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SECTOR ANLYSIS AND PLANNING FOR AN ADEQUATE AGRICULTURAL AND REGIONAL DEVELOPMENT: A CASE STUDY

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1 INTRODUCTION

The XXI International Conference of Agricultural Economists in Tokyo hosted different topics under the main theme of sustainable agriculture. Within the context of regional and agricultural development this article will focus on the aspect of sector analysis and planning required to promote development actions. Specifically it will refer to a research project developed at the Institute of Agricultural Economics of the ETH and presented as a poster at the Conference. The aim of the article is twofold: on the one hand to give some background about recent research in this area at the ETH and on the other hand to draw more attention on the relevance of the sector analysis and simulation in order to provide a suitable development strategy.

The Sri Lankan agricultural sector was chosen as a case study and the applied methodology for the sector analysis and the impact simulation of exogenous interventions relies on Linear Programming. The tool of analysis and simulation is a spatial equilibrium model. The first part of the article is devoted to the explanation of the model structure and its fonctioning; the second part deals with some of the model results. They should give a rough idea of the analysis capability of this methodology on the one hand and of its simulation potential on the other hand.

2 THE MODEL

The methodology applied relies on a spatial equilibrium model. The objective function corresponds to the sum of producer and consumer surpluses. The advantage in using this function as the maximand consists in reaching the equilibrium by simultaneous interaction of both producer and consumer behaviors, under derivation of equilibrium prices and quantities. The endogenous derivation of both prices and quantities, however, raises the problem of non linearities, which is solved by linearizing the objective function.

The Sri Lankan model is disaggregated into three submodels dealing with production, transformation and consumption; external trade is considered within the transformation equations. The production submodel is further disaggregated vertically at sector, regional and farmtype levels. Both the transformation and the consumption submodels are considered at sector level,the latter been disaggregated into two main consumption groups.

The links among the different submodels are given by balance equations.

The model comprehends 2,034 constraints, 2,784 activities and 11,858 coefficients. The LP-matrix is generated by means of LPL-software package and the optimization problem is solved by Lamps-software package on Cray computer.

The production submodel

The country is divided into three main production regions with homogeneous agroecological features. The following three areas are outlined:

The dry zone, the intermediate dry zone and the wet zone.

Within each region, farms are aggregated into groups represented by an "average" farm unit. The "average" farm unit defines the group farming structure and it is introduced into the LP format as an endogenous variable.

In the dry zone farmtypes can be differentiated along with the number of cattle and buffaloes, since the land distributed within the colonization schemes is not marke-

table.Four farmtypes are established in the dry zone, i.e. farming units without animals (FT1), with fewer than 5 animals (FT2), with more than 5 but less than 10 animals (FT3), with more than 10 animals (FT4).
In the case of the intermediate dry zone, farm size is not fixed and land can be marketed. So far, the two outstanding criteria by which farm groups can be distinguished are farm size and the availability of lowland. Five "average" farm units for the intermediate dry zone are established, i.e. holdings producing on both high- and lowland with less than 2.025 ha (FT5), with more than 2.025 ha but less than 4.05 ha (FT6); holdings producing only on highland with less than 2.025 ha (FT7), with more than 4.05 ha (estates) (FT8); landless people (FT9).

The criteria used to define the farm groups in the wet zone once again rely on farm size on the one hand and on the type of land availability on the other. Six farm types are given: Holdings producing on both high- and lowland with less than 2.025 ha (FT10), with more than 2.025 but less than 4.05 ha (FT11); holdings producing only on highland with less than 2.025 ha (FT12), with more than 4.05 ha (estates) (FT15); holdings producing only on lowland with less than 2.025 ha (FT13); landless people (FT14).

