutional variables (e.g., production, extension, input, and market institutions, price regulations, and trade and rural development policies). This is illustrated in Figure 5 (where the pathways are traced and depicted) and in the system model (where they are formally characterized).

[4] For instance, a review of the available approaches, as presented and illustrated by Baker (2000) and reviewed in Bourguignon and Silva (2003), and Center for Global Development (2006), suggests that their main application is with respect to an individual project, policy, or intervention, their evaluation is in terms of their isolated impacts, and their focus is on the ultimate policy goal or few of their intermediaries.

[5] This fact plus the difficulties in getting adequate and comparable data on variables of different nature also point to the need to tap and use all forms of available information.

[6] Of them, system rehabilitation was already implemented, but bulk water distribution is being implemented only as a pilot in canal areas of the basin. Crop diversification, is only being planned, though the Government of Sri Lanka has a national policy to promote diversification.

From here, the paper is structured as follows. Section 2 demonstrates the welfare impacts of development synergies and institutional impacts, and shows the policy value of their *ex-ante* evaluation. Section 3 sets the conceptual foundation and the analytical framework of the proposed methodology and also describes the institution-impact matrix in a generic context. Section 4 describes the main physical and economic features of the Kala Oya Basin, Sri Lanka. Section 5 applies the institution-impact matrix to the development and institutional context of the study region. Section 6 presents and analyzes the results of the econometric models of institution-impact interaction and illustrates the role of institutional impacts and development synergies. The final section concludes with the analytical and empirical insights of the paper, the limitations of the present attempt, and the scope for it future extension and refinement.

2. IMPACT SYNERGIES AND INSTITUTIONAL ROLES: AN ILLUSTRATION

When selecting policies, policy makers usually make an *ex-ante* assessment of their effects both on total welfare and also on its distribution across groups.[7] But, the *ex-ante* issue of how this welfare and its distribution would change significantly if the roles of relevant institutions and synergies of related policies are ignored in such assessments. The policy value of such *ex-ante* consideration can be graphically demonstrated using Figure 1, which is an adaptation of a framework suggested by Just et al. (2004).

Figure 1 depicts a simple economy with two individuals (or groups), i.e., I (rich) and J (poor), who, with a given bundle of resources, can produce/consume two goods, i.e., food (F) and recreation (R). Given current technologies and institutions, the production possibility frontier for the economy is OP. Assume that the economy is in a status quo at $(i, j)^0$ with a corresponding welfare levels for the two-person society. J's welfare is: JF(0)+JR(0) and I's welfare is [P-JF(0)]+[O-JR(0)]. Now, suppose the government wants to take the economy towards the frontier OP and improve, thereby, both the total welfare and its distribution. For this, it considers two polices, which could *a priori* achieve such economic and social objectives, i.e., a 'dashed' (dashed line) policy intervention (D) and a 'solid' (solid line) policy intervention (S). As can be seen from Figure

[7] The distributional impacts are particularly important in policies, such as the MDGs, which, by their nature, target the special and disadvantaged population groups.

1, the ‘dashed’ policy intervention moves the economy from $(i,j)^0$ to $(i,j)^D$ and the ‘solid’ policy intervention moves the economy to $(i,j)^S$. Both policy interventions are Pareto optimal in the sense that they satisfy the condition of utility maximization for both individuals/groups. But, the ‘dashed’ policy is less efficient as it falls short of the production possibilities frontier (OP) and ends with an inner frontier, O’P’<OP. However, from a political economy perspective, the ‘dashed’ policy becomes the second best option and it can very well be the final policy choice of the government.[8]

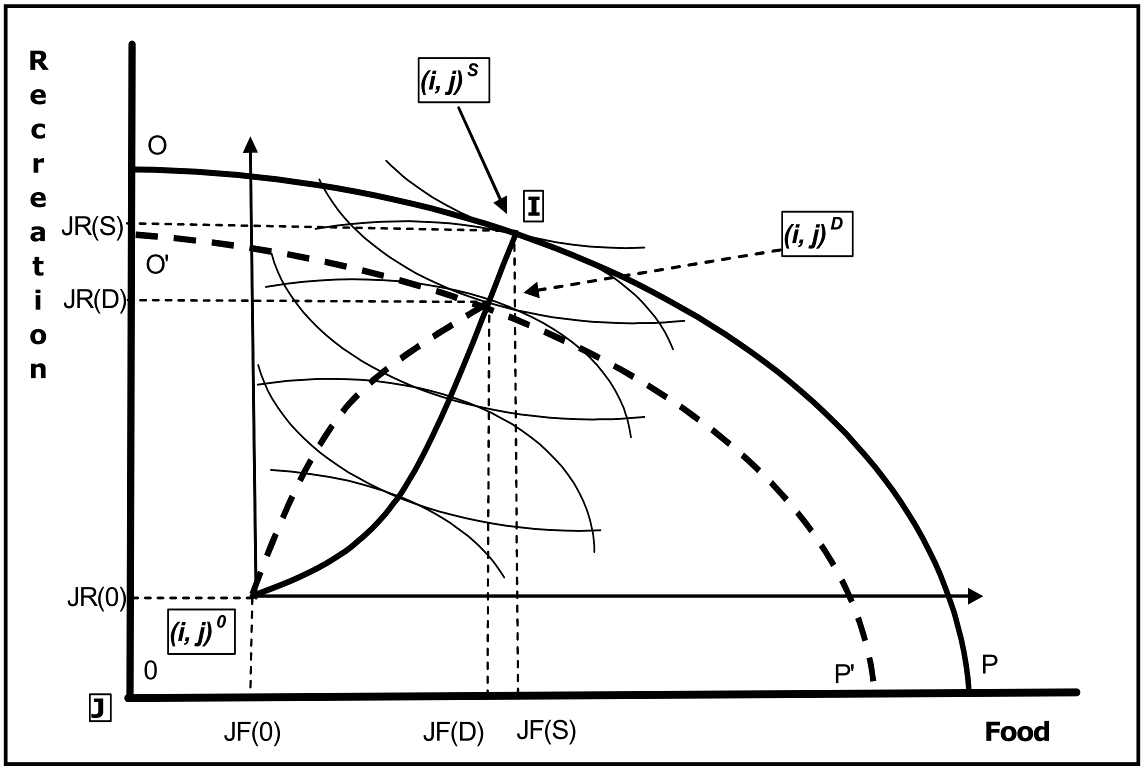

Figure 1: Evaluation of Alternative Policy Paths and Societal Welfare

In the discussion so far, the focus is on the welfare and distribution implications of two alternative policies. In this case, an *ex-ante* assessment of the development path and its economic implications is usually conducted with actual and expected information before the policy choice is made. But, such

[8] Although the ‘dashed’ policy is less efficient, it may be politically less controversial, as pressure from individual I (rich) may be less because the loss in I’s share is lesser with this policy than with the ‘solid’ policy. Thus, the ‘dashed’ policy can be a politically feasible second-best policy option.

assessments are not usually accounting for the impact externalities from related interventions and institutional facilitations. Using Figure 1, we can demonstrate how the welfare gains are missed when impact synergies and institutional roles are ignored. Let us assume that the economy is, again, in status quo at $(i,j)^0$. Suppose that a development intervention, say, an irrigation project, is implemented, leading to a development path represented by the dashed line and the economy attains a new equilibrium at $(i,j)^D$ on the production frontier O'P'. Clearly, the new equilibrium increases the welfare with more food and recreation. Suppose we also consider another program, say, crop intensification that is ongoing, implemented in the past, or planned for the near future. Since crop intensification enhances the welfare impacts of the irrigation-based intervention, the latter can receive considerable development synergies from the former intervention. When these impact synergies are taken into account, we will have a different production frontier and development path with a new equilibrium, say, at $(i,j)^S$. This new equilibrium, which accounts for the impact synergies, generates higher welfare and more equitable allocation.

In a similar vein, we can also demonstrate the welfare gains from incorporating institutional impacts. Suppose the irrigation-based development intervention is implemented in conjunction with the introduction of a water allocation institution (e.g., rotational water supply or volumetric water allocation). In this case, the production possibility frontier will shift outward and the development path will also change from the dashed line. To minimize notations and complications, let us consider the new production frontier is OP and the development path is the solid line. With this, the equilibrium will move from $(i,j)^D$ to $(i,j)^S$. The difference between the two equilibriums captures, in fact, the welfare gains of capturing the development impacts of institutions. What is to be noted in the context of impact synergies between development interventions is that although the economy is actually at a higher welfare level, project-based impact assessments are not able to fully account for them. The problem is still more serious in the context of institutional effects because the roles of institutions are not incorporated with proper detail within development planning itself let alone their impact assessment. Admittedly, the welfare effects of impact synergies and institutional roles are not that unknown to development planners. But, the reason why they are not addressed in the practical context of development planning relate to methodological problems, especially the analytical and informational difficulties in empirically accounting for them. In this paper, we aim to demonstrate one approach that can overcome these methodological and empirical difficulties by adopting an *ex-ante* approach and stakeholder-based qualitative data.

3. The Analytical Framework

The reality of impact synergies associated with multiple interventions and the roles that institutions play in enhancing and channeling these synergies obviously requires a major change in the way development impacts are assessed. What is needed is an analytical framework and evaluation methodology that is capable of capturing the individual and collective impacts of development interventions as well as the intrinsic roles of institutions in this impact process, particularly within a common analytical framework, single evaluation context, and quantitative perspective. Clearly, this is a major challenge because the required methodology has to be generic enough to transcend disciplinary boundaries, evaluation domains, and empirical limitations. But, with an open mind for unconventional but innovative approaches, one can develop such a generic methodology by selectively combining useful elements from existing methodologies used both in impact assessment and institutional analysis.

3.1. Building Blocks of the Methodological Framework

Although most impact assessment methods have analytical and empirical limitations, some of them do have useful methodological elements for the present purpose. One of them is the Method for Impact Assessment of Programmes and Projects (MAPP).[9] Despite its ability to allow an integrated evaluation of multiple interventions with stakeholder-based information, MAPP has few major but avoidable analytical and empirical limitations. First, it is not capturing the complete impact process between the interventions and the final goal. Second, the important roles of institutions, especially their interactions

[9] MAPP is a stakeholder-centred method involving an open approach and a seven-step procedure where the stakeholders are asked to award points on various aspects and criteria related to one or more development interventions and their impacts on development goals. See Susanne (2000 and 2006) for a detailed description of this method.

with other development and impacts factors are not incorporated. In fact, this problem emerges essentially from the first limitation. Finally but more importantly, the point-based evaluation used in this method allows a qualitative but not a quantitative analysis, for instance, with econometric tools.[10] The first two problems can be rectified with suitable extensions and adjustments of the analytical framework. The last one can also be solved with few intermediate steps to make the point system relative and comparable (see Susanne, 2006).[11]

The other method that has still more useful methodological inputs is the Poverty and Social Impact Assessment (PSIA) method.[12] Despite its focus on single intervention, PSIA not only focuses on few specific impact paths but also allows the use of stakeholder-based perceptional data and *ex-ante* analysis (see Coudouel, Dani, and Paternostro, 2006: 12). PSIA, with few adjustments, can provide some key elements for building a more generic and robust methodology. First, the number of impact channels pathways has to be increased to consider all major, if not all possible, impact pathways. This is essential to enrich the framework for capturing both the development synergies and institutional roles. Second, while PSIA recognizes the exogenous influence of institutional factors, it is necessary to explicitly incorporate them within the evaluation framework and analytically capture their interactions with other variables. Third, the *ex-ante* approach and stakeholder data are essential to deal with impact expectations and uncertainty. But, as long as the evaluation is done by the direct beneficiaries, there will be a serious bias, unless a neutral group of stakeholders are used for the evaluation (Coudouel, Dani, and Paternostro, 2006: 11).[13]

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[10] This is because the points awarded by stakeholders do not correspond to metric scale as there is no absolute zero to serve as benchmark.

[11] Another approach in this respect can be the use of a scale (e.g., 0-10) when performing stakeholder evaluation. The requirements and assumptions underlying the use of a scale for stakeholder evaluation are addressed in section 6.1.

[12] PSIA is a method for evaluating the distributional consequences of policy reforms on different groups in terms of the direct and indirect as well as the immediate and future impacts as transmitted through channels such as: prices and wages, employment, access to goods and services, assets, transfers and taxes, and authority. To account for the temporal differences and varying nature in the flow of reform impacts, the method combines secondary data and objective and perceptional data from a sample of intended beneficiaries/losers. See the Department of International Development and World Bank (2005) and Coudouel, Dani, and Paternostro (2006) for the description and application of this method.

[13] The PSIA is originally intended to be participatory. But, with an excessive focus on objective data and scientific quality, it has tended to become more technocratic (Coudouel, Dani, and

Besides the selective adjustments and use of relevant analytical and empirical elements from the impact assessment literature, the paper also combines some of the methodological elements from the institutional economics literature, particularly for capturing the institutional dimension of the required methodology. In particular, the analytical framework developed by Saleth and Dinar (2004) is also used explicitly account for the role of institutions within the process of impact generation and transmission.[14] The building blocks of this framework are: the *institutional ecology* principle, the *institutional decomposition and analysis* (IDA) approach [similar to that of E. Ostrom (1990)], the *ex-ante* approach, and the *adaptive instrumental evaluation* (Tool, 1977; Kahneman and Tversky, 1984; Bromley, 1985). While these concepts are elaborated in detail by Saleth and Dinar (2004) and described briefly in Annex-A, here, let us note how they are used to set the analytical framework for evaluating the institution-impact interaction. The institutional ecology principle enables one to view regional or river basin level institutions as a nested and interlinked system embedded within a given physical, social, and political economy context. The IDA framework allows an analytical unbundling of regional or basin institutions (i.e., water, land, agricultural and environmental) to identify their key components, show the structural and functional linkages among them, and trace the relevant institutional configurations operating beneath various impact pathways of different development interventions. As we will show later, the adaptive instrumental evaluation is used to provide theoretical support and practical justification for the reliance on perception-based *ex-ante* qualitative information collected from sample stakeholders.

3.2. Conceptual Model

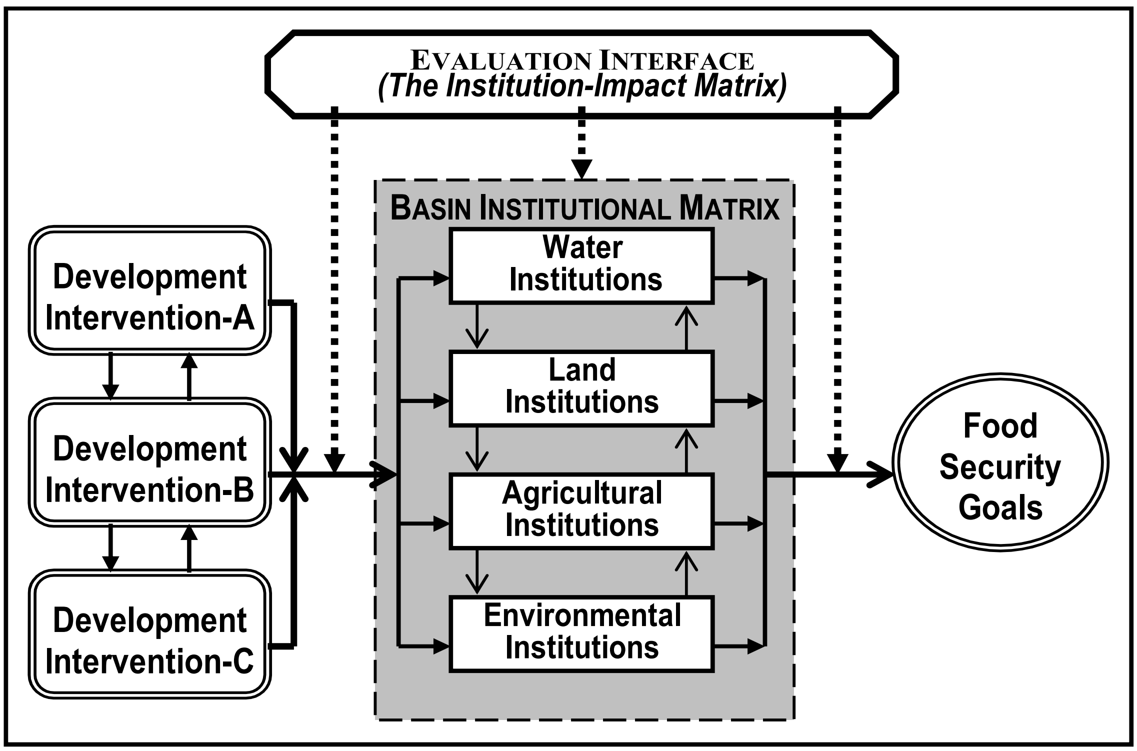
The development of the analytical framework begins first with the simple conceptualization of the relationships among the development interventions, institutional configurations, and food security goals. The basic conception of the model of institution-impact interaction is shown in Figure 2, which is too self-explanatory to require any special explanations. But, what is more important

Paternostro, 2006: 12), making it unable to capture the valuable information held by stakeholders, both beneficiaries and those involved in development research, planning, and implementation.

