APIP

PA-ABI-681

Agricultural Policy Implementation Project

General Directorate for Development Planning and Agricultural Investments (DGPDIA)
Ministry of Agriculture, Republic of Tunisia

A LINEAR PROGRAMMING MODEL FOR AGRICULTURAL PLANNING IN TUNISIA: A STUDY OF THE NORTH WEST PUBLIC SECTOR

Final Report 91-1

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by

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In collaboration with

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Sponsored by

US AID/Tunis Special Mission for Economic and Technical Cooperation

AID Contract No. 664-03430C-00-8016-00

PN-ABI-681

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Supported by USAID/Tunis Special Mission for Economic and Technical Cooperation

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EXECUTIVE SUMMARY

A LINEAR PROGRAMMING MODEL FOR AGRICULTURAL PLANNING IN TUNISIA: A STUDY OF THE NORTHWEST PUBLIC SECTOR

(1) Agricultural policy decisions require detailed analysis of the economic performance of the farm sector. By improving the understanding of the competitiveness of various crop and livestock enterprises, analysts are better able to gauge the adjustments in agriculture resulting from changing economic conditions. This study examines the competitiveness of agricultural activities in the north-west public sector, under alternative pricing policies and institutional reforms proposed within the framework of the Tunisian structural adjustment program. Impacts of these policies on net income, cropping patterns, output response, input use and opportunity cost of owned resources are simulated with a linear programming model developed from primary and secondary data sources. The model covers activities of the Unités Cooperatives de Production, the Agro-Combinats, and the Fermes Pilotes in the gouvernorats of Béja, Jendouba, Le Kef, Siliana and Zaghouan.

(2) The work leading up to this report had four objectives: (1) to assist the Ministry of Agriculture (MOA) in evaluating the economic performance and impacts of alternative price and institutional policies in the public sector; (2) to illustrate the usefulness of linear programming models for improving the efficiency of state farms; (3) to strengthen the skills of staff in the Direction Générale de la Planification, du Développement et des Investissements Agricoles (DGPDIA) in economic modeling and linear programming techniques; and (4) to help focus data needs and strengthen linkages between the bureaus of statistics and planning in the Ministry of Agriculture (MOA). This work was carried out as a collaborative effort by staff of the DGPDIA/MOA, the Department of Agricultural Economics in the Tunisia National Institute of Agriculture, and the International Agricultural Programs of the University of Wisconsin.

(3) The choice of region (northwest) and sector (state versus private) were determined by a number of factors. First, technical operations in the public farm sector are relatively better understood and documented than in the private sector, facilitating data collection and model construction. Second, the decision was made to focus on food policy concerns, thus shifting the focus to the northwest region (with 77 percent of cereals area, 55 percent of the cattle, and 53 percent of the sheep and goats in the total public sector). The northeast public sector has a heavier orientation toward tree crop production. Because of problems of data availability, development of a private sector model was postponed for a later stage of the analysis.

(4) Inputs in the public sector model include temporary and permanent labor, mechanization, Ammonium Nitrate fertilizer, super phosphate fertilizer, potassium fertilizer, irrigation water, and herbicides, all purchased at official prices. Land in the model is sub-divided into five soil types based on differences in moisture, soil depth and topography.

(5) Activities in the model include principal sole crops and crop rotations for cereals (durum wheat, bread wheat, barley), legumes (fava beans), commercial vegetables (tomatoes, melons, potatoes, peppers); sugar beets; green forages (vetch-oats, barley, berseim ray-grass and alfalfa), hay (vetch-oats), straw (wheat and barley), ensilage (maize, sorghum and vetch-oats), worked fallow, and pasture fallow. The output of cereals, legumes, and vegetables, are sold at official prices. Forages and ensilage are produced as feedstuffs for sheep and cattle. Meat, milk, and wool produced as offtake from animal herds are sold at market prices. Wheat straw and hay can be either fed to sheep and cattle, or sold on the market.

(6) A short-course in Operations Research Methods for Policy Analysis was taught in the DGPDIA, August-September 1989. Following its completion, work began on developing a simple model of the north-west public sector to help focus questions on farm operations and to identify data requirements. A field visit to 5 public farms in December 1989 yielded data on technical coefficients associated with crop and livestock enterprises. In addition, discussions were held with agronomists, livestock specialists and economists of the National Institute of Agriculture to gather information on public sector farm operations and on technical norms. Estimates of input and output coefficients were also synthesized from official bulletins and other secondary sources. By March 1990, a preliminary model was operational and being used for policy analysis. The model presented here includes further changes in model specification and refinements in data made through December 1990.