The production factors available to each "average" farm unit are given exogenously. Land, labor (human, mechanical and animal), water, capital, fertilizer and seed capacities are taken from the actual farming pattern and are defined at farm type level. The factors bounded at regional level are land, farm labor, landless labor and water.
Land availability per farm unit is divided into 2 periods of 6 months each. This corresponds to the two main cultivation seasons, the maha and the yala. Two restrictions define land availability at farm level and regional level and a third restriction at farm level contains crop rotation prescriptions. Three categories of labor are defined: human labor, further specified in farm and

landless labor, animal labor and mechanical labor. Availability of farm labor is specified over 4 periods of 3 months each and is globally quantified in man/days per period. Farm labor and rented labor from a landless farmers' pool satisfy the requirements of the production activities. As for mechanical labor, farms could not be endowed with a machine stock, as no data were provided. The mechanical labor is then available without restrictions in form of rented machines at a fixed fee.

Animal labor is treated similarly to mechanical labor. The animal stock on farm consisting of buffaloes may be integrated with rented animals from other holdings at a fixed fee for draught purposes.

The water restrictions set applies to the three areas, though it is of relevance for the dry and the intermediate dry zone only. The water availability is defined over 2 periods of 6 months each, corresponding to the dry and the rainy seasons.

The requirement of pesticides, fertilizers and seeds is defined for each crop activity. The fertilizer application for perennial crops is aggregated over two periods of 6 months each, whereas for the seasonal crops it varies according to the crop activity. The seed and pesticide factors are considered over one period and connected to the crop activity. Fertilizers are differentiated into two categories,i.e. organic manure, produced on the farm, and chemicals, purchased outside the farm. Pesticides, whenever they are applied, are only purchased outside the farm.

Three kinds of animal feed are considered: fodder, concentrates and feed mixes. Rice straw, which potentially represents a major feedstuff, is considered together with grass as fodder, due to its present limited utilization. The feed requirement is distributed over two periods of 6 months each, coinciding with the yala and the maha seasons.

Livestock is not directly in function of the land surface, due to the circumstances on which the animal feeding occurs. Fodder is actually collected on marginal lands or in forests, and rice by-products, like straw, or coconut by-products, like poonac, contribute to the nutritional balance. Fodder availability in the model is given on the basis of an average fodder yield for an estimated surface.

As far as this study is concerned, two different production technology sets are considered.The first will rely on so-called "modern technologies" and the second one on "traditional technologies". In order to be able to qualify the production pattern as "modern" the application of fertilizers or pesticides must be accompanied by the use of high yield varieties and mechanization in field operations.If these conditions are not satisfied then the production pattern has to be considered "traditional".
Irrigation, though part of the production set, is considered independently from the other factors, due to its relevance.
Furthermore, activities are defined according to calendar practices which divide the year into two cropping seasons. Each crop therefore represents a different activity, relying on a different production pattern and yield.
As far as livestock is concerned, the key element in the definition of the technologies applied is related to the genetic breed of the cattle. The stock replacement equation, the cow balance equation and the calve balance equation rules the herd size at farm level.The balance equations related to cattle sales and purchases at regional level rule the livestock market.

The transformation submodel
The transformation sector is modelized by means of balance equations between the production and the consumption submodels. At regional level the production activity is either self-consumed by the farmer or sold on the market. An accounting activity represents the physical quantity of the commodity which is traded and transformed in processing plants. The total quantity of the processed activity is further marketed and reaches the final consu-

mers. At this stage of the model, the import and export activities are incorporated into the demand balance equations, linking the processed activities to the consumed activities.
Shadow prices related to the transformation balance equations play a major role in the model results. The first equation, linking production activities to trading activities provides the farm gate prices for each commodity traded. The shadow price of the balance equation, linking each processed activity to the corresponding consumption activity, represents the consumer price.
Export and import prices are given exogenously.

The consumption submodel

The consumption unit is represented by the household. It comprises an average fixed number of persons and corresponds by analogy to the average farm unit of the production model. Two household groups have been considered, i.e. rural households and urban households.
Both the rural and the urban population are bounded at sector level.
The rural household is allowed to consume self-produced commodities, whereas for the urban one the market is the only supply source.
The commodity mix demanded by each household group is related to its calory and protein requirements, so-called "physiological" restrictions. Protein restriction is further divided into animal protein and vegetable protein requirements.
Consumption commodities are grouped according to the substitution criterion. Within the commodity group, substitution can occur according to given patterns and derived on the basis of the observed substitution rate. These patterns are commodity mixes that approximate a part of the substitution isoquant at constant rate. For a comprehensive review of the methodology about substitution in demand in equilibrium models refer to Hazell and Norton (1986).