[14] A general application of this framework for a global ranking of institutional health and reform prospects within the water sector is illustrated in Dinar and Saleth (2005).

here is to note how the conceptual model can be operationalized to set the analytical framework of this paper. To operationalize this conceptual model, the original methodology of Saleth and Dinar (2004), which was developed for the particular context of institution-performance interaction within water sector, requires some important adjustments. The needed adjustments are:

Figure 2: Conceptual Frame for Institution-impact Interface



First, institutional evaluation is to be specialized within a regional context (e.g., river basin or other compact regions), where it is easier to (a) identify relevant development interventions, which are completed, ongoing, and planned (b) trace their major and theoretically possible impact pathways, (c) map all the relevant institutions operating at various points of these impact paths, and (d) evaluate the development impacts and institutional roles in various paths with contextual information.

Second, the evaluation is to be extended to cover not just water institutions but also the land, agricultural, rural, and economic institutions within an integrated framework. The focus is as much on the individual performance of these institutions as on their collective performance as evaluated in terms of their structural and operational linkages (North, 1990; Saleth and Dinar, 2004).

And, third, the evaluation has also to be performed within the framework of a multi-dimensional institution-impact matrix, which captures the impact pathways and their underlying institutions associated with different development interventions and relates the development impacts with the development goals within a functional context. The derivation of this multi-dimensional matrix, including its analytical implications, is illustrated in the following section.

3.2. Institution-Impact Matrix

The institution-impact matrix translates the conceptual model shown in Figure 2 into an operational form. This matrix captures the functional relationships and synergy among development interventions, impact pathways, institutional configurations, and food security goals. To illustrate how this institution-impact matrix can be derived for the context of multiple development interventions, let us take three development interventions, i.e., water development project (or dam construction), program for introducing a new crop variety, and watershed development program for land/soil improvement. These three interventions are related to each other not only in terms of their development synergies but also in terms of their direct or indirect impacts on the development goal, i.e., food security. The next step is to identify the major impact pathways of these three interventions and characterize the possible institutional configurations operating beneath these pathways. Given these impact pathways and their institutional configurations, the next step is to link them with the income, price, and resource components (or the intermediary targets) of the food security goal. As we put them together in a matrix form, as shown in Figure 3, we obtain the required institution-impact matrix. This matrix gives a generic operational form for the conceptual model depicted in Figure 2.

Development Intervention 3 (Watershed Development)

Development Intervention 2 (Introduction of New Crop Varieties)

Development Intervention 1 (Water Development Projects-Dams)

Impact Pathways	Institutional Configurations (*Defined by combinations of variables capturing the land, water, agricultural, and resource/environment institutions*)				Development Goals (*In terms of variables capturing poverty, food and resource conservation goals*)		
	Water Institutions	Land Institutions	Agricultural Institutions	Res/Env Institutions	Income/ Jobs	Food Price/ Output	Efficient Use of Resources
Irrigation	Water rights/ User organs ($$$)	Land tenure/ Tenancy ($$$)	Input system/ extension ($$$)	Water/soil quality codes ($$$)	($$$)	($$$)	($$$)
Regional Growth	Basin institutions ($$$)	Land markets ($$$)	Farm wage policy ($$$)	Pollution regulations ($$$)	($$$)	($$$)	($$$)
Urbanization	Sectoral water Allocation ($$$)	Farmland use rules ($$$)	Rural-urban markets ($$$)	Wastewater regulations ($$$)	($$$)	($$$)	($$$)
Water Supply	Pricing & cost recovery ($$$)	Property ownership ($$$)	Wastewater use practice ($$$)	Sanitation Policy ($$$)	($$$)	($$$)	($$$)
Ecological Effects	Project choice & scale ($$$)	Policy on commons ($$$)	Policies on fragile areas ($$$)	Forest laws & policies ($$$)	($$$)	($$$)	($$$)

Note: $$$ = Values of actual or perception-based information on one or more variables designed to capture both the status and effectiveness of each of the institutional aspects as well as the level of impacts on each of the food security aspects.

Figure 3: Institution-impact Matrix, a Simplified Presentation

Let us note few points that will enhance our understanding of the institution-impact matrix. First, it is only to simplify its exposition that the matrix includes only the main impact pathways of the development interventions.[15] Since the impacts in each of these pathways are transmitted through several routes, there will be more rows than five, each with different institutional configurations. Second, although each of the impact pathways (and their routes or channels) obviously involve the physical, agronomic, and economic variables, they are not shown in the matrix partly to avoid expositional complications and partly to highlight what sort of institutional elements can be involved in these impact pathways. Third, the institutional configurations

[15] For instance, in the case of water development intervention, we have included only five main paths, though, in reality, each of these paths will affect the development goals through several routes. For instance, the irrigation path will have different but related routes such as production route (i.e., irrigation-cropping intensity-productivity-food supply), income route (irrigation-productivity-employment-income), price routes (irrigation-production-food prices), resource routes (irrigation-waterlogging-salinity-land degradations), etc. Similar routes and the associated chain of variables can also be found for the other four impact paths.

specified for different impact pathways are not exhaustive but only illustrative. It only shows how different institutional configurations are involved in the generation and transmission of impacts passing through the pathways. Fourth, although the rows in Figure 3 show only the generic institutional aspects, it is possible to identify one or more specific variables to represent these aspects. With such variables as well as the variables underlying various impact routes of the pathways, it is also possible to characterize the interaction between institutional and impact variables.[16] And, finally, even though an institutional configuration involved in a given impact pathway is the same, the relative impact of individual institutions in that configuration can be different depending on the three sub-components or intermediary targets of the development goal.

In view of the points noted above, we can see that each row of the matrix implicitly has additional rows representing the various possible impact routes underlying different impact pathways. Since we have three intermediary targets goals, each of these rows also involves three separate but related relationships. That is, in these relationships, the impact and institutional variables will form the independent variables and the variable(s) representing the three goals will be the dependent variable. In this sense, all the rows corresponding to each of the three development programs can, therefore, be translated into an empirically testable set of relationships (equations), which capture the interactions among the development interventions, existing institutions, the interim impacts, and the ultimate impacts on the final goal. Obviously, the dimension of the matrix or the number of these equations depends on the number of development interventions, the impact pathways and their underlying impact routes, and the sub-goals being considered. This will become clear as we provide an empirical illustration of the application of this framework in a real life context of the Kala Oya Basin in Sri Lanka.

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[16] In the impact routes characterized by different chains of variables (see note 3), it is possible to include relevant institutional variables. For instance, production, input, and extension-related institutional variables can be added with the impact variables characterizing the production route. Similarly, institutional variables related to market, trade, and price regulation can be added with the impact variables underlying the price route. This will help us to formally and functionally capture the direct and interactive effects of the impact and institutional variables on the intermediary and final goals. We will see this more clearly in Section 5.

4. THE EMPIRICAL CONTEXT: THE KALA OYA BASIN, SRI LANKA

We apply the institution-impact assessment framework to the institutional and development context of the Kala Oya Basin in Sri Lanka (Figure 4). The Kala Oya Basin, which is one of the 108 basins in Sri Lanka, covers an area of 2,873 square kilometers and supports a population of about 0.41 million. Of the total land area of 287,303 hectares (ha), far less than a third is cultivable due to land and soil-related problems and water-related constraints. Paddy cultivation and home gardens with coconuts and fruit trees account for 40 percent of the cultivated area (de Silva et al., 2006). The average farm size is only about a ha in areas under minor irrigation and dryland farming, and less than half a ha in areas under major irrigation schemes. Besides, 27 percent of the population own only homestead and 11 percent of the population own neither land nor homestead (see Bandara, undated). On the demographic side, increasing population density and aging are the main the issues.

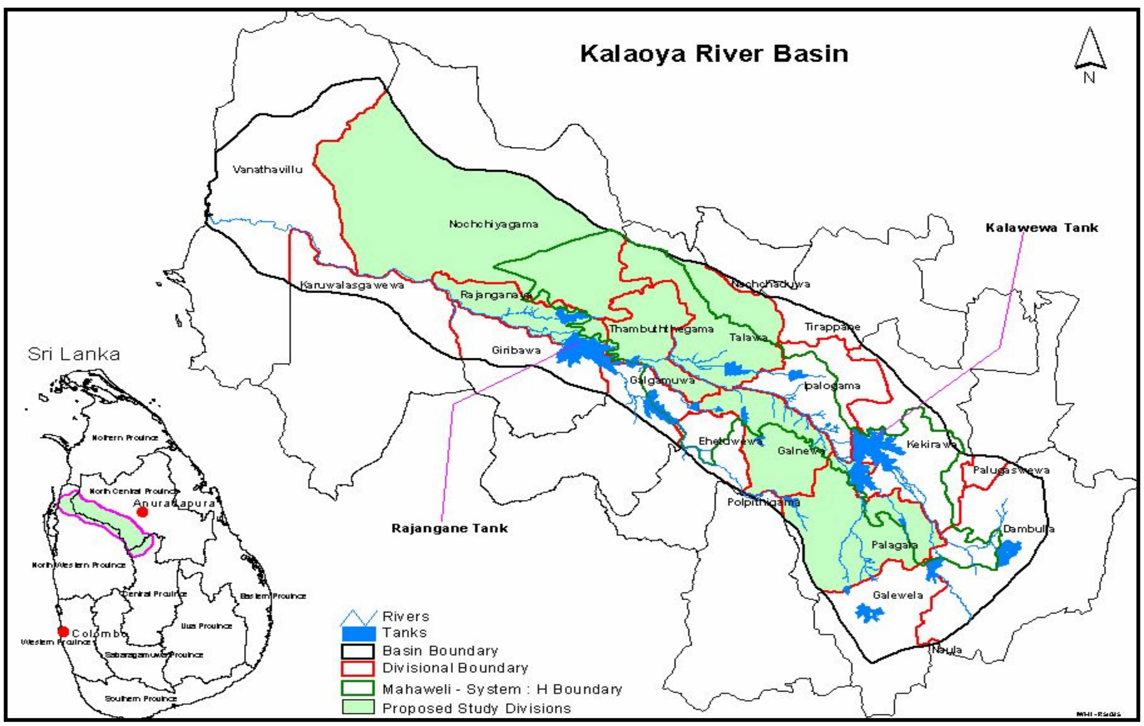

Figure 4: The Kala Oya Basin, Sri Lanka

Water scarcity is also serious due to low level and seasonal patterns of rainfall as well as groundwater quality problems. The Basin is generally dry for most part of the year with the rainfall ranging from less than 50 mm to about 300 mm. While the high level is being observed only during October and November, the low level is being observed for February, March, June, July, and August. With an annual local inflow of about 343 million cubic meters (mcm), the Basin also receives an annual diversion of about 480 mcm from the Mahaweli system. But, given the total demand of 1695.28 mcm, there is still a major gap, creating a serious water scarcity problem for the basin (see Bandara, undated; de Silva et al, 2006). The issue is getting complicated further by serious problems of groundwater quality caused hardness, fluoride, and iron concentration. Only 26 percent of the groundwater in the basin is completely free from fluoride and 40 percent of the groundwater is affected by unsafe iron concentration (Bandara, undated).

The incidence of poverty remains substantial in the basin. For example, in the Anuradhapura district, which accounts for half of the basin area, the percentage of people below the official poverty line (Rs. 1423 or US$14/capita/month) was estimated to be 20 percent during 2000-01 (de Silva et al., 2006). In addition, 44 percent of the families in the basin rely regularly on *Samurthi,* the poverty reduction program of the government. Food insecurity is also a serious problem, as many villages in the basin area fall under the most vulnerable categories of food insecurity (DCS and WFP, 2005). A more detailed review of the Basin's poverty level and the strategic reasons for its selection for our case study can be found in Saleth et al. (2007).

5. Empirical Specification of the Model

For the empirical translation of the matrix in Figure 3, what we need first are the development goal, few development interventions, and the relevant set of institutions. Considering the poverty levels and food insecurity conditions in the study area, we obviously selected food security, which is directly related to the hunger reduction target of the first MDG, as the development goal. As to the candidate development interventions, we selected three development interventions relevant for the study region, i.e., system rehabilitation (already completed) and bulk water delivery (being piloted), and crop diversification (potentially useful).[17] Given the development goal and interventions, it is now possible to trace and delineate some of the major pathways through which these interventions may affect food security. Given these impact pathways, it is also possible to identify the set of institutions (i.e., agriculture, water, and land-related legal, policy, and organizational aspects) that are likely to affect the generation and transmission of impacts at different points of the pathways. Figure 5 depicts these impact pathways and their underlying institutional configurations.

Before interpreting Figure 5, it is important to recognize that it shows only one of the many possible ways of conceptualizing the impact pathways. But, depending on the details required, it can be made richer (and also complicated) by adding more impact pathways and their underlying institutional and impact details. Although only few impact pathways are covered, Figure 5 is still able to capture the most important and policy-wise more relevant among them. Within this point in mind, we can see from Figure 5 how the interventions interact to generate the development synergies and also the specific point at which different institutions influence the impact flows. While it is normal to read the Figure 5 from left to right in line with the direction of pathways and impact flows, for analytical convenience, it is useful to move recursively, i.e., starting with the development goal, then, tracing back to its immediate and intermediate determinants till we reach finally the development intervention. In doing so, we can identify all possible impact pathways and channels evident in Figure 5. In view of their sequential and functional linkages, these pathways and channels can also be characterized as functional relations using appropriate chains of development, institutional, and impact variables defined in Table 1.[18] Thus, with the help of these variables, Figure 5 can also be equally represented in a mathematical from as a system of linked equations.

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[17] These interventions were actually selected from list of 16 interventions—both completed, ongoing, and potentially relevant in the particular context of the study region—based on the priority points of the sample stakeholders.

[18] The impact variables are actually the economic, technical, and physical variables that act as the 'impact transmission variables'. They are not to be confused with those in the impact assessment literature, where 'impact variables' relate only to the ultimate end-goals (see Neubert, 2000). In the context of our framework, it is still appropriate to treat them as impact variables because (a) they do capture the intermediary impacts (or, outcomes) and (b) such impacts are specifically evaluated using equations representing different impact layers.

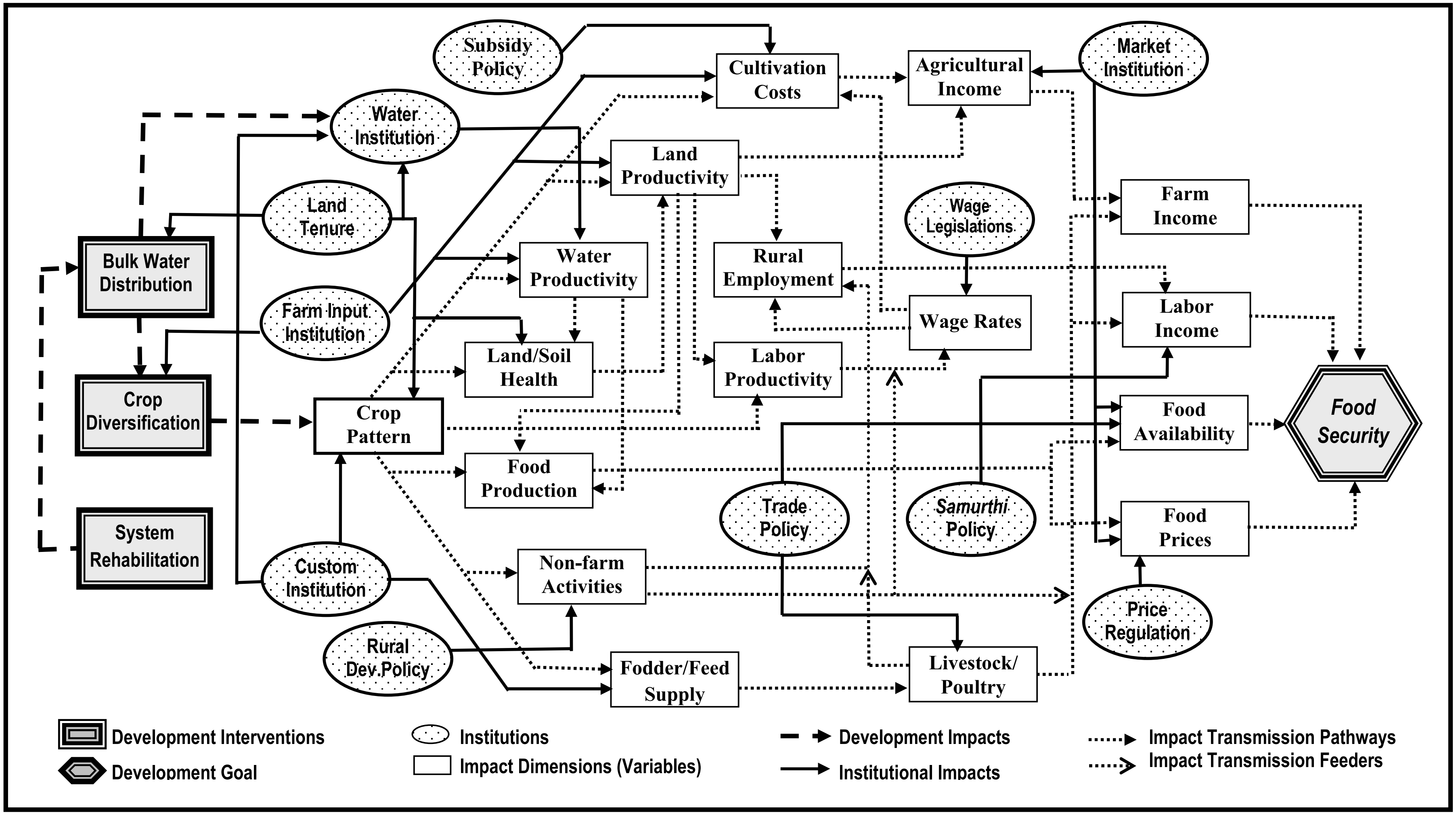

Figure 5: Institution-Impact Interactions with 3 Development Interventions

Table 1: Variables in the Institution-impact-Impact Model

Categories of Variables	No	Names of Variables	Acronym Used
Development Goal	1	Food Security	FOODSECT
Development Interventions	1	System Rehabilitation	SYSREHAB
	2	Bulk Water Distribution	BULKWATD
	3	Crop Diversification	CROPDIVR
Impact Variables	1	Crop Pattern	CROPATEN
	2	Land Productivity	LANPRODY
	3	Water Productivity	WATPRODY
	4	Labor Productivity	LABPRODY
	5	Rural Employment	RURALEMP
	6	Wage Rates	WAGERATE
	7	Cultivation Costs	CULTCOST
	8	Agricultural Income	AGLINCOM
	9	Land Quality/soil Health	LANHELTH
	10	Food Production	FOODPROD
	11	Non-farm Enterprises	NFAMENTS
	12	Fodder & Feed Supply	FEDSUPLY
	13	Livestock/Poultry	LIVSTOCK
	14	Farm Income	FAMINCOM
	15	Wage Income	LABINCOM
	16	Food Availability	FOODAVAL
	17	Food Price	FOODPRIC
Institutional Variables	1	Land Tenure	LANTENUR
	2	Water Institutions	WATINSTN
	3	Customary Institutions	CUSINSTN
	4	Farm Input Institutions	FAMINSTN
	5	Market Institutions	MKTINSTN
	6	Price Regulations	PRICREGL
	7	Wage/Labor Legislations	WAGELAWS
	8	Rural Development Policy	RDVPOLCY
	9	Trade Policy	TRDPOLCY
	10	Farm Subsidy Policy	SUBPOLCY
	11	*Samurthi* Policy	SAMPOLCY

As can be seen from Table 1, the variables cover one development goal variable and three intervention variables, 17 impact variables, and 11 institutional variables.[19] Obviously, the variables differ considerably in terms of their unit of measurement, evaluation domain, amenability for observation, and scope for getting actual data. To avoid the problems due to their diverse features, we conceive all the variables essentially in a notional and qualitative sense to be evaluated on an interval of 1-10, with 1 being the lowest and 10 being the highest.[20] In this format, the variables capture only the overall perception of the evaluators (i.e., sample stakeholders) as to their status, change, effectiveness, or impact. For example, the food security variable represents only an overall perception of its overall status considering implicitly, the adequacy and quality of food consumption across income/social groups.[21] Similarly, the variables representing the development interventions are considered to capture their overall effectiveness or impact potential.[22]

Institutional variables capture the status, effectiveness, or impact of institutions with respect to different impact pathways and contexts. For example, the variable LANTENUR captures the conduciveness of land tenure (farm size and ownership) to crop pattern changes, land productivity, etc. The impact variables capture the actual or expected changes due to the impacts of interventions and institutions in different contexts of impact generation and

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[19] Notice that the 17 impact variables also include the four variables, i.e., farm income, wage income, food availability, and food price, which are actually the intermediate goals linked immediately with the final goal of food security.

[20] Such an approach also enables us to circumvent the non-availability of data by tapping the knowledge of stakeholders with a carefully designed survey instrument. Note that in the case of quantitative variables (e.g., productivity, income, employment, and food consumption, these scores can be easily converted into quantitative equivalents by using the range of minimum and maximum values observed in the study area. But, in the context of cross-sectional regression and when using with qualitative variables (e.g., the performance and effects of most institutional variables) where performance scores are indispensable, the results will not be qualitative different whether one uses the scores or their quantitative equivalent for the quantitative variables.

[21] It is considered to be affected by four proximate variables, i.e., income, food prices, food availability, and self-consumption possibilities from home grown livestock/poultry products.

[22] The major assumption in getting perceptional information in terms of scores is that the sample stakeholders have, more or less, common reference points for their evaluation. These points related to the minimum and maximum values observed or expected in the case of quantitative variables such as productivity and income and the best or worst performance observed or expected in the case of qualitative variables such as the status and effectiveness of institutional variables and development programs. This assumption is reasonable if the sample stakeholders are well versed with the economic, technical, and institutional conditions of the region.

transmission. Among the income variables, a distinction is made between farm income (covering agricultural income and livestock incomes) and labor income (covering wage and livestock income) to capture the differential income potentials between those with and without access to land.[23] Given the set of variables listed in Table 1, the institution-impact framework in Figure 5 can be formally represented in a mathematical form with a set of following 21 equations that comprise the system model of institution-impact interaction.

BULKWATD = $\boldsymbol{f_1}$ (SYSREHAB, LANTENUR) .... [1]
CROPDIVR = $\boldsymbol{f_2}$ (BULKWATD, FAMINSTN) .... [2]
CROPATEN = $\boldsymbol{f_3}$ (CROPDIVR, LANTENUR, CUSINSTN) .... [3]
WATINSTN = $\boldsymbol{f_4}$ (BULKWATD, LANTENUR, CUSINSTN) .... [4]
WATPRODY = $\boldsymbol{f_6}$ (CROPATEN, WATINSTN, FAMINSTN) .... [5]
LANHELTH = $\boldsymbol{f_7}$ (CROPATEN, WATPRODY, LANTENUR) .... [6]
LANPRODY = $\boldsymbol{f_5}$ (CROPATEN, LANHELTH, FAMINSTN) .... [7]
FEDSUPLY = $\boldsymbol{f_{15}}$ (CROPATEN, CUSINSTN) .... [8]
LIVSTOCK = $\boldsymbol{f_{16}}$ (FEDSUPLY, TRDPOLCY) .... [9]
NFAMENTS = $\boldsymbol{f_9}$ (CROPATEN, RDVPOLCY) .... [10]
LABPRODY = $\boldsymbol{f_{10}}$ (LANPRODY, CROPATEN) .... [11]
WAGERATE = $\boldsymbol{f_{11}}$ (LABPRODY, NFAMENTS, WAGELAWS) .... [12]
RURALEMP = $\boldsymbol{f_{12}}$ (LANPRODY, WAGERATE, NFAMENTS, LIVSTOCK).......... [13]
CULTCOST = $\boldsymbol{f_{13}}$ (CROPATEN, WAGERATE, FAMINSTN, SUBPOLCY) .... [14]
AGLINCOM = $\boldsymbol{f_{14}}$ (LANPRODY, CULTCOST, MKTINSTN) .... [15]
FAMINCOM = $\boldsymbol{f_{19}}$ (AGLINCOM, NFAMENTS, LIVSTOCK) .... [16]
LABINCOM = $\boldsymbol{f_{20}}$ (RURALEMP, NFAMENTS, LIVSTOCK, SAMPOLCY) .... [17]
FOODPROD = $\boldsymbol{f_8}$ (CROPATEN, LANPRODY, WATPRODY) .... [18]
FOODAVAL = $\boldsymbol{f_{17}}$ (FOODPROD, TRDPOLCY, MKTINSTN) .... [19]
FOODPRIC = $\boldsymbol{f_{18}}$ (FOODPROD, PRICREGL, MKTINSTN) .... [20]
FOODSECT = $\boldsymbol{f_{21}}$ (FOODAVAL, FOODPRIC, FAMINCOM, LABINCOM) .... [21]

It can be verified that each of these equations correspond to one of the 21 impact pathways evident in Figure 5. The configuration of variables chosen for

[23] Note that unlike the convention in the west where agriculture is defined to include crop and livestock enterprises, here agriculture is defined to cover only crop cultivation.

each equation is based on two considerations: (a) the functional relationship expected between them and the independent variable as per economic reasoning and (b) the need for avoiding linkages among independent variables to minimize the scope for the econometric problem of multicollinearity.[24] As we look into the structure of the equations, it can be seen that they are arranged sequentially, starting with the initiation of the development interventions, then, with their impacts in the order of their occurrences, and finally, ending with the impact on the ultimate development goal, i.e., food security. Figure 6 depicts these sequential linkages among the equations.[25] Thus, the order in which the equations are sequenced captures the relative position of different layers within the upstream-downstream continuum of impact transmission. Given the functional linkages among variables and sequential linkages among equations, the impact and institutional variables can be hierarchically arranged by tracing their role and positions both within and across the impact pathways.

Another important aspect to be noted of the system model is that of the 32 variables, the 11 underlined variables are independent or exogenous (includes one of the development interventions—SYSREHAB and all the institutional variables except water institution—WATINSTN). But, the remaining 21 variables are dependent or endogenous covering 17 impact variables, two development variables representing respectively the two interventions of CROPDIVR and BULKWATD, and one institutional variable representing WATINSTN. Given the way all the 21 equations are specified in terms of the configuration of endogenous and exogenous variables, they satisfy both the rank and order conditions necessary for their econometric identification and unbiased estimation (Kennedy, 1987).[26]

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[24] These two considerations can be at odd because the economic consideration can warrant the inclusion of one or more independent variables, even though they may be closely related. Whether this leads to the econometric problem of multicollinearity can be tested using (a) correlation analysis of the independent equations and (b) indicators such as very high R^2, low t-ratio, and changing signs of some key variables. Note that the multicollinearity problem will neither affect the model fit nor the efficiency properties of the estimated coefficients.

[25] As we will see later when performing the sensitivity analysis, the sequential linkages depicted here will be basis for deriving the reduced form equation of the system model and also for tracing the marginal effects of all exogenous variables on other variables, including food security.

[26] The order condition requires that in the case of each equation, the number of excluded exogenous variables is greater than the number of included endogenous variables less one. In simple terms, this condition ensures that there are enough exogenous variables excluded so that

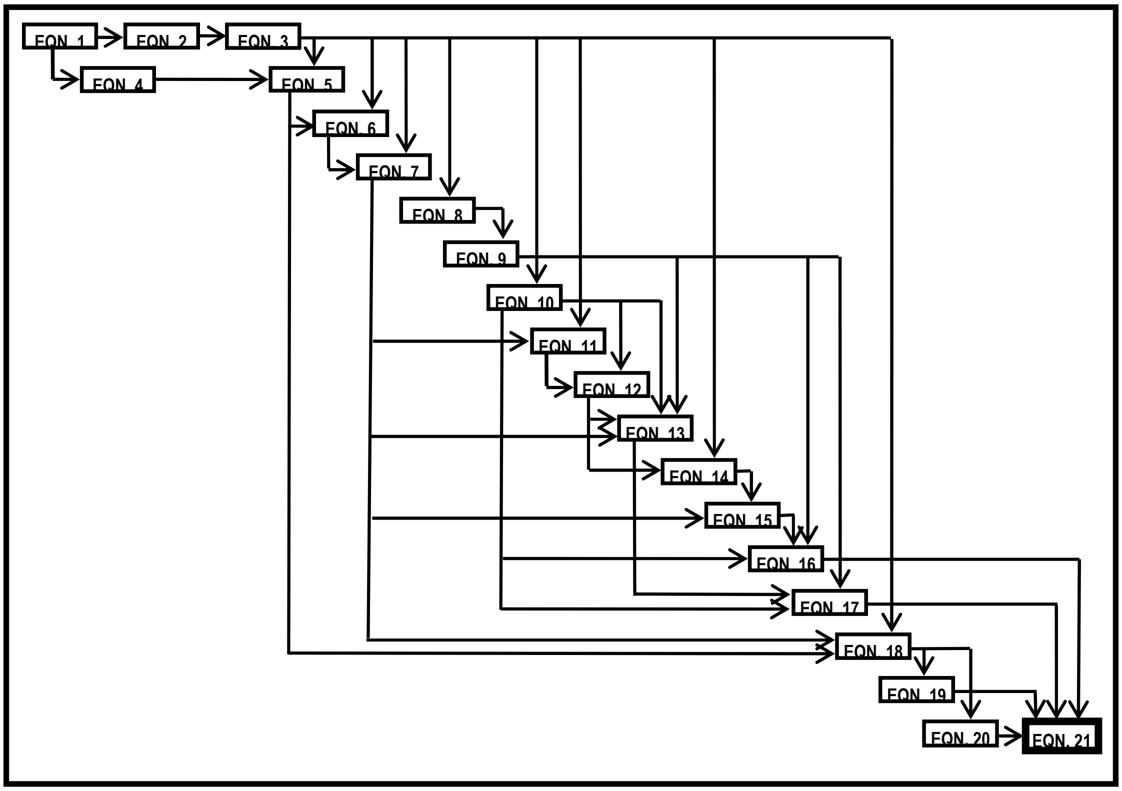

Figure 6: Structural Linkages within the Model

6. Data and Econometric Results

The system model with 21 equations is econometrically consistent and intuitively appealing, but it has a major empirical challenge. This is because of the fact that consistent and comparable data on both the development, institutional, and impact variables are very difficult to obtain. It is certainly possible to acquire observed data on some of the impact variables (e.g., productivity, employment, income, and wage rates) through, for example, published records or a household survey. However, information collected in such a manner will represent only the past impact of an already implemented development intervention and could not capture the synergy from the expected impacts of ongoing and planned intervention. Still more serious are the difficulties in getting the data on the institutional variables, especially on their diverse but specific roles in the

they can serve as instrumental variables for estimating the endogenous variable appearing as the dependent variable in each equation. The rank condition, though quite technical, requires, in simple terms, that all the equations are distinct in the sense that none of them can be formed with the linear combinations any other two equations in the system (see Kennedy, 1987: 138 & 142).

generation and transmission of development impacts. Since this study involves multiple institutions that transcend sectoral boundaries and vary across provinces, it is essential to select the study area to be entirely within a single jurisdictional boundary. Consequently, the evaluation is confined to the North Central Province, which accounts for 80 percent of the Kala Oya Basin selected for the study.