3 THE MODEL RESULTS

The statistical mean used to calculate the deviation of the model results from the historical data is a simple percentage absolute deviation (PAD), i.e. the ratio between the sum of the absolute differences between the observed values and the calculated values and the sum of the observed values. The PAD of the supply side of the model is 11%, whereas on the consumption side it amounts to 19%.

The basis solution

As far as the basis solution is concerned, the most characterizing aspects depicting the Sri Lankan agricultural sector are outlined below. The results of the basis solution are presented in this chapter in a very reduced form, as synthesis of the quantitative analysis done for each model section.

Key-elements of the production section

Irrigation water and availability of agricultural land determine the farming structure and the production mix in the three production areas. To this extent the ratio between lowlands and highlands within each farm group is the key element for optimal farming structure allocation. In dry areas the composition of the farm allottee must take into account the effective availability of water. Holdings with a high lowland share tend to leave land fallow in the dry season, mis-using this factor. In the context of today's availability, the lowland share in total acreage should be kept between 50% and 60% according to the results. The farm labor intensity is the second main factor in the optimal choice of farming structure. Farmtypes with a higher farm labor intensity are privileged in respect of those without, especially in the wet zone.
The dry and intermediate dry zones allow an intensive paddy production, whereas the wet zone allows an extensive one. Among the export crops, tea is the most compe-

titive and occupies all available estate land in the wet zone. The tea industry, however, seems to have exhausted its capacity and a production increase can be achieved only through an increase of productivity. On the other hand rubber production finds itsels on a downward trend, as it is being increasingly displaced by tea and coconut. The livestock sector shows a disproportion between the number of buffaloes and the draught power required. The model re-allocates part of the livestock potential to cattle and particularly milk cows. The wet zone enjoys comparative production advantages as far as milk is concerned.

Key-elements of the transformation section

The model confirms the most relevant role played by self-consumption. The small holding producers retain substantial quantities of the produce for their own nutrition.
Among processed commodities, milk products and coconut products are given particular attention.
Fundamental factors for the development of the dairy sector are the price policy on the one hand and the infrastructure policy on the other. The results show that by a milk powder duty of 26% milk imports would be completely substituted by domestic production. However, the substitution of milk imports can only occur if the collecting capacity of the dairy industry is adjusted.
The competitiveness of coconut export products globally and among themselves depends on the absolute price level and on their price differences respectively. The decreasing price trend shows a severe loss of competitiveness of the whole coconut processing industry, and the growing relevance of copra as export product, due to its better performance at export price/production costs level. Desiccated coconut and coconut oil follow copra in the "processing priority".

Key-elements of the consumption section

Due to lack of information on the demand side, it is not possible to determine the demand curve for each consumers group and therefore the consumption allocation occurs arbitrarily, on the basis of the lowest generating costs. The basic foodstuffs are rice, for which self-sufficiency is around 90%, and coconut. Main imports are rice, milk powder, wheat, dhal and sugar. The substitution specifications made to increase the performance of the model are unsatisfactory.

A note on the shadow prices

The complementarity between factor land and factor water in the dry zone is decisive for the level of the shadow prices for these two factors. There is a negative correlation between them.

The intensity of the pressure on land exerted by the principal cash crops turns out to be the decisive element in determining the shadow price for land in the wet region.

Landless labor shadow prices show a downward sloping gradient from the wet to the dry zone.

The most binding element in the Sri Lankan nutritional situation is energy, followed by animal proteins. Plant proteins are usually in excess in the typical diet.

The global consumer surplus is much higher than the global producer surplus, indicating an inelastic aggregated demand curve. Among the commodity groups, coconut and cereals show the highest, and milk and meat products the lowest consumer surplus.