6.1. Stakeholder Perceptions as a Data Source

Lack or absence of data on most variables does not, however, mean a complete absence of information on institutional variables and their roles in development implementation. Such information are constantly processed and stored in people involved in the development process either as planners and implementers or as beneficiaries. Therefore, a carefully conducted survey can provide highly relevant information that individuals and society use regularly in making decisions. Such information embodied in individuals is particularly valuable for the analysis of institutional roles and development synergy because they have many desirable properties often missed in observed data. For example, unlike observed data characterizing a past and static situation, the survey data can capture and synthesize objective, subjective, and aspiration-related information. It is also theoretically legitimate in view of the subjective nature of institutions (Commons, 1934; V. Ostrom, 1980; Douglas, 1986; E. Ostrom, 1990) and the roles that the 'subjective model' of the 'agents of institutional change' play in institutional change and performance (North, 1990). As a result, there is a long tradition of using such data for institutional analysis (e.g., Knack and Keefer, 1986; Gray and Kaufmann, 1998; Barret and Graddy, 2000; Kaufmann, Kraay, and Mastruzzi, 2006). As noted already, qualitative data are also used in the case few impact assessment methods (Neubert, 2000; Coudouel, Dani, and Paternostro, 2006).

Perceptions can be used as an evaluation mechanism not only to synthesize variables in different domains but also to operationalize 'adaptive instrumental evaluation', where the outcomes are evaluated in positive and relative terms with respect to reference points that are not static but change with learning and expectations (Tool, 1977; Kahneman and Tversky, 1984;

Bromley, 1985). In view of these properties, perception-based information is similar in format and quality to those derived from alternative non-market data generation techniques such as 'Delphi', 'Contingent Valuation', and 'Stated Preference' (Saleth and Dinar, 2004). It is on the strength of these theoretical and practical considerations that this paper uses the stakeholder-based *ex-ante* qualitative information as a basis for the empirical evaluation of the model of institution-impact interactions.

Understandably, the empirical approach used in this paper is underpinned by two inter-related facts: (a) practically valuable information on the status and performance of institutions and on the spread and intensity of development impacts are constantly processed, updated, coded, and used in various forms and in many impact assessments and decision-making and (b) such real but latent information can be obtained with innovative procedures that explicitly recognize the central role of stakeholders both as change agents and as information source for the evaluation of institutional impacts and development synergies. Thus, the two key components of the empirical approach are 1) the selection of a suitable sample of stakeholders and 2) the elicitation of their perception-based information for all the variables in the structural model.

The sample of stakeholders selected for data collection includes 67 persons, who are directly involved in development planning, implementation, and evaluation in the Kala Oya Basin.[27] The sample covers government officials at different levels (32), researchers/academics (32), and farmers/community leaders (3).[28] The names of the respondents are listed in Annex-B. To collect the information on all the 32 variables included in the model, a special survey

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[27] Notably, these stakeholders, though knowledgeable about the region and its development process, are not all necessarily from the study region or the direct beneficiaries of the development interventions. This is partly to avoid the potential bias and partly to address the macro-micro dichotomy evident in empirical impact evaluation literature, i.e., micro evaluations report considerable impact whereas macro evaluations find little or no impact, or *vice versa* (Neubert, 2000; Coudouel, Dani, and Paternostro, 2006).

[28] Considering the technical nature of the analytical framework and the nature of the questions, the original plan was to cover only the government officials and experts in the sample. However, in the end, we also tried to test whether the questionnaire can be administered to farmers and community leaders. This is how the three farmers and community leaders were added to the sample. Since the experience shows that farmers and community leaders are able to understand and answer the questions well, the present exercise can very well be repeated with a sample exclusively of farmers and local leaders.

instrument was developed and administered to the sample of stakeholders in May 2006. The survey instrument is included as Annex-C. It shows how different variables are defined and how the data on them were derived from the answers to one or more questions. In most cases, the values of the variables were obtained as the average of the values for the related questions. Table 2 presents the descriptive statistics for the 32 variables.

Table 2: Descriptive Statistics for Model Variables

No	Endogenous Variables	Mean	Standard Deviation	Minimum	Maximum
1	BULKWATD	6.32	1.75	1.00	9.00
2	CROPDIVR	6.04	1.79	2.00	10.00
3	CROPATEN	5.60	1.00	2.79	7.57
4	WATINSTN	5.03	1.88	1.00	9.00
5	WATPRODY	7.29	1.42	4.00	10.00
6	LANHELTH	7.62	1.33	3.50	10.00
7	LANPRODY	6.84	1.40	2.63	10.00
8	FEDSUPLY	5.32	1.43	1.00	8.00
9	LIVSTOCK	3.64	1.62	0.90	7.90
10	NFAMENTS	7.07	1.29	2.25	9.50
11	LABPRODY	4.94	2.21	1.00	9.00
12	WAGERATE	6.10	1.27	2.50	8.50
13	RURALEMP	5.31	2.08	1.00	10.00
14	CULTCOST	5.66	1.68	1.00	8.00
15	AGLINCOM	6.90	1.49	3.00	10.00
16	FAMINCOM	5.50	1.09	3.00	9.00
17	LABINCOM	4.64	1.31	2.00	8.00
18	FOODPROD	5.22	1.23	2.33	7.67
19	FOODAVAL	5.24	1.36	2.50	8.50
20	FOODPRIC	4.37	1.31	1.50	7.50
21	FOODSECT	5.07	1.59	0.75	8.00
No	**Endogenous Variables**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
1	SYSREHAB	6.75	1.19	1.67	8.83
2	LANTENUR	6.20	1.15	3.56	8.33
3	CUSINSTN	4.71	1.28	1.40	7.60
4	FAMINSTN	5.52	1.68	1.00	9.00
5	MKTINSTN	5.10	1.35	1.67	9.33
6	PRICREGL	4.62	1.57	1.00	8.75
7	WAGELAWS	3.51	1.74	1.00	8.50
8	RDVPOLCY	5.07	1.85	1.50	9.00
9	TRDPOLCY	6.57	1.41	3.00	9.00
10	SUBPOLCY	6.82	1.38	3.00	10.00
11	SAMPOLCY	5.12	1.97	1.00	10.00

6.2. Model Results and Institution-impact Analysis

Before presenting the results, it is instructive to note the econometric background within which they are obtained. First, the specification test suggested by Hausman (1978) [29] was performed to select the appropriate functional forms for the model equations. This test was used to compare two models both with constant terms but with different function forms, i.e., linear and log-linear. Since this test suggested that the specification with linear form yields a more efficient and consistent estimates, we adopted this specification for the model. Second, we also performed a test for multicollinearity.[30] Although multicollinearity was not a serious problem with the model variables as such, we also tried to ensure that this is also true at the level of individual equations. The correlation matrix for variables at the equation levels suggest that in the context of many equations, few variables are highly correlated mainly with the constant term. To eliminate this potential for multicollinearity, we estimated all equations without the constant term.

With the same specification, i.e., the linear form with no constant term, we have also estimated two versions of the model of institution-impact interaction. The first is a single equation model, where food security is postulated as a simple linear function of all the remaining 31 development, institutional, and impact variables. This simple model, in fact, captures the conventional approach, which assumes away the specifics and dynamics of institution-impact interaction. The second version is the system model, which specifically captures the mechanics of impact generation and transmission in terms of 21 sequentially linked equations. By comparing the two models and their results, we can show both the realistic way of modeling and evaluating the

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[29] Essentially, the Hausman test checks econometrically whether the estimates of the coefficients of a model obtained from two different estimation procedures (i.e., different specifications, functional forms, and data transformations) differ significantly or not. This test ensures that the efficiency and consistency of the estimated results.

[30] Multicollinearity or correlation among independent variables, a common problem in structural linear models, can cause the estimates to be unstable (see Perloff and Shen, 2002; Hoetker and Mellewigt, 2004). To test for this problem, a correlation analysis, which is one of the normally used methods (Gujarati, 1995), was performed for the 32 variables. The correlation matrix showed that only in four cases (SYSREHAB vs. BULKWATD and WATINSTN, RURALEMP vs. FEEDSUPLY, and AGLINCOM vs. FAMINCOM) did the correlation coefficient was over the threshold of $r>0.5$ (see Hair et al. 1995). Since none of them were used together as independent variables in any equation, the multicollinearity can be taken not as a serious problem.

process of institution-impact interaction as well as the specific points in the impact pathways where different institutions have their influence on and interaction with other impact variables.

As to the estimation procedure, the single equation model was estimated using the Ordinary Least Square (OLS) method whereas the system model was estimated using the Three-Stage Least Squares (3-SLS) approach. The OLS results of the single equation model, which captures the conventional approach to institution-impact interaction, are provided in Annex-D. Since the single equation model postulates the development, institutional, and impact variables to directly influence food security, it is not able to characterize the actual paths and mechanics of the interactions and impacts. Consequently, as can be seen from Annex-D, the OLS results shows that none of the institutional variables is statistically significant and neither are the variables representing the three development interventions. Even among the 17 impact variables, only five are significant at the level of 20 percent or better. These significant impact variables are: LABPRODY, WAGERATE, AGLINCOM, FAMINCOM, and LABINCOM. Notably, all of them, except AGLINCOM, have the expected positive effect. The negative effect of AGLINCOM, especially given the positive effect of FAMINCOM, is clearly inconsistent with expectation, as it suggests a negative association between agricultural income and food security. This inconsistency taken with the insignificance of institutional and development variables clearly suggests the potential for serious anomalies when a single equation model is used to describe the reality of a complex set of sequential and simultaneous interactions among the model variables. This problem gets still more serious when the roles of institutions are treated superficially or exogenously missing the reality of their intricate and endogenous role within development process.

In contrast, the system model results presented in Table 3 demonstrate the additional policy insights that can be derived with a more realistic treatment of institutions, especially considering their mediating roles both in the generation and transmission of development impacts. Since Development impacts and institutions influence each other, the mediating roles can be seen better when the specific points at which these influences are fed within the process of impact

Table 3: System Model of Institution-Impact Interaction: 3-SLS Results

Eqn. No	Dependent Variables	Independent Variables	Estimated Coefficient	Asymptotic T-Ratio	Level of Significance	Elasticity at Means	R^2
[1]	BULKWATD	SYSREHAB	**0.886**	10.240	0.000	0.947	0.333
		LANTENUR	0.056	0.591	0.555	0.055	
[2]	CROPDIVR	BULKWATD	**0.594**	5.993	0.000	0.621	-0.366
		FAMINSTN	**0.385**	3.572	0.000	0.352	
[3]	CROPATEN	CROPDIVR	**0.438**	7.381	0.000	0.473	-0.354
		LANTENUR	**0.141**	1.897	0.058	0.156	
		CUSINSTN	**0.446**	7.107	0.000	0.375	
[4]	WATINSTN	BULKWATD	**0.851**	6.548	0.000	1.068	0.148
		LANTENUR	-0.014	-0.097	0.923	-0.017	
		CUSINSTN	-0.058	-0.465	0.642	-0.054	
[5]	WATPRODY	CROPATEN	**1.099**	8.446	0.000	0.845	-0.104
		WATINSTN	0.167	1.174	0.240	0.115	
		FAMINSTN	0.047	0.553	0.581	0.036	
[6]	LANHELTH	CROPATEN	**1.000**	4.747	0.000	0.736	-0.089
		WATPRODY	**0.358**	2.450	0.014	0.343	
		LANTENUR	-0.102	-0.800	0.424	-0.083	
[7]	LANPRODY	CROPATEN	**0.520**	2.323	0.020	0.425	0.285
		LANHELTH	**0.584**	4.039	0.000	0.650	
		FAMINSTN	***-0.093***	-1.515	0.130	-0.075	
[8]	FEDSUPLY	CROPATEN	**0.821**	7.167	0.000	0.864	-0.004
		CUSINSTN	0.152	1.160	0.246	0.134	
[9]	LIVSTOCK	FEDSUPLY	**0.613**	3.295	0.001	0.901	-0.686
		TRDPOLCY	0.028	0.192	0.847	0.052	
[10]	NFAMENTS	CROPATEN	**1.164**	20.910	0.000	0.922	-0.471
		RDVPOLCY	**0.107**	2.001	0.045	0.076	
[11]	LABPRODY	LANPRODY	-0.425	-1.230	0.219	-0.588	0.223
		CROPATEN	**1.413**	3.354	0.001	1.602	
[12]	WAGERATE	LABPRODY	0.138	1.158	0.247	0.111	-0.122
		NFAMENTS	**0.650**	8.605	0.000	0.753	
		WAGELAWS	**0.222**	2.969	0.003	0.128	
[13]	RURALEMP	LANPRODY	***0.671***	1.282	0.200	0.865	-0.120
		WAGERATE	***-0.450***	-1.474	0.141	-0.517	
		NFAMENTS	**0.752**	1.847	0.065	1.001	
		LIVSTOCK	**-0.515**	-2.931	0.003	-0.351	
[14]	CULTCOST	CROPATEN	-0.066	-0.134	0.893	-0.065	-0.337
		WAGERATE	**1.048**	1.905	0.057	1.130	
		FAMINSTN	-0.017	-0.105	0.916	-0.017	
		SUBPOLCY	-0.045	-0.312	0.755	-0.054	

Table 3 (Continued)

Eqn No	Dependent Variables	Independent Variables	Estimated Coefficient	Asymptotic T-Ratio	Level of Significance	Elasticity at Means	R^2
[15]	AGLINCOM	LANPRODY	**0.609**	3.963	0.000	0.605	0.030
		CULTCOST	**0.394**	2.909	0.004	0.323	
		MKTINSTN	0.097	0.950	0.342	0.072	
[16]	FAMINCOM	AGLINCOM	0.136	1.131	0.258	0.170	0.116
		NFAMENTS	**0.437**	3.773	0.000	0.561	
		LIVSTOCK	**0.412**	6.153	0.000	0.271	
[17]	LABINCOM	RURALEMP	**-0.437**	-2.545	0.011	-0.501	-0.649
		NFAMENTS	**0.550**	2.560	0.010	0.839	
		LIVSTOCK	**0.778**	5.153	0.000	0.608	
		SAMPOLCY	0.061	0.758	0.449	0.067	
[18]	FOODPROD	CROPATEN	**0.823**	5.501	0.000	0.883	0.400
		LANPRODY	**0.312**	1.949	0.051	0.409	
		WATPRODY	**-0.206**	-2.115	0.034	-0.287	
[19]	FOODAVAL	FOODPROD	**0.451**	2.816	0.005	0.449	0.149
		TRDPOLCY	**0.319**	3.629	0.000	0.400	
		MKTINSTN	***0.160***	1.426	0.154	0.156	
[20]	FOODPRIC	FOODPROD	**0.474**	4.329	0.000	0.566	0.096
		PRICREGL	**0.131**	1.812	0.070	0.139	
		MKTINSTN	**0.257**	2.504	0.012	0.300	
[21]	FOODSECT	FOODAVAL	**0.520**	2.280	0.023	0.538	-0.670
		FOODPRIC	**-0.965**	-2.932	0.003	-0.833	
		FAMINCOM	***0.767***	1.603	0.109	0.833	
		LABINCOM	***0.507***	1.622	0.105	0.465	
Sample Size							67
Endogenous Variables							21
Exogenous Variables							11
Right-hand side Variables							61
System R^2							0.878
Chi-Square (with 61 degrees of freedom, P=0.000)							140.900

Notes: (a) This model is estimated with no constant term in all equations.

(b) Bold coefficients are significant at 10 percent or better. Bold and italicized coefficients are significant at 11-20 percent.

(c) Elasticity at means are the weighted coefficients with the weights being the ratio of the means of the concerned dependent and independent variables, This standardization enables a comparison of the relative importance of the independent variables both within and across equations.

(d) Unlike OLS, where R^2 have the range of 0-1, the R^2 in the case of 3-SLS can be range from -∞ to 1. The relevant statistic to be considered in the case of 3-SLS estimation is the System R^2, which captures the explanatory power of the whole model. The Chi-Square is another statistic that constitutes a test of overall significance of the model.

transmission. From this perspective, the key aspect to note from Table 3 is the way both the institutional influences and the development impacts are transmitted across the equations. The operational mechanisms for such transmissions are obviously the sequential linkages among the equations (see Figure 6). Considering this fact, our interpretation of the results will proceed along the equations to show how the dependent variables in the initial and intermediate equations capture and transmit development synergies and institutional impacts onto the ultimate development goal of food security. In the process of such interpretation, we will also show how the relative magnitude and statistical significance of different institutional and impact variables can be used to indicate some of the possible weak spots and missing links both within and across the impact transmission pathways.