Simulation

The scenarios presented in the integral version of the study are six, dealing with several agro-political topics. In this paper only one of them is reported under the heading: "More water and more land".

This scenario reproduces a situation in which both water for irrigation purposes and cultivable land as basic production factors are made more available. This are the details:

The water availability in the second water period (yala season) in the dry zone is enhanced by 50%. Land availability for agricultural use (both highlands and lowlands) in the dry zone is enhanced by 20%.

Production

The first remarkable change takes place in the farming structures of the dry zone. The key role played by the water/land ratio in determining the farming structures once again becomes evident. In a situation where water is less binding, those farmtypes having a higher lowland share in the total acreage are privileged. The FT2-group, which constituted 7% of all holdings in the basis solution, increases its presence, reaching 57%. The other group appearing in the basis solution, FT4, decreases to 43% from 93%.

The human labor factor is utilized almost at the same level as in the basis solution as far as the first two periods are concerned; in the third and fourth periods FT2 shows a remarkable release of rented landless labor, whereas FT4 does not differ substantially from the basis values. The shift from vegetable crop to paddy has mainly reduced the rented landless labor in the cropping periods. This fact confirms how vegetable production is an alternative to rice because of its lower water requirement only.

The production pattern shows some interesting developments. First, the paddy production occurs on the whole less intensively, as paddy activities in the first crop rely mostly on traditional technologies.

Extensification occurs only in the maha season, according to the greater availability of water, and concerns the 74% of the total paddy surface in this period.

As far as the highland crops are concerned, i.e. mainly coconut, their extent does not show any variation. The greater land availability is compensated by the fact that there has been a shift towards the lowland in the regional allocation, due to the enhanced presence of the FT2 farmtype. The vocation of the dry zone for paddy production is once again evident.

Being the livestock production linked to paddy production, since both the "after crop-grazing" and the rice straw are relevant fodder sources, the livestock population increased. The buffalo herds in particular increased due to the higher requirement of draught power for paddy cultivation.

The regional farming structure of the intermediate dry zone does not show any remarkable shifts from the basis solution.
The production pattern remains almost the same, except for an extensification of the paddy production. The conditions for the extensification of the paddy production rely on the changed price ratio between fertilizer and paddy.

The re-allocation of paddy production in the dry zone has caused an increase in the wet zone of the area devoted to highland crops at holding level. This originates in a slight shift in the farming structure from holdings with emphasis on paddy production to holdings with less emphasis on this production branch (on marginal lowlands) or having only highland. The FT10 group decreases by about 14% whereas the FT12 group increases by 4% and the FT13 group by 19%.
As far as the production pattern is concerned, paddy extent diminishes, whereas vegetable extent is enhanced especially on the specialized highland farms (FT12). Marginally in FT10 and predominantly in FT12 greater emphasis is put on the minor export production and the fruit production together with coconut production to the disadvantage of rubber production.
As far as the livestock sector is concerned the lower availability of rice straw as fodder causes the intensification of the dairy production in FT12. The price for fodder has risen, due to lower availability, which has caused a factor substitution, through concentrates and consequently the production intensification.

As far as the sector production is concerned, the paddy output has augmented by 12%, which has caused the achievement of full self-sufficiency. The paddy production has shifted proportionally in the dry region, where the total output increased by 23%. On the other hand, the coconut production, though keeping the same value as in the basis solution, has shifted slightly in the wet zone. The minor export crops have grown in their output as well as vegetables, the latter concentrated in the up country highland farms. Milk production has also benefitted from the boost in paddy production. More fodder has become available in the dry zone from rice straw, and a production intensification has occurred in the wet zone up country. The total milk quantity has increased by 8%.

Trade and processing

The rice imports done in the basis solution, which represented the 11% of the total consumed quantity, dropped to zero, and were substituted completely by domestic production.

Since milk production has increased, more domestic milk is available for local processing. The collecting capacity of the dairy industry is fully exploited. The raw milk price decrease turns the milk processing into milk powder economically viable; this causes an import substitution through the domestic product of about 10%.

Consumption

As to the consumption pattern, no major changes take place.

Shadow prices

Looking at the shadow prices of the factors, a relevant change occurs in relation to the land shadow price. The land marginal cost in the dry zone shows an increase of about 42%. As during the dry period water is not binding any more, land represents the only binding factor to the further exploitation of the highly comparative advantages of the rice production found in this region. A decrease of 17% in the land price of the wet zone relies on the

lower relevance of paddy production for the region, which is not totally compensated by the increased relevance of the highland crops production. The land shadow price of the intermediate zone remains more or less constant showing a slight decrease of 3% only.
For those commodities which, due to the greater production factor availability, could expand their output, a price decline is shown. Both the rice producer and consumer price have decreased by about 39%, the vegetable prices by about 10%, since no exports were allowed.
The producer price for milk shows a decrease of 6% due to the milk supply expansion, which is, however, contained by the full exploitation of the collecting capacity of the industry. The paddy price decline has caused an increase of consumer surplus linked to this commodity by about 35%. Globally, the consumer surplus on the whole demand of foodstuffs increases by about 7%, whereas the corresponding producer surplus diminishes by 8%.

Table 1 shows the most relevant model results comparing the basis solution figures with those calculated in the scenario .

Table 1 (a) : Farmtypes distribution

FARMTYPE	UNITY	BASIS	SCENARIO 1
Farmtype 1	tdhs		
Farmtype 2	tdhs	19.80	219
Farmtype 3	tdhs		
Farmtype 4	tdhs	258	164
Farmtype 5	tdhs	597	600
Farmtype 8	tdhs	0.39	0.34
Farmtype 9	tdhs	23.08	23.08
Farmtype 10	tdhs	297	255
Farmtype 11	tdhs		
Farmtype 12	tdhs	2450	2537
Farmtype 13	tdhs	186	221
Farmtype 14	tdhs	50.33	50.33
Farmtype 15	tdhs	1.74	1.74

Table 1 (b) : Production quantities

COMMODITY	UNITY	BASIS	SCENARIO
Paddy	th. tonnes	2330	2611
Manioc	th. tonnes	302	302
Tea	th. tonnes	196	196
Coffee	th. tonnes	1.14	1.61
Cocoa	th. tonnes	4	5
Vegetables	th. tonnes	490	541
Coconut	mill. nuts	2528	2528
Rubber	th. tonnes	36.80	13
Plantain	th. tonnes	258	258
Mango	th. tonnes	258	258
Pepper	th. tonnes	10.53	10.73
Nutmeg	th. tonnes	10.80	11.16
Cloves	th. tonnes	2.28	2.35
Greengram	th. tonnes	29.12	29.12
Cowpea	th. tonnes	102	102
Ginger	th. tonnes	10.50	10.86
Chilli	th. tonnes	9.64	9.95
Milk	th. l.	2709	2939
Meat	th. tonnes	15.57	15.57
Cows IN	th. animals	2026	1989
Calves IN	th. animals	380	373.18
Bulls IN	th. animals	30.38	29.84
Buffaloes IN	th. animals	243.72	388.48
Cows XB	th. animals	29.63	50.43
Calves XB	th. animals	7.40	12.60
Bulls XB	th. animals	0.44	0.75

Legend: IN = indigenous breed type; XB = crossbreed type

Table 1 (c) : Consumption quantities: self-consumed (own produce) and purchased in the market (market).