Before proceeding with the interpretation of Table 3, we note that the results presented have the necessary econometric credentials, particularly in terms of their efficiency, consistency, and stability properties as ensured both by the specification test and multicollinearity correction. Despite a low R^2 for individual equations, the System R^2 is relatively high and Chi-Square statistic is statistically significant, suggesting the overall explanatory power of the model as a whole. These econometric properties do suggest that the model has fitted well the data, but what is more important for the interpretation of the results are the implications of the nature of the data source being used. Since the data is based on stakeholders' perception, the regression coefficients provide a statistical representation of the prevailing consensus on the effects of different variables. For that same reason, the coefficients capture the effects of both the perceived objective reality but also the expressed subjective expectation of the stakeholders. With these points in mind, let us begin with the interpretation of equation-specific results along with their system level implications.

Equations [1] and [2] capture the potential impact synergies among the three development interventions.[31] As per the results, these synergies are both positive and statistically significant. In Equation [1], SYSREHAB, the physical

[31] As we will show later quantitatively, these synergies also percolate through the rest of the equations since these development variables interact with other variables in the system.

intervention that can improve the performance of water infrastructure, has a significant positive effect on the BULKWATD, the institutional intervention that can improve water distribution. As can be seen in Equation 2, BULKWATD, in turn, has a significant positive effect on the agricultural intervention of CROPDIVR, suggesting that bulk water allocation enhances the prospects for crop diversification.[32] As to the role of institutional variable in these equations, unlike the LANTENUR in Equation [1], FAMINSTN in Equation [2] is significant and also has a positive effect. This suggests that land tenure is not at all a constraint for bulk water distribution whereas farm institutions related to input supply and extension have a facilitative role in crop diversification.

The results of equations [1] and [2] suggest that the infrastructural and institutional factors are conducive for crop diversification in the region. But, it is important to see whether such a diversification prospect is actually translated in terms of changes in existing crop pattern. Obviously, the extent of crop pattern changes depends not only on the effectiveness of the crop diversification intervention but also on the role of institutional factors such as land tenure and customary practices in crop choice. The results for Equation [3] show that all the three variables—representing both the CROPDIVR intervention and the CUSINSTN and LANTENUR institutions—have significant positive effects on CROPATEN. Since CROPATEN captures the extent the food crops dominate the existing crop pattern, the positive effects of both CUSINSTN and LANTENUR are understandable in view of the fact that both customs and farm size favor food crops. But, the positive effect of CROPDIVR means that the diversification intervention even when it is actually implemented in the region will not be able to alter existing food crop dominated crop pattern. In effect, this suggests the powerful role of customs and other economic and institutional constraints.

Equation [4] captures the effects that bulk water delivery, land tenure, and customary institutions have on the overall functioning and performance of water institution. As expected, the intervention of bulk water delivery has a positive and highly significant effect on water institutions, suggesting its

[32] The result is somewhat surprising because the bulk water provision, as being piloted in the study region, is only to farmer groups and not to individual farmers as needed for promoting independent crop decisions.

potential role in strengthening user organizations and promoting orderly water distribution. But, both the customary practices and land tenure system have a negative but non-significant effect, which means that these two institutions do not pose any problem to the functioning of water institutions. Equation [5] evaluates the relative role of factors affecting water productivity. The results for this equation shows that of the three variables postulated to affect WATPRODY, only CROPATEN is significant with a positive effect. Despite their positive effects, both WATINSTN and FAMINSTN remain insignificant. This means that water productivity is perceived to depend not on the water and farm-related institutions but only on the food-crop dominated crop pattern.[33]

It can be seen in Equation [6] that of the three variables expected to affect LANHELTH, both CROPATEN and WATPRODY have significant positive effects whereas LANTENUR has a negative but insignificant effect. This result is understandable partly because the biomass of cereals, especially paddy straw, is commonly used for mulching and partly because higher water productivity is likely to lead to efficient water use favorable for soil conservation. Equation [7] provides statistical evidence for the relative role of physical, agronomic, and institutional factors in determining land productivity. Although the result shows all the three variables to be significant, only the two physical and agronomic variables, i.e., land and soil health and crop pattern, have the expected positive effect. Notably, FAMINSTN, the variable capturing the overall effectiveness and performance of farm input and extension institutions, has a negative effect. This clearly means that these institutions, though have the capacity to perform routine roles as well as to support crop diversification (see Equation [2]), are not tuned well to make a difference either in water productivity (see Equation [5]) or in land productivity (see Equation [7]). From a policy perspective, the results also suggest that the farm institutions related to input supply and extension systems need to be reoriented and strengthened, particularly to enhance their performance in their productivity enhancing roles.

[33] This result seems to contradict the expectation that water productivity, especially in value terms, will be higher with non-food and commercial crops. But, given the ineffectiveness of crop diversification policies, the weakness of water and farm institutions, and the low physical productivity and poor market institutions for non-food crops, this result need not be surprising.

The results for Equation [8] show that of the two variables expected to affect the feed supply potential, only CROPATEN has a positive and statistically significant effect on FEDSUPLY. CUSINSTN, the other institutional variable included in this equation has a positive but insignificant effect. What this results suggest is the fact that the cereal-dominated, especially paddy-dominated, crop pattern obviously contributes to feed and fodder supply in terms of crop residues whereas the potential roles of customary institutions in preserving areas and maintaining rules for open grazing and biomass collection need to be strengthened. This is another instance of institutional gaps, the correction of which requires policies and programs to revive and strengthen local level customary institutions for managing common pool resources. The importance of enhancing the supply of feed supply from a better utilization of the biomass both from crop residues and from common grazing lands is underlined further by the results for Equation [9]. Of the two variables included in this equation, only FEDSUPLY is significant with the expected positive effect on the prospects for livestock development (LIVSTOCK). But, TRDPOLCY, the institutional variable capturing the effects of the policy of importing milk and other dairy products, though widely considered to be a major deterrent for the livestock development in the country, is not at all significant.[34]

The results for Equation [10] provide an interesting aspect of the linkage between farm and non-farm activities observed in the study region. The statistically significant positive effect of CROPATEN suggests that existing crop pattern dominated by food crops has a significant positive effect on the prospects for rural non-farm enterprises. This is mainly due to the fact that most non-farm activities observed in the study region are linked to the processing and marketing of food crops, especially paddy. Such dependence is obviously not conducive for the expansion and diversification of the rural non-farm sector. Nevertheless, the significant positive effect of RDVPOLCY indicates that active rural development policies have the potential to substantially contribute to the growth and diversity of rural non-farm options. In Equation

[34] This implies the consensus among the sample of experts that the main constraint here comes more to the lack of a concerted national policy for livestock development than the trade-related external policies.

[11], it is interesting to note that labor productivity depends not on land productivity but mainly on crop pattern. The direct relation between crop pattern and labor productivity requires a more careful interpretation.[35] But, the lack of association between the two productivity variables is easy to explain. That is, with the similar crop pattern and productivity levels, land productivity may not explain well the variations in labor productivity.

In Equation [12], among the three variables postulated to affect WAGERATE, only NFAMENTS and WAGELAWS are significant with the expected positive effects. Notably, LABPRODY is not at significant suggesting the prevailing wage rates are not related much to labor productivity. In contrast, non-farm activities have a strong effect on wage rate both due to their influence on both rural labor demand and rural wage levels. Similarly, the institution of formal state regulations and informal local conventions governing wage levels and working conditions also have a positive effect wage rates. Coming to equation [13], all the four variables included in this equation have a statistically significant effect on RURALEMP. However, as expected, two of them (i.e., LANPRODY and NFAMENTS) have a positive effect whereas the other two (i.e., WAGERATE and LIVSTOCK) have a negative effect. Notably, land productivity, which had an insignificant effect on labor productivity in Equation [11], has here a significant positive on rural employment. The positive employment effect of NFAMENTS is consistent with the results in Equation [12]. While the negative coefficient for WAGERATE implies both the higher levels of wage rates and the same for labor scarcity, the same for LIVSTOCK suggests that livestock expansion, though good for rural income, can also aggravate labor scarcity.[36]

The results for Equations [14] show that cultivation cost has a strong positive linkage only with the wage rate. This confirms with the general concern

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[35] Note that the strong positive effect of CROPATEN on LABPRODY cannot be interpreted simply as food crops are more conducive for labor productivity. It needs to be explained in the light of the inverse relation between WAGERATE and RURALEMP seen in Equation [13], which means that high wage limits labor use and with a given farm productivity, lesser labor use causes labor productivity to be higher than otherwise. It is this effect occurring in the face of a labor scarcity and paddy domination that is behind the positive association seen between CROPATEN and LABPRODY.

[36] The inverse relation between RURALEMP and LIVSTOCK suggests the tradeoff in labor time allocation between wage employment and livestock rearing, which is particularly so among the groups which need both sources of income.

in the study region about the cost implications of higher wage rates. Notably, all the other three variables, i.e., CROPATEN, FAMINSTN, and SUBPOLCY, have negative but non-significant effect on cultivation cost. Although not significant, the negative effect of FAMINSTN and SUBPOLCY does suggest their potential role in reducing cultivation costs. Indeed, this is another case where improving the performance of institutions (i.e., farm institutions, especially in terms of their roles in delivering farm inputs at reasonable cost and subsidy policy, especially in terms of their design and targeting) can enhance the development impact. Turning to Equation [15], AGLINCOM, which represents the income only from farm operations, is influenced positively by both land productivity and cultivation cost. The positive effect of CULTCOST, unlike that of LANPRODY, is unexpected, particularly given the prevailing concern in the study region in particular and the country in general regarding the economic viability of farming in the face of rising cultivation costs. But, as we recognize the possibility for rising level of crop income to coincide with increasing cultivation costs, the result does not any reduction in net income as long as land productivity and crop price levels have a dominant and neutralizing effect.

Equations [16] and [17] evaluate the relative size, sign, and significance of the relative effects of the factors influencing respectively the income levels of farmers and landless farm workers. Equation [16] evaluates the relative effects of AGLINCOM, NFAMENTS, and LIVSTOCK on farmers' income (FAMINCOM). The results show that although all three variables are positive, only NFAMENTS and LIVSTOCK are significant. This is not to be interpreted as agricultural income is unimportant for farmers. What this means actually is the fact that with a more or less stable income from farming, the other two sources of income are more important in terms of their incremental impact on farmers' income. As can be seen from Equation [17], the incremental impact of these two sources on the income of farm workers is still more pronounced, suggesting livestock and non-farm options are much more important as income sources for landless workers. Importantly, RURALEMP has a significant negative effect. This can be partly due to the inverse association between wage rate and rural employment seen in equation [13] and partly due to the fact that more farm employment can reduce the days available for relatively attractive non-farm and livestock activities causing, thereby, a fall in total labor income. Notably, SAMPOLCY, the variable representing the payment under the government's poverty alleviation program of *Samurthi* meant for landless workers, is insignificant, though has a positive effect. From an overall perspective, the results of equations [16] and [17] provide a clear evidence for the fact that despite their low level of development in the study region, non-farm and livestock sectors are very important income sources for both farmers and workers.

The next set of three equations captures the relative role and significance of the variables affecting respectively the three key determinants of food security, i.e., food production, food availability, and food prices. In Equation [18], the statistically significant positive effect of CROPATEN and LANPRODY indicates the obvious fact that a crop pattern dominated with food crops and a higher level of land productivity contribute directly to food production. The results for Equation [19] are on the expected lines as food production, trade policy, and market institution are all have a positive and significant effect on food availability. But, the same for equation [20] are contrary to expectation because food production, price regulation, and market institution, which are supposed to discipline food prices, are all significant with a positive effect. However, this result is not entirely inconsistent as it only shows the reality that food prices can continue to rise despite increasing food production either due to hoarding or due to a higher gap between food demand and supply. The results also suggest that the procurement, distribution and price related regulations as well as the market mechanisms in the context of the study are not really effective in moderating food prices. Here is another case where improvement in institutional performance can vastly contribute to development impact.

Equation [21] is the ultimate equation in the system, as it brings together various direct and indirect effects of the development, impact, and institutional variables flowing through all the previous equations and also link them with the final development goal of food security. The results for this equation show that all the four variables are significant and have the expected signs. The positive sign for FOODAVAL, FAMINCOM, and LABINCOM suggests clearly that better food availability and higher income will directly strengthen food security. The negative sign for FOODPRIC, on the other hand, means that lower (higher) prices will enhance (reduce) food security. But, as we consider the relative size of the coefficients, the price effect is much more important than the supply and income effects. Similarly, among the income variables, farm income is more important than labor income. This result is important as it shows clearly that food security depends more on food prices and farm income than on food availability and labor income. Another implication here is that food security is stronger among people with access to land than among those without that access.

6.3. Tracing Development Synergies and Institutional Effects

So far, the attention was focused mainly on the relative role and significance of the development, institutional, and impact variables in the context of each of the individual equations within the system model. Now, let us show the system level effects of the local effects of different variables within individual equations. To show this analytically and numerically, we can form a reduced form single equation for the system model utilizing the sequential linkages evident among the model equations (see Figure 6). The derivation of the reduced form equation is shown in Annex-E. As can be seen, the reduced form equation shows food security, the ultimate dependent variable of the system model, as a function of all the previous equations with their characterizing variables and embedded linkages. By differentiating this reduced form equation with respect to different variables and substituting the estimated coefficients from Table 3, we can numerically calculate how the marginal effects of different development and institutional variables are being captured at subsequent levels and getting consolidated finally at the ultimate dependent variable.[37] It is this exercise that is used here to trace and quantify the impacts of development synergies and institutional effects on all the endogenous or dependent variables in the system. Tables 4 and 5 show respectively how the impacts of development synergies and institutional effects are captured by the 21 exogenous variables.

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[37] Since the reduced form is an equation of equations, when it is differentiated with respect to a given variable, the effect will not only be on the equation where this variable appears as an argument but also be on all the other equations where the dependent variable of this equation appears as arguments. As a result, the calculation of the total effect due to a change in a given variable involves either the multiplication of intermediate coefficients (when the relevant equations are embedded) or the addition of relevant coefficients (when the equations are separate). The former case involves a single impact channel but the latter case involves multiple impact channels.