COMMODITY	UNITY	BASIS	SCENARIO1
OWN PRODUCE			
Rice	tonnes	1569974	1751937
Manioc	tonnes	302550	302550
Coconut	th. nuts	1442839	1101026
Tea	tonnes	23242	21508
Coffee	tonnes	1138	1611
Cocoa	tonnes	4008	5239
Fresh milk	th. l.	184052	184052
Vegetables	tonnes	489200	540463
Bananas	tonnes	25730	25730
Mango	tonnes	25730	25730
Ginger	tonnes	10521	10862
Chilli	tonnes	9633	9945
Pepper	tonnes	5752	5938
Nutmeg	tonnes	10815	11165
Cloves	tonnes	2281	2355
MARKET			
Coconut oil HT2	tonnes	38220	38220
Milk powder HT1	tonnes	20445	20445
Meat HT1	tonnes	15583	15583
Rice HT2	tonnes	185243	
Greengram HT2	tonnes	29120	29120
Manioc HT2	tonnes		
Cowpea HT2	tonnes	102040	102040
Coconut HT2	tonnes	85040	426853
Past milk HT2	tonnes	56903	56903
Cond. milk	tonnes	13647	13647
Milk powder HT2	tonnes	14063	14063
Dahl HT2	tonnes	22043	22001
Wheat flour HT1	tonnes		
Sugar HT2	tonnes	227100	227100
Wheat flour HT2	tonnes	415928	415151

Legend: HT1 = rural households; HT2 = urban households

Table 1 (d) : Producer (PPrice) and Consumer (CPrice) prices for commodities; Economic surpluses (Mill. Rs.)

COMMODITY	UNITY	BASIS				SCENARIO 1			
		PPrice			CPrice	PPrice			Cprice
		R1	R2	R3		R1	R2	R3	
Rice	rs/kg	4.89	4.89	4.89	7.28	2.98	2.98	2.98	4.54
Dhal	rs/kg				15.70				15.70
Wheat flour	rs/kg				5.82				5.82
Chilli	rs/kg		10.3	12.17	10.32		8.37	10.67	8.75
Manioc	rs/kg	0.27	0.27	0.53	0.42	0.26	0.26	0.46	0.37
Greengram	rs/kg		7.53	14.97	7.68		7.14	10.79	7.29
Cowpea	rs/kg		7.33	14.26	7.48		7.14	10.79	7.29
Tea	rs/kg	10.62			59	10.61			59
Coffee	rs/kg	24.82			67	24.55			67
Cocoa	rs/kg	8.28			37	7.39			37
Vegetables	rs/kg	6.09	6.09	6.09	6.10	5.40	5.40	5.40	5.55
Coconut	rs/nut	0.64	0.64	0.64	0.79	0.61	0.61	0.61	0.76
Cocooil	rs/1				9.45				9.07
Copra	rs/kg				5.07				4.84
Dess. Coco	rs/kg				13.45				13.45
Rubber	rs/kg	9.25			27	9.25			27
Plantain	rs/kg	0.43	0.43	0.83	0.50	0.41	0.46	0.78	0.48
Mango	rs/kg	1.23	1.23	2.23	1.28	1.18	1.18	2.02	1.23
Ginger	rs/kg		7.16	14.61	7.76		7.56	13.16	7.56
Pepper	rs/kg	13.46	13.46		69.46	13	13		67.62
Nutmeg	rs/kg	22.27	22.52		30	21.35	21.65		30
Cloves	rs/kg	32.35	32.20		120	31.24	31.07		120
Sugar	rs/kg				5				5
Fresh milk	rs/1	3.31	3.31	3.31	3.31	3.12	3.12	3.12	5.18
Past milk	rs/1				7.31				7.18
Cond milk	rs/kg				25.49				25.20
Milk powder	rs/kg				36.80				36.80
Meat	rs/kg	28.62	28.62	28.62	31.62	47.74	47.74	47.74	50.74

ECONOMIC SURPLUSES

Consumers	Basis	Scenario 1
Cereal	5235	7046
Milk/Meat	143	-91
Pulse	795	803
Vegetables	2576	2824
Coco	10265	10311
Fruits	1001	1010
Cocoil	2846	2861
Spices	1506	1491
Beverage	448	455
Sugar	3187	3187
Producers	2395	2215

4 CONCLUSIONS

The model has proved to be quite a powerful instrument to analyze complex relationships such as those of a whole agricultural sector. The most relevant interdependencies within the Sri Lankan agricultural sector have been singled out, providing a quantitative basis to many issues of Sri Lankan agricultural policy.

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