Table 4: Size and Flow of Development Impacts and Synergies

Endogenous Variables	Equation Numbers	Development Interventions			Total Effects Received
		System Rehabilitation	Bulk Water Delivery	Crop Diversification	
BULKWATD	***y1***	0.886	-	-	0.886
CROPDIVR	***y2***	0.526	0.594	-	1.120
CROPATEN	***y3***	0.231	0.261	0.438	0.930
WATINSTN	***y4***	0.754	0.851	-	1.605
WATPRODY	***y5***	0.379	0.427	0.481	1.287
LANHELTH	***y6***	0.366	0.346	0.172	0.884
LANPRODY	***y7***	0.334	1.289	0.583	2.206
FEDSUPLY	***y8***	0.189	0.213	0.395	0.797
LIVSTOCK	***y9***	0.116	0.130	0.220	0.466
NFAMENTS	***y10***	0.268	0.302	0.509	1.079
LABPRODY	***y11***	0.374	0.035	0.522	0.931
WAGERATE	***y12***	0.280	0.310	0.484	1.074
RURALEMP	***y13***	0.229	0.261	0.426	0.916
CULTCOST	***y14***	0.278	0.417	0.655	1.350
AGLINCOM	***y15***	0.313	0.106	0.166	0.585
FAMINCOM	***y16***	0.262	0.081	0.137	0.480
LABINCOM	***y17***	0.275	0.782	0.249	1.306
FOODPROD	***y18***	0.239	0.296	0.390	0.925
FOODAVAL	***y19***	0.108	0.133	0.176	0.417
FOODPRIC	***y20***	0.113	0.140	0.185	0.438
FOODSECT	***y21***	0.011	0.226	0.395	0.632
Total Effects Generated		6.531	7.200	6.583	20.314

Table 5: Size and Flow of Institutional Impacts

Endogenous Variables	Equation Number	Institutional Variables										Total Effect Received
		LANTENUR	CUSINSTN	FAMINSTN	MKTINSTN	PRICREGL	WAGELAWS	RDVPOLCY	TRDPOLCY	SUBPOLCY	SAMPOLCY	
BULKWATD	*y1*	0.056	-	-	-	-	-	-	-	-	-	0.056
CROPDIVR	*y2*	0.033	0.385	-	-	-	-	-	-	-	-	0.418
CROPATEN	*y3*	0.156	0.446	0.169	-	-	-	-	-	-	-	0.771
WATINSTN	*y4*	0.034	-0.058	-	-	-	-	-	-	-	-	-0.024
WATPRODY	*y5*	0.177	0.481	0.232	-	-	-	-	-	-	-	0.890
LANHELTH	*y6*	0.117	0.618	0.252	-	-	-	-	-	-	-	0.987
LANPRODY	*y7*	0.149	0.593	0.142	-	-	-	-	-	-	-	0.884
FEDSUPLY	*y8*	0.128	0.518	0.139	-	-	-	-	-	-	-	0.785
LIVSTOCK	*y9*	0.078	0.318	0.085	-	-	-		0.028	-	-	0.509
NFAMENTS	*y10*	0.181	0.519	0.196	-	-	-	0.107	-	-	-	1.003
LABPRODY	*y11*	0.145	0.648	0.129	-	-	-	-	-	-	-	0.922
WAGERATE	*y12*	0.119	0.493	0.111	-	-	0.222	0.015	-	-	-	0.960
RURALEMP	*y13*	0.140	0.391	0.148	-	-	-0.114	0.073	-0.013	-	-	0.879
CULTCOST	*y14*	0.114	0.487	0.088	-	-	0.233	0.016	-	-0.045	-	0.427
AGLINCOM	*y15*	0.136	0.553	0.121	0.097	-	0.092	0.006	-	-0.018	-	0.987
FAMINCOM	*y16*	0.146	0.498	0.147	0.040	-	0.038	0.049	0.004	-0.007	-	0.915
LABINCOM	*y17*	0.174	0.451	0.186	-	-	-0.089	0.116	-0.022	-	0.061	0.877
FOODPROD	*y18*	0.152	0.395	0.182	-	-	-	-	-	-	-	0.729
FOODAVAL	*y19*	0.069	0.178	0.082	0.319	-	-	-	0.160	-	-	0.808
FOODPRIC	*y20*	0.072	0.187	0.086	0.131	0.257	-	-	-	-	-	0.733
FOODSECT	*y21*	-0.003	0.055	0.004	0.332	0.130	0.106	-0.086	0.146	-0.004	0.059	0.739
Total Effects Generated		2.373	8.156	2.499	0.919	0.387	0.250	0.296	0.329	-0.074	0.120	15.255

Table 4 shows the size and flow of the marginal impacts of the three development interventions across the equations. These marginal impacts cover not only the effects of synergies among the interventions but also the effects of improved effectiveness and performance of individual interventions. Given the way the sequential interactions among the interventions are conceptualized,[38] the flow of the synergy among them is unidirectional, i.e., from system rehabilitation to bulk water policy and, then, from the latter to crop diversification. As per the results in Table 4, the value of synergy derived by bulk water policy from system rehabilitation is 0.886. But, crop diversification derives synergies both directly from bulk water policy (i.e., 0.594) and also indirectly from system rehabilitation through its synergy on bulk water policy (0.526).[39] Since crop diversification, unlike bulk water policy, has two routes for synergies, its total development synergy is equal to 1.200, which is more than that of bulk water supply. However, the development externalities for both bulk water policy and crop diversification are substantial and from a policy perspective, they can be improved with a better and more effective monitoring and implementation of related development interventions.

More importantly, the development synergies flow throughout the system because they are being captured by many, if not all, the intermediate variables and are getting finally transmitted to the ultimate variable of food security. As noted above, besides the synergy effects, these variables also capture the effects of improvement in the performance of the individual interventions as well. That is, the effects captured by the intermediary and final variables are actually the combined effects of both the individual and collective performance of the three interventions with an effective implementation and coordination. As can be seen from Table 4, the combined effects as well as the sum of the total effects derived by some of the variables are quite substantial while that by

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[38] Notice that the relationship among the interventions is conceptualized in the model by considering the feasibility of their potential interactions. For instance, it is possible to see system rehabilitation to facilitate bulk water delivery and the latter, in turn, to influence crop diversification. But, crop diversification cannot be modeled to influence neither bulk water policy nor the system rehabilitation program.

[39] While the value of direct synergy is simply the value of coefficient for BULKWATD in Equation [2], the value for the indirect synergy is obtained by multiplying the coefficients of SYSREHAB (0.886) in Equation [1] and BULKWATD (0.594) in Equation [2].

others are very low. For instance, water institution derives the highest combined effects from both system rehabilitation (0.754) and bulk water delivery (0.851). On the other hand, food security, food availability, food price, farmers' income, and labor productivity capture relatively less of the impacts of all the three interventions. In terms of the total synergy derived from all the interventions, land productivity comes first with the value of 2.206, followed by water institution (1.605), cultivation cost (1.350), labor income (1.306), and water institution (1.287). Among the interventions, in terms of their total synergy effects, bulk water delivery policy with a value of 7.200 is relatively more important than the other two with a value of around 6.500.

Table 5 shows the size and flow of the impacts of the institutional variables, which are exogenous to the model.[40] The impacts of these variables are captured both directly as well as indirectly by the 21 endogenous variables or the dependent variables of the 21 equations. The institutional variables obviously differ in terms of their interaction with the development and impact variables depending on their location in the impact pathways. As a result, the impacts of some institutional variables are captured in many equations while the impacts of others are captured only by few equations, especially those capturing the interactions further down the impact pathway. For instance, land tenure, customary institution, and farm institution affect almost all the equations, but market institution, price regulation, trade policy, subsidy policy, and *Samurthi* policy affect only few equations. Obviously, the total impacts generated by the institutional variables affecting many equations are obviously larger than that by others affecting few equations. In terms of their relative impacts on food security, some of the institutional variables affecting few equations (e.g., market institution, price regulation, and trade policy) have a relatively larger impact than those affecting many equations. This results two very important aspects. First is the role of impact dissipation within the impact transmission process due to their long impact chains, weak impact links, and en route impact distortions. Second is the role of relative proximity of institutions to the final and proximate

[40] Even though bulk water delivery and water institution also relate to institutions, they are endogenous in the model because the former is specified as a function of system rehabilitation and the later is specified as a function of bulk water delivery.

goals. It is the impact dissipation that explains why the institutional variables related to land tenure, custom, and farm input supply and extension could not sustain their substantial initial impacts. On the other hand, it is the role of relative proximity that explains why the institutions related to market, price, wage, and trade have a larger impact on food security. From a policy perspective, while it is important to focus on institutions with proximate effects, it is important to address the issue of impact dissipation by locating and strengthening the weak links.[41]

From an overall perspective, the results in Table 5 suggests that the institutions having a major impact on food security are market institution, trade policy, price regulation, and wage laws. This is mainly due to their direct impact on food supply, food price, and wage income. Notably, despite their positive intermediary impacts, the food security impacts of land tenure, rural development policy, and subsidy policy are all negative, suggesting their ineffectiveness. Although customary institution, farm institution, and land tenure have a larger impact on the system as a whole, their food security impact is either low or negative. Among them, since customary institution is not that easy to change through deliberate policies and land tenure is politically difficult, practical considerations require a greater policy attention on the reorientation of farm input and extension institutions. This is particularly so given the substantial contributions that farm institutions can potentially make. Finally, as we compare the total effects of development interventions and institutions as captured by different endogenous variables in tables 4 and 5, we find the development impacts are more than the institutional effects in most cases. Notably, in the case of water institution, the total institutional impact is even negative. But, it is interesting to note that in seven cases including food security and some of its proximate variables the total effects derived from institutions are more than that derived form development interventions. This fact plus the role institutions have in the generation and transmission of development impacts clearly suggest the importance of institutions.

[41] From the regression results presented in Table 3, it is possible to locate these weak links by locating what variables have caused such dissipation in which equation.

7. Conclusions and Implications

This paper has argued that the impact synergies among development interventions and the impact enhancing role of institutions, though well known, are not being taken into account in actual development planning, implementation, and evaluation. This problem has far reaching implications, especially for meta-development goals such as MDGs, which require effective institutions and an integrated approach to development planning and implementation. It is demonstrated graphically how an insufficient treatment of the impact enhancing role of institutions leads to substantial welfare loss and how the ignorance of the impact synergies among past, ongoing, and planned interventions leads to biased impact assessment. To help address these serious problems, this paper has presented one approach for developing an analytical framework and evaluation methodology and also illustrated it in the empirical context of the Kala Oya Basin in Sri Lanka, using stakeholder-based qualitative information.

The analytics of the institution-impact-impact framework shows both the specific point at which different institutions influence the impact generation and transmission process as well as the mechanics of impact synergies among the past, ongoing, and planned interventions. The mathematical representation of this framework provides additional insights into the functional relations among the development, institutional, and impact variables and the sequential linkages among the impact pathways. For policy purpose, a better understanding of all these analytics, mechanics, and linkages are valuable because they can help package and sequence interventions, and identify and strengthen the major impact transmission paths and their underlying institutions.

Despite the preliminary nature of the model and the qualitative nature of the information, the results, especially those from the comparison of single equation and system models, do provide considerable insights into the roles that institutions play in the generation and transmission of impacts across impact pathways as well as the impact synergies that development interventions derive from others. These development synergies are captured not only by the coefficients of not only the variables representing the development interventions but also those of other impact and institutional variables because these synergies flow though the system through their direct and indirect effects. As a result, these synergies, in fact, make the institutional evaluation more complex but rich because they provide the scope for considering the linkages between institutional and impact variables within the process of development. Since the regression results are, in effect, the statistical representation of the consensus prevalent among the selected stakeholders, there is ample support for most of the relations postulated by the system model. Since the system model unbundles the impact process and deciphers its transmission channels, it is able both to capture the flow and direction of development impacts and to show which institutions affect what channel. These are valuable information for policy design, institutional analysis, and impact assessment.

From the perspective of policy design, the results suggest that when planning an intervention in a given region, it is critical to consider the potential synergies possible from past, ongoing, and planned interventions. In our study region, for example, the implementation of system rehabilitation has had a substantial facilitating impact on the performance of bulk water distribution and this positive synergy has the potential to enhance the prospects for crop diversification. The results also indicate that the development synergies among the interventions can be enhanced with a fine-tuning of the laws, policies, and organizations related to the land, water, agriculture, market, and trade spheres. Although the institutions covered here are not exhaustive, the results do show that among the institutions considered, those operating in the production and marketing spheres are relatively more important in terms of their role in channeling the impacts to the ultimate goal of food security. Specifically, since food prices and farm income are the most dominant factors affecting food security, all their intermediary variables and their underlying institutions (e.g., market, price regulation, land tenure, and credit and extension) are very important.

Besides the production-related farm institutions and distribution-related market institutions, there are also major influences from national level policies and laws such as those related to farm subsidy, rural industrialization, poverty alleviation, and wage rates and working conditions. But, at the same time, customary institutions related to cultivation practices and common grazing lands have significant effects on crop choice and livestock development. Notably, customary tendencies towards paddy cultivation, though a serious constraint for crop diversification, have a positive effect on the supply side of food security. To what extent changes in the performance of these rural institutions could affect the ultimate goal can, in fact, be evaluated in terms of chain functions capturing how a marginal change in any of the institutions leads to a series changes within the equation systems and culminates finally in the marginal change in food security. Similarly, how impact synergies among development interventions contribute to the final goal can also be evaluated in terms of the marginal changes in one or more of the variables characterizing various impact chains. Sensitivity analysis of this nature can provide valuable information for policy makers in prioritizing institutions and sequencing development interventions.

While the methodology is intuitive and the results provide insights, we also recognize some of the limitations and scope for further refinements, especially those related to the specification and structuring of the equations. For example, the insignificance of all the variables in Equation [12] makes it redundant and, hence, creates a gap in the system. Either this equation has to the re-specified or excluded from the system. Similarly, the unexpected signs of some variables, insignificance of crucial variables in the some equations, and the inclusion of variables with a strong association as independent variables in the same equation are problems that can be avoided with a more refined set of equations. From an empirical perspective, although only the perception-based qualitative data is used here to provide an empirical demonstration of evaluation approach, it is possible to explore ways for using observed and quantitative data from secondary sources and household surveys for as many variables as possible. In this case, a mix of quantitative and qualitative data can be used to estimate the model. Given the preliminary nature of the analytical framework and empirical approach, some of the analytical, empirical, and econometric limitations are only to be expected at this stage. Obviously, there is a considerable scope for refinement and extensions both on the analytical and empirical fronts, which can be explored well in future works. Despite its current limitations, the paper has still succeeded both in highlighting two of the most serious problems in current development planning, implementation, and assessment, i.e., the impact synergies and institutional roles, and also providing an empirical illustration of an analytical framework and evaluation methodology that can be useful to deal with them in practical contexts.

REFERENCES

Baker, Judy L., 2000, Evaluating the Impact of Development Projects on Poverty: A Handbook for Practitioners, Directions in Development Series, World Bank, Washington DC.

Bandara, K. R. Neil, undated, "Assessment of Kala Oya River Basin Project", PowerPoint Presentation, Kala Oya Basin Secretariat, Mahaweli Authority of Sri Lanka, Colombo.

Barrett, Scott, and Kathryn Graddy, 2000, "Freedom, Growth, and the Environment", *Environment and Development Economics*, 5: 433-456.

Bourguignon, F., and L. A. Pereira da Silva, 2003, *The Impact of Economic Policies on Poverty and Income Distribution: Evaluation Techniques and Tools*, Washington, DC and New York: World Bank and Oxford University Press (Available at: *http://www.worldbank.org/psia*).

Bromley, D.W., 1985, "Resources and Economic Development", *Journal of Economic Issues*, 19(September): 779-96.

Bromley, D.W., 1989, *Economic Interests and Institutions: The Conceptual Foundations of Public Policy*, New York: Basil Blackwell.

Centre for Global Development, 2006, When Will We Ever Learn? Improving Lives through Impact Evaluation, Report of the Evaluation Gap Working Group, May.

Coudouel, Aline, Anis A. Dani, and Stefano Paternostro, 2006, "Lessons from the Implementation of Poverty and Social Impact Analysis of Reforms", in Aline Coudouel, Anis A. Dani, and Stefano Paternostro, eds., *Poverty and Social Impact Analysis of Reforms: Lessons and Examples from Implementation*, World Bank, Washington DC, pp. 1-28.

Commons, J.R., 1934*, Institutional Economics*, New York: Macmillan

De Silva, S., Ranjith Ariyaratne, and Sarath Abayawardana, 2006, Kala Oya Basin, Sri Lanka: A Resource and Development Profile, IWMI Working Paper, Colombo, Sri Lanka.

Department of Census and Statistics (DCS) and UN World Food Program (WFP), 2005. *Vulnerability of GN divisions to food insecurity, Anuradhapura District 2004*. Colombo, Sri Lanka

Department for International Development (DfID) and World Bank, 2005, *Tools for Institutional, Political and Social Analysis in PSIA: A Sourcebook*, Washington, DC: World Bank and DfID (*http://web.worldbank.org/wbsite/ external/topics/extsocialdevelopment/exttoppsisou).*

Dinar, Ariel and R. Maria Saleth, 2005, "Can Water Institution Be Cured? A Water Institutions Health Index", *Water Science and Technology: Water Supply*, l5(6):17-40, 2005.

Gray, Cheryl W., and Daniel Kaufmann, 1998, "Corruption and Development", *Finance & Development*, 35(1): 7-10.

Gujarati, D., 1995, *Basic Econometrics*, 3rd Edition, New York, McGraw-Hill.

Hair, J. F., R. E. Anderson, R. L. Tatham, and W. C. Black, 1995 *Multivariate Data Analysis*. New Jersey: Prentice Hall.

Hausman, J. A., 1978, "Specification Tests in Econometrics", *Econometrica*, 46: 1251-1271.

Just, Richard E., Darrell L. Hueth, and Andrew Schmitz, 2004, *The Welfare Economics of Public Policy: A Practical Approach to Project and Policy Evaluation*, Cheltenham, UK: Edward Elgar.

Kahneman, Daniel, and Amos Tversky, 1984, "Choices, Values, and Frames", *American Psychologist*, 39(4): 341-350.

Kaufmann, Daniel, Aart Kraay, and Massimo Mastruzzi, 2006, Governance Matters V: Governance Indicators for 1996-2005, Research Department, World Bank, Washington DC (*http://ssrn.com/abstract=929549*)

Kennedy, Peter, 1987, *A Guide to Econometrics* (Second Edition), Cambridge, MA: The MIT Press.

Knack, Stephen, and Philip Keefer, 1986, "Institutions and Economic Performance: Cross-Country Tests Using Alternative Institutional Measures", *Economics and Politics*, 7(3): 207-227.

Neubert, Susanne, 2000, *Social Impact Analysis of Poverty Alleviation Programmes and Projects*, Illford, Essex: Frank Cass.

Neubert, Susanne, 2006, "Impact Analysis in Development Cooperation and Approaches Adopted in Research and Practice", German Development Institute, Bonn.

North, Douglass C., 1990, *Institutions, Institutional Change, and Economic Performance*, Cambridge, MA: Cambridge University Press.

Ostrom, Elinor, 1990, *Governing the Commons: The Evolution of Institutions for Collective Action*, Cambridge, UK: Cambridge University Press.

Ostrom, Vincent, 1980, "Artisanship and Artifact", *Public Administration Review*, 40(July-Aug): 309-317.

Saleth, R. M., and Ariel Dinar, 2004, *The Institutional Economics of Water: A Cross-Country Analysis of Institutions and Performance*, Cheltenham, UK: Edward Elgar.

Saleth, R. M., Ariel Dinar, Susanne Neubert, Bandi Kamaiah, Seenithamby Manoharan, Sarath Abayawardena, and Ranjith Ariyaratne, 2007, "Evaluating Institution-Impact Interactions in the context of Millennium Development Goals: Analytical Framework With Empirical Results From Kala Oya Basin, Sri Lanka", Research Report, International Water Management Institute, Colombo, Sri Lanka (*Forthcoming*).

Tool, M. R., 1977, "A Social Value Theory in Neo-institutional Economics", *Journal of Economic Issues*, 11(December): 823-849.

Annex-A: Technical Notes

***Institutional Ecology Principle*:** This principle extends the 'ecosystem' concept to institutional systems to analytically show (a) the linkages and synergies among institutions across domains (law, policy, and organization), spheres (land, water, agricultural, rural, and environmental), and scales (basin, region, and national) and (b) the nested and embedded character of institutions within the social, economic, political, and resource systems.

***Institutional Decomposition and Analysis Framework*:** This framework unbundles institutions into a set of interrelated rules, characterizes them using quantitative and qualitative variables, and formalizes the relations and linkages among these rules (Saleth and Dinar, 2004). The approach is similar in spirit to the Institutional Analysis and Development framework developed by Ostrom (1990) for application to local level institutions for common pool resources management.

***Ex-ante Approach*:** This approach tries to evaluate the futuristic changes and expectation aspects related to institutions based on the convergence in stakeholders' perception. Such consensual perception can summarize objective evaluation, learned judgments, aspirations, and expectations of participating stakeholders. Unlike the *post mortem* approach underlying the *ex-post* evaluation and analysis, the *ex-ante* approach is very useful for designing anticipatory and coping strategies that would allow enough lead time for policy/program adjustments and modifications.

***Adaptive Instrumental Evaluation*:** Unlike other evaluation approaches in economics relying on normative and absolute concepts such as 'efficiency' based on the assumption of individual rationality and perfect information, the adaptive instrumental evaluation is based on a positive and relative approach (Tool, 1977; Kahneman and Tversky, 1984; Bromley, 1985). It allows the evaluation of events/aspects with respect to relevant reference points (e.g., best practices, desirable conditions, and stated objectives) rather than with respect to ideals or absolute conditions. It also allows the reference points to be flexible and changeable within the evaluation process itself (Saleth and Dinar, 2004). This approach is very pertinent for evaluating aspects such as institutions and their performance involving considerable level of qualitative and subjective considerations.

Annex-B: List of Experts/Stakeholders in the Sample

	Name	Professional Position
1	K. A. Upali S. Imbulana	Director (Water Resources)
2	H. P. S. Somasiri	Additional Secretary (Irrigation)
3	H. P. Somathilaka	Assist Director (Planning)
4	Wasantha Ekanayake	Director (Lands and Development)
5	E. Wijepala	Senior Executive (Additional Secretary)
6	G. D. Perera	Director (Agriculture)
7	Neil Bandara	Project Director (PEACE Project)
8	Christy Perera	Deputy Director (Agricultural Extension)
9	W. M. M. U. R. Mahakumbura	Deputy Director (Horticultural Research)
10	R. A. D. Jayanthie	Chartered Engineer
11	W. L. W. Premadasa	Resident Project Manager (INMAS)
12	N. Samaratunga	Irrigation Engineer
13	L. S. Fernando	Irrigation Engineer
14	Eng. D. M. N. Janaka Dhanapala	Civil Engineer
15	Ananda Jayasinghe	Additional Director, Agronomy, IMD
16	H. M. B. Karunaratne	Farmer
17	W. A. N. A. Wijesinghe	Civil Engineer (Water Resources Development)
18	Lalitha Seneviratne	Deputy Resident Project Manager (Technical Services)
19	Ms. O. P. Prematilaka	Deputy Manager (Natural Resources), Kala Oya Basin
20	Ranjith Premalal de Silva	Senior Lecturer
21	Lakshman Galgedara	Senior Lecturer
22	Dr. B. V. R. Punyawardena	Head, Agro-climatology Division, Dept. of Agriculture
23	Dr. R. S. K. Keerthisena	Research Officer
24	K. M. Seneviratne Banda	Research Officer
25	M. A. K. Munasinghe	Research Officer
26	A. Sellahewa	Deputy Director (Water Management), MASL
27	M. Weerasinghe	Sri Lanka Administrative Service
28	J. A. S. A. Jayasinghe	Director, Kala Oya Basin Secretariat
29	H. H. Padmasiri Premakumara	Kala Oya River Basin Manager
30	Dr. S. Pathmarajah	Senior Lecturer
31	Sisirakumara Mohotti	Rural Sector Community Dev. Consultant
32	N. Indrasenan	Director (Plan Implementation)
33	Dr. S. Thiruchelvam	Senior Lecturer in Resource Economics
34	Dr. L. H. P. Gunaratne	Senior Lecturer
35	Susil Premaratne	Agrarian Services Development Officer
36	W. M. P. B. Wijesooriya	Divisional Secretary (DS)
37	K. T. Dayaratne	Chairman, Lift Irrigation Farmers' Cooperative
38	Premadasa Kaluarachchi	President ,Tract 01 Farmer organization
39	S. D. M. Rajapaksa	Institutional Development Officer, IMD, Rajangana.
40	J. M. J. B. Jayawardena	Divisional Officer (Agrarian Development Office)
41	S. B. Niyangoda	Chair, Sri Lanka Water Partnership
42	Dixon Nilaweera	Regional Coordinator, GWP-SAS, Regional Office.
43	Lalith Dassenaike	Regional Manager – IWMI
44	Mrs. Anula Indrani	Divisional Secretary (DS)
45	W. G. A. W. Gamage	Agriculture Research and Produce Assistant (APRS)
46	Mr. N. B. Muthubanda	Agrarian Development Officer
47	R. M. Samanthilaka Ratnayaka	Secretary Farmer Organization (Farmer)
48	K. Wijeweera	A.P.R.S.
49	Ranjith Ariyaratne	Benchmark Basin Coordinator, IWMI.
50	D. J. Bandaragoda	Senior International Consultant
51	K. Jinapala	Researcher, IWMI
52	Sarath Abayawardana	Head, Sri Lanka Program, IWMI
53	Ranjith Ratnayake	Ex-Director, Water Resources, Ministry of Irrigation
54	Madar Samad	Principal Researcher, IWMI
55	Nilantha Gamage	Remote Sensing/GIS Specialist, IWMI
56	P. G. Somaratne	Senior Research Officer
57	Deeptha Wijeratne	Agricultural Economist/Research Officer, IWMI
58	Priyantha Jayakody	Research Officer, IWMI
59	R. W. Kulawardhana	Remote Sensing/GIS Specialist, IWMI
60	P. B. Dharmasena	Deputy Director (Research)
61	Sampath Abeyrathne	Research Officer, IWMI
62	Upali Amarasinghe	Researcher, IWMI
63	N Abeywickrama	Senior Adviser, IWMI
64	A M Jabir	Free Lance Consultant
65	M Jehanathan	Assistant Director (Agriculture)
66	A P Keerthipala	Principle Research Officer, Sugar Research Institute
67	R S Kulathunga	Deputy Conservator of Forest

Annex-C: Survey Instrument

STUDY ON THE

INSTITUTIONAL ASSESSMENT FOR FOOD SECURITY IN THE KALA OYA BASIN, SRI LANKA

(Research Preparation Work funded by WB and IWMI)

Survey Instructions

(1) The conceptual framework is generic, but captures as much as possible the relevant aspects of KOB basin in particular and Sri Lanka in general;

(2) It is focused on the impact of the three development programs on food security, particularly from the perspective of small farmers, farm workers, and other rural poor;

(3) 'Impact pathways' are the routes through the economic impacts of development interventions are transmitted to the development goals. These impact transmissions are carried out by the 'impact variables'. In the present context, three development interventions (i.e., crop diversification program; system rehabilitation, and bulk water allocation policy) and one development goal (i.e., food security) are considered.

(4) Before asking questions, the conceptual framework is briefly explained to give adequate background for the respondents. First, the 3 development interventions and their role in food security, then, their impact pathways defined by the impact variables, and, finally, the role of institutional factors in affecting these pathways are all explained to them.

(5) The respondents are also informed that the questions to be asked are related to different components of the framework and answers are expected with respect to the conditions prevalent in KOB in particular and Sri Lanka in general.

(6) More importantly, it is necessary to convince them that the evaluation is done in an ex-ante context and what they perceive or believe about various relationships in the conceptual framework are very important and valuable for the evaluation and analysis. Also, it is important to inform them that the development programs can both those that are implemented as well as those that are contemplated or potentially relevant for the KOB or Sri Lanka.

(7) All questions are formulated as yes or no questions or questions requiring answers within the scale of 1-10, with '1' being low or weak and '10' being high or strong, depending on the context. For coding purpose, a 'no' answer is treated as 0 and the 'yes' answer is evaluated within the scale of 1-10. Thus, all answers are recorded within the scale of 0-10.

PART-A

Basic Details

(1) <u>Respondent's Details:</u>

(a) Name ……………………………………….

(b) Qualification ……………………………………….

(c) Discipline ……………………………………….

(d) Professional Position ……………………………………….

(e) Years of Experience ……………………………………….

(f) Contact Details ……………………………………….

……………………………………….

……………………………………….

……………………………………….

Email…………………………………

(2) <u>Interview Details:</u>

(a) Interviewers Name ………………………………………

(b) Place and Date ………………………………………

PART–B

Detailed Questionnaire

1. Food Security (FOODSECT)

(a) How strong, in your opinion, is the food security status of small farmers? .... ☐

(b) How strong, in your opinion, is the food security status of farm workers? .... ☐

(c) How strong, in your opinion, is the food security status of the rural poor? .... ☐

(d) How strong, in your opinion, is the nutritional status of children and aged? .... ☐

2. Crop Diversification (CROPDIVR)

(From low to high-value crops; e.g., paddy to vegetables, oilseeds, and fruits)

(a) How bright are the economic and technical prospects for crop diversification? .... ☐

(b) How effective are the crop diversification efforts of the government? .... ☐

(c) How important are customs in crop choice? .... ☐

(d) How serious are customs in constraining crop diversification? .... ☐

(e) How important is water delivery system for crop diversification? .... ☐

(f) How serious is small farm size as a constraint for crop diversification? .... ☐

(g) How important is land and soil quality as a factor for crop diversification? .... ☐

3. System Rehabilitation (SYSREHAB)

(a) How effective is the system rehabilitation program? .... ☐

(b) How far can rehabilitation improve land and soil health (by limiting salinity)? .... ☐

(c) How important is system rehabilitation as a contributing factor for land productivity? .... ☐

(d) How far system rehabilitation is effective in facilitating bulk water allocation? .... ☐

4. Bulk Water Distribution (BULKWATD)

(a) How far can bulk water distribution improve existing water allocation procedures? .... ☐

(b) How far can bulk water distribution strengthen water user organizations? .... ☐

(c) How far can bulk water distribution contribute to crop diversification? .... ☐

(d) How far can bulk water distribution improve water use efficiency? .... ☐

(e) How far can bulk water distribution contribute to land & soil health? .... ☐

5. Cropping Pattern (CROPATEN)

(a) To what extent can crop diversification alter crop pattern? .... ☐

(b) How far can diversification lead to the adoption of high-value crops? .... ☐

(c) How far can the changes in crop pattern lead to water savings? .... ☐

(d) Haw far can the changes in crop pattern improve land and soil health (via crop rotation)? ...... ☐

(e) How far can the changes in crop pattern negatively affect foodgrain output? .... ☐

(f) How far can the changes crop pattern negatively affect fodder/feed supply? .... ☐

(g) How far can the changes in crop pattern raise cultivation costs? .... ☐

(h) If crop pattern shifts towards high-value crops, how important is this shift for the development of rural non-farm activities? .... ☐

6. Land Productivity (LANPRODY)
(Output per unit of land; it differs by crops)

(a) How important is land productivity for farm employment? .... ☐

(b) How important is land productivity for farm income? .... ☐

(c) How important is land productivity for labor productivity? .... ☐

(d) Generally, higher land productivity leads to higher water productivity. How strong will be this relationship between land and water productivity? .... ☐

(e) Crop pattern changes, though reduce the area under food crops, can also improve the overall farm productivity. If so, how significant will be this effect? .... ☐

(f) System rehabilitation and bulk water delivery can improve water delivery and contribute, thereby, to overall farm land productivity. If so, how significant will be this effect? .... ☐

7. Water Productivity (WATPRODY)
(Output per unit of applied water; it differs by crops)

Generally, efficient water use contributes to land productivity, partly by minimizing the negative effects of water over use (e.g., waterlogging; Salinity) and partly by enhancing the efficiency and productivity of other farm inputs. If this is so,

(a) How strong will be the impact of water use efficiency on land productivity? .... ☐

(b) How strong will be the impact of water use efficiency on the efficiency of other inputs? ....

8. Labor Productivity (LABPRODY)
(Output per labor; it differs by crops)

(a) Generally, higher labor productivity will lead to higher wage rate. If so, how strong (or weak) is the relationship between labor productivity and wage rates? ....

(b) Generally, efficient and productive workers do the same or more work. If so, how important is the role of productivity in determining the overall level of farm employment? ....

9. Rural Employment (RURALEMP)

(a) Generally, given the level of land productivity, more employment means less labor productivity. If so, how strong is this negative relationship? ....

(b) Generally, for given wage rates, more employment means more income. But, with low or declining wage rates, more employment may not always lead to more income. How relevant and realistic is this fact? ....

10. Wage Rates (WAGERATE)

(a) How strong is the influence of higher wage rates on cultivation costs? ....

(b) Are the wage rates high enough to provide incentive for improved labor productivity? If so, how strong will be this effect? ....

(c) Are the wage rates adequate enough to assure decent income for farm workers? If so, how strong will be this fact? ....

11. Cultivation Costs (CULTCOST)

(a) Obviously, increasing cultivation costs reduce agricultural income. But, the issue is whether the additional costs due to crop diversification are high enough to affect the farm income of small farmers. If so, how serious is this cost effect on farm income? ....

(b) At the same time, the additional costs due to diversification can also be smaller in relation to the additional income from the same. If so, how important is this fact for crop choice? ....

12. Agricultural Income (AGLINCOM)

(a) While farm income is a necessary condition for food security, other non-income factors (e.g., food price and supply, its quality and composition, and family size) are also important. Given this, how important is the relative role of income in ensuring food security? ....

13. Land and soil Health (LANHELTH)

(a) How important is land and soil health for land productivity, especially in the long-run? .... ☐

(b) How important is the land and soil health for flexible crop choice? .... ☐

14. Food Production (FOODPROD)

(a) Normally, higher food production means more food supply in the market. But, export, procurement, and hoarding can reduce food availability. If so, how serious is this effect? ...... ☐

(b) Similarly, higher food output means low food prices for consumers. But, the factors noted above may act against such price decline. If so, how serious is this effect? .... ☐

15. Non-farm Enterprises (NFAMENTS)
(e.g., small enterprises, petty trade, handicrafts, services)

(a) Does labor scarcity affect farm wage rates? If so, how significant is this effect? .... ☐

(b) How important are non-farm activities for rural employment? .... ☐

(c) Do non-farm activities create farm labor scarcity? If so how serious is this effect? .... ☐

16. Fodder & Feed Supply (FEDSUPLY)
(e.g., rice straw, husks, and other farm by-products)

(a) How important is the role of agriculture in supplying fodder & feeds? .... ☐

(b) Does change in crop pattern (say from paddy to vegetables or oilseeds) will affect fodder supply? If so, how serious will be this negative effect? .... ☐

(c) If the farm families with livestock rely on green fodder from public grazing lands and home gardens, crop pattern changes does not matter much. How realistic is this fact? .... ☐

17. Livestock & Poultry (LIVSTOCK)
(This does not relate to commercial enterprises, but only maintained by rural families)

(a) How important are livestock & poultry for self-employment? .... ☐

(b) How important are livestock & poultry as an income source for small farmers? .... ☐

(c) How important are livestock & poultry as an income source for farm workers and the poor? .. ☐

(d) How important are livestock & poultry for the family consumption of milk & meat? .... ☐

(e) How important are livestock & poultry for the nutritional security of the children and aged? .. ☐

18. Farm Income (FAMINCOM)

(a) How food-secure are the small farmers? ....

(b) Is this security due to their cultivating food (paddy) crops? If so, how realistic is this fact? .....

(c) Does this food security role of food (paddy) crops act against crop diversification? If so, how realistic is this fact ....

19. Labor Income (LABINCOM)

(a) How adequate are the wage income of rural workers to assure their food security? ....

(b) How critical are the livestock and non-farm income sources for rural workers and the poor? ..

20. Food Availability (FOODAVAL)

(a) How adequate is food availability to assure food security for rural workers and the poor? ....

21. Food Price (FOODPRIC)

(b) How affordable are food prices to rural workers and the poor? ....

22. Land Tenure (LANTENUR)
(Farm size; Tenure Security)

(a) How important is farm size for adopting improved farm technologies and practices? ....

(b) How important is tenure security for adopting improved farm technologies and practices? .....

(c) How important is land titles in securing farm credits? ....

(d) How serious are small farms as constraints for efficient water delivery? ....

(e) Are smaller farms more efficient in water use? If so, how realistic is this fact? ....

(f) Generally, small farms are unable to benefit from scale economies. If so, how serious is this fact in affecting their cultivation costs? ....

23. Water Institutions (WATINSTN)
(Water release policy; allocation procedures)

(a) How flexible is the water release policy for promoting diverse crops? ....

(b) How suitable are the existing water allocation practices for efficient water use? ....

24. Farm Input Institutions (FAMINSTN)
(Credit, farm inputs, and extension institutions)

(a) How effective and accessible is the farm credit system for small farmers? ....

(b) How effective and accessible are the fertilizer and seeds supply systems for small farmers? ...

(c) How effective and accessible is the farm extension system for small farmers? ....

(d) Are the farm input supply systems, including credit, too costly for small farmers? If so, how serious is this problem? ....

(e) Are the farm input supply systems, including credit, focused on particular crops (e.g., paddy or coconut)? If so, how serious is this as a constraint for crop diversification? ....

25. Customary Institutions (CUSINSTN)
(Local customs, conventions, traditions, and informal rules)

(a) Normally, farmers' choice of food or traditional crops (e.g., paddy) is thought to be influenced by customary practices. If so, how limiting are local customs for crop diversification? ....

(b) How influential are local customs and conventions in water allocation and use decisions? ......

(c) Are there strong traditions in maintaining local commons as grazing areas for livestock? ....

26. Rural Development Policy (RDVPOLCY)

(a) How effective are state policies in promoting rural non-farm activities? ....

(b) Are there special programs for developing specific non-farm enterprises (e.g., handicrafts; food processing units)? If so, how effective are they? ....

27. Market Institutions (MKTINSTN)

(a) How effective are the agricultural markets in providing the right prices for farmers? ....

(b) How important is the role of traders and middlemen in the marketing of farm outputs? ....

(c) How effective are markets in stabilizing harvest and post-harvest price fluctuations? ....

(d) How effective is the procurement policy in supporting farm prices? ....

28. Wage/Labor Legislations (WAGELAWS)
(Legislations on wage rates and working conditions)

(a) How effective are the minimum wage legislations in guiding rural wage rates? ....

(b) How strong are local customs and social pressures in influencing rural wage rates? .... ☐

(c) How effective are the special legal provisions (e.g., child labor; minimum working hour) in affecting rural labor supply and employment? .... ☐

29. Trade Policy (TRDPOLCY)
(Farm import and export policies)

(a) Do the trade policies on the import of milk and meat products limit livestock & poultry development? If so, how serious is this constraint? .... ☐

(b) Do the trade policies on the import of food products add to domestic food availability? If so, how important is this policy for food and nutritional security? .... ☐

30. Price Regulations (PRICREGL)

(a) How effective are price regulations in controlling the food prices for consumers? .... ☐

(b) Do price regulations distort agricultural markers? If so, how serious is this effect? .... ☐

31. Farm Subsidy Policy (SUBPOLCY)
(Fertilizer and credit subsidies)

(a) Are there subsidies for fertilizers and farm credits? If so, how effective are they in controlling cultivations costs? .... ☐

(b) Do these subsidies have a favorable effect on farm income? If so, how significant are they for farmers? .... ☐

32. *Samurthi* Policy (SAMPOLCY)
(Special State program for Poverty alleviation)

(a) How effective is the ***Samurthi*** policy in supporting the income of the rural poor? .... ☐

(b) How effective is the ***Samurthi*** policy in improving the food availability to rural poor? .... ☐

Annex-D: OLS Results for the Single Equation Model

Dependent Variable	Independent Variables	Estimated Coefficient	T-Ratio	Level of Significance	Elasticity at Means	R^2
FOODSECT	BULKWATD	0.317	***1.485***	0.146	0.395	0.447
	SYSREHAB	-0.053	-0.152	0.880	-0.070	
	CROPDIVR	-0.038	-0.251	0.803	-0.045	
	CROPATEN	-0.267	-0.652	0.519	-0.295	
	WATINSTN	0.255	***1.351***	0.185	0.253	
	WATPRODY	0.013	0.056	0.955	0.018	
	LANHELTH	-0.212	-0.864	0.393	-0.318	
	LANPRODY	-0.135	-0.459	0.649	-0.182	
	FEDSUPLY	0.124	0.554	0.583	0.130	
	LIVSTOCK	-0.111	-0.633	0.531	-0.080	
	NFAMENTS	0.057	0.258	0.798	0.080	
	LABPRODY	0.253	***1.606***	0.117	0.247	
	WAGERATE	0.506	**1.752**	0.088	0.610	
	RURALEMP	0.077	0.475	0.637	0.081	
	CULTCOST	0.125	0.715	0.479	0.140	
	AGLINCOM	-0.785	**-2.707**	0.010	-1.068	
	FAMINCOM	1.128	**2.910**	0.006	1.225	
	LABINCOM	0.452	***1.907***	0.065	0.414	
	FOODPROD	-0.118	-0.342	0.735	-0.122	
	FOODAVAL	0.125	0.487	0.629	0.129	
	FOODPRIC	-0.215	-0.898	0.375	-0.185	
	LANTENUR	-0.139	-0.613	0.544	-0.170	
	CUSINSTN	-0.102	-0.402	0.690	-0.095	
	FAMINSTN	-0.129	-0.618	0.540	-0.141	
	MKTINSTN	-0.253	-1.184	0.244	-0.255	
	PRICREGL	-0.003	-0.020	0.984	-0.003	
	WAGELAWS	-0.053	-0.256	0.800	-0.037	
	RDVPOLCY	0.107	0.634	0.530	0.108	
	TRDPOLCY	0.184	0.729	0.471	0.239	
	SUBPOLCY	-0.134	-0.720	0.476	-0.180	
	SAMPOLCY	0.173	0.876	0.387	0.175	

Annex-E: Deriving Reduced Form Single Equation

No	*Exogenous Variables*	*Notation used*
1	SYSREHAB	X1
2	LANTENUR	X2
3	CUSINSTN	X3
4	FAMINSTN	X4
5	MKTINSTN	X5
6	PRICREGL	X6
7	WAGELAWS	X7
8	RDVPOLCY	X8
9	TRDPOLCY	X9
10	SUBPOLCY	X10
11	SUMPOLCY	X11
No	*Endogenous Variables*	*Notation used*
1	BULKWATD	Y1
2	CROPDIVR	Y2
3	CROPATEN	Y3
4	WATINSTN	Y4
5	WATPRODY	Y5
6	LANHELTH	Y6
7	LANPRODY	Y7
8	FEDSUPLY	Y8
9	LIVSTOCK	Y9
10	NFAMENTS	Y10
11	LABPRODY	Y11
12	WAGERATE	Y12
13	RURALEMP	Y13
14	CULTCOST	Y14
15	AGLINCOM	Y15
16	FAMINCOM	Y16
17	LABINCOM	Y17
18	FOODPROD	Y18
19	FOODAVAL	Y19
20	FOODPRIC	Y20
21	FOODSECT	Y21

With the notations for all the exogenous and endogenous variables as assigned in the above table, the 21 equations of the system model can be represented as follows:

$$Y_1 = F_1(X_1, X_2)$$
$$Y_2 = F_2(Y_1, X_4)$$
$$Y_3 = F_3(Y_2, X_2, X_3)$$
$$Y_4 = F_4(Y_1, X_2, X_3)$$
$$Y_5 = F_5(Y_3, Y_4, X_4)$$
$$Y_6 = F_6(Y_3, Y_5, X_2)$$
$$Y_7 = F_7(Y_3, Y_6, X_4)$$
$$Y_8 = F_8(Y_3, X_3)$$
$$Y_9 = F_9(Y_8, X_9)$$
$$Y_{10} = F_{10}(Y_3, X_8)$$
$$Y_{11} = F_{11}(Y_3, Y_7)$$
$$Y_{12} = F_{12}(Y_{10}, Y_{11}, X_7)$$
$$Y_{13} = F_{13}(Y_7, Y_9, Y_{10}, Y_{12})$$
$$Y_{14} = F_{14}(Y_3, Y_{12}, X_4, X_{10})$$
$$Y_{15} = F_{15}(Y_7, Y_{14}, X_5)$$
$$Y_{16} = F_{16}(Y_9, Y_{10}, Y_{15})$$
$$Y_{17} = F_{17}(Y_9, Y_{10}, Y_{13}, X_{11})$$
$$Y_{18} = F_{18}(Y_3, Y_5, Y_7)$$
$$Y_{19} = F_{19}(Y_{18}, X_5, X_9)$$
$$Y_{20} = F_{20}(Y_{18}, X_5, X_6)$$
$$Y_{21} = F_{21}(Y_{16}, Y_{17}, Y_{19}, Y_{20})$$

Given these equations and their sequential linkages depicted in Figure 6 in the main body of the paper, the reduced form equation can be specified as a single but very long equation shown below.

$$
\begin{aligned}
Y_{21} = F_{21} \oint\, & F_{20} \int \Big\| F_{18} \Big| F_7 \Big\langle F_6 \Big\{ F_5 \Big[F_4\{F_1[X_1,X_2],X_2,X_3\},F_3\{F_2[F_1(X_1,X_2),X_4],X_2,X_3\},X_4 \Big], \\
& \quad F_3\Big[F_2[F_1(X_1,X_2),X_4],X_2,X_3 \Big],X_2 \Big\},F_3\Big\{ F_2[F_1(X_1,X_2),X_4],X_2,X_3 \Big\},X_4 \Big\rangle, \\
& \quad F_5\Big\langle F_4\{F_1[X_1,X_2],X_2,X_3\},F_3\{F_2[F_1(X_1,X_2),X_4],X_2,X_3\},X_4 \Big\rangle, F_3\Big\langle F_2[F_1(X_1,X_2),X_4],X_2,X_3 \Big\rangle \Big|,X_5,X_6 \Big\| \int , \\
& F_{19} \int \Big\| F_{18} \Big| F_7 \Big\langle F_6 \Big\{ F_5 \Big[F_4\{F_1[X_1,X_2],X_2,X_3\},F_3\{F_2[F_1(X_1,X_2),X_4],X_2,X_3\},X_4 \Big], \\
& \quad F_3\Big[F_2[F_1(X_1,X_2),X_4],X_2,X_3 \Big],X_2 \Big\},F_3\Big\{ F_2[F_1(X_1,X_2),X_4],X_2,X_3 \Big\},X_4 \Big\rangle, \\
& \quad F_5\Big\langle F_4\{F_1[X_1,X_2],X_2,X_3\},F_3\{F_2[F_1(X_1,X_2),X_4],X_2,X_3\},X_4 \Big\rangle, F_3\Big\langle F_2[F_1(X_1,X_2),X_4],X_2,X_3 \Big\rangle \Big|,X_5,X_9 \Big\| \int , \\
& F_{17} \int \Big\| F_{13} \Big| F_{12} \Big\langle F_{11} \Big\{ F_7 \Big[F_6 \Big(F_5\{F_4[F_1(X_1,X_2),X_2,X_3],F_3[F_2(F_1 < X_1,X_2 >,X_4),X_2,X_3],X_4\}, \\
& \quad F_3\{F_2[F_1(X_1,X_2),X_4],X_2,X_3\},X_2 \Big),F_3\Big(F_2[F_1(X_1,X_2),X_4],X_2,X_3 \Big),X_4 \Big], \\
& \quad F_3\Big[F_2[F_1(X_1,X_2),X_4],X_2,X_3 \Big] \Big\},F_{10}\Big\{ F_3\{F_2[F_1(X_1,X_2),X_4],X_2,X_3\},X_8 \Big\},X_7 \Big\rangle, \\
& \quad F_{10}\Big\langle F_3\{F_2[F_1(X_1,X_2),X_4],X_2,X_3\},X_8 \Big\rangle,F_9\Big\langle F_3\{F_2[F_1(X_1,X_2),X_4],X_2,X_3\},X_9 \Big\rangle, \\
& \quad F_7\Big\langle F_6\Big(F_5\{F_4[F_1(X_1,X_2),X_2,X_3],F_3[F_2(F_1 < X_1,X_2 >,X_4),X_2,X_3],X_4\}, \\
& \quad F_3\{F_2[F_1(X_1,X_2),X_4],X_2,X_3\},X_2 \Big),F_3\Big(F_2[F_1(X_1,X_2),X_4],X_2,X_3 \Big),X_4 \Big\rangle \Big|, \\
& \quad F_{10}\Big| F_3\{F_2[F_1(X_1,X_2),X_4],X_2,X_3\},X_8 \Big|,F_9\Big| F_3\{F_2[F_1(X_1,X_2),X_4],X_2,X_3\},X_9 \Big|,X_{11} \Big\| \int , \\
& F_{16} \int F_{15} \Big\| F_{14} \Big| F_{12} \Big\langle F_{11} \Big\{ F_7 \Big[F_6 \Big(F_5\{F_4[F_1(X_1,X_2),X_2,X_3],F_3[F_2(F_1 < X_1,X_2 >,X_4),X_2,X_3], \\
& \quad X_4\},F_3\{F_2[F_1(X_1,X_2),X_4],X_2,X_3\},X_2 \Big),F_3\Big(F_2[F_1(X_1,X_2),X_4],X_2,X_3 \Big),X_4 \Big], \\
& \quad F_3\Big[F_2[F_1(X_1,X_2),X_4],X_2,X_3 \Big] \Big\},F_{10}\Big\{ F_3\{F_2[F_1(X_1,X_2),X_4],X_2,X_3\},X_8 \Big\},X_7 \Big\rangle, \\
& \quad F_3\Big\langle F_2[F_1(X_1,X_2),X_4],X_2,X_3 \Big\rangle,X_4,X_{10} \Big|, \\
& \quad F_7\Big| F_6\Big(F_5\{F_4[F_1(X_1,X_2),X_2,X_3],F_3[F_2(F_1 < X_1,X_2 >,X_4),X_2,X_3],X_4\}, \\
& \quad F_3\{F_2[F_1(X_1,X_2),X_4],X_2,X_3\},X_2 \Big),F_3\{F_2[F_1(X_1,X_2),X_4],X_2,X_3\},X_4 \Big|,X_5 \Big\|, \\
& \quad F_{10}\Big\| F_3\{F_2[F_1(X_1,X_2),X_4],X_2,X_3\},X_8 \Big\|,F_9\Big\| F_3\{F_2[F_1(X_1,X_2),X_4],X_2,X_3\},X_9 \Big\| \int \oint
\end{aligned}
$$