(7) The base case solution provides the gauge for measuring the model's ability to approximate actual public sector operations. The base solution includes outputs, land use patterns, input use, and the opportunity cost of fixed resources (land, water, permanent labor, animal units) generated by the model for the base year 1986. Model results compare remarkably well with data reported in official statistics, indicating that the model provides a good representation of crop and input management decisions in the public sector.

(8) Five policy scenarios are simulated with the model: (I) eliminate fertilizer subsidies; (II) eliminate subsidies on irrigation water; (III) eliminate quotas on irrigation water supply; (IV) simulate the impact of reducing public sector employment; and (V) eliminate two sets of production quotas that reflect institutional policies of the public sector: a minimum requirement on area of sugar beets, and a maximum ceiling on vegetables.

(9) Increasing the price of Ammonium Nitrate from 118 to 128 D/ton, and the price of Super 45 from 110 to 141 D/ton (Scenario I), has only marginal effect on the base solution. Net farm income declines 1 percent. Cropping patterns are unaffected, indicating that changes in profitability are not sufficient to shift cropping patterns to less fertilizer intensive activities. Fertilizer use also remains the same, a result similar to earlier APIP findings of no significant relationship between fertilizer use and fertilizer prices in the northern region over the period 1975-87. Shadow prices of land resources decline marginally due to higher costs of field crop production. The economic value of livestock units decline slightly due to higher costs of feed grain production and of feedstuffs in animal rations.

(10) Under scenario II, water prices are increased from 25,000 to 60,000 Dinars per million m^3. The higher price of water results in a substantial decline in public sector income, but does not alter output, cropping patterns or input use because water prices do not reduce water demand to below quota levels. Increasing water prices while simultaneously reducing water quotas (Scenario III) has a profound effect on public sector production and income. Compared with the water subsidies scenario alone, net farm income increases 19 percent. Irrigated area expands from 29,865 to 34,000 hectares. Water use increases from 150 to 171 million m^3. The shadow price of irrigable land nearly doubles from 229 to 425 D/ha as irrigable land not water becomes the binding constraint. Enhanced profitability of relatively water intensive crops (fava beans, bersim ray-grass, ensilage) results in the substitution of forage for cereals on irrigated land. Opportunity costs of livestock increase substantially due to lower feed costs.

(11) In Scenario IV, the size of the permanent work force is reduced in the model by 50 percent, equivalent to about 2,255 workers in the northwest public sector. A critical mass of permanent workers is allowed to remain for supervisory purposes and for critical day-to-day farm operations. Temporary workers are allowed to substitute freely for permanent workers. Net income for the sector rises slightly from 36,183 to 36,667 thousand Dinars due to a lower wage bill. Changes in labor costs, however, are not sufficient to alter output, cropping patterns, or input use. Employment of permanent labor declines from 1,367 to 684 thousand days annually. Temporary labor increases from 642 to 1,165 thousand days, resulting in a net reduction of 160 thousand days overall. These results derive from the fairly steady hiring of temporary workers throughout the year, and the absence of strong seasonal permanent labor underutilization.

(12) Simulations (I) to (IV) are conducted with two output quotas in place: the area in vegetables is constrained not to exceed 6,490 ha; and users of irrigation water are required to plant a fixed proportion (1/5) of their irrigated land in sugar beets to satisfy government quotas. Both constraints are eliminated in Scenario (V), allowing state farms in the model to freely choose the crop mix they find most profitable. Based on model results, growers would shift from sugar beets to vegetables. Net public sector income increases 61 percent. The substitution of vegetables for ensilage on irrigated land results in net water savings sufficient to relax the water constraint, and to expand the area under irrigation. The value of livestock declines substantially due to higher feed costs. From strictly an efficiency perspective, profitability would be improved by permitting growers to increase vegetable production, and by eliminating quotas on sugar beets.

(13) Results of the five simulations combined indicate that state farms could improve their profitability by increasing production of vegetables, by lowering the quotas on sugar beets, by expanding the area of irrigable land, and by providing more flexible labor contracts. Even with higher costs of fertilizer, due to losses of input subsidies, net income with these changes rises 47 percent. Sugar beets, given current technology, prices and yields, do not appear to represent an optimal use of resources. Further investment in yield increasing or cost-reducing technology would be necessary if the sugar beet industry is to remain competitive with imported sugar.

(14) The stability of the linear programming solution also provides useful insights on the possibilities for structural adjustments. On non-irrigated land (70 percent of total cultivated land), for example, the north-west region has a comparative advantage in cereal production under a wide range of market prices. This reflects the relative rigidity of the food production system in face of agro-climatic constraints. Economic conditions that lower the profitability of cereals would directly affect net farm income, but would result in only minor substitutions between cereals and other crop enterprises. Efforts at crop diversification to raise income, would require higher levels of technology, prices and irrigation than are now possible.

(15) Total cereal supply or input demands tend to be very inelastic, as market prices have only a small impact on production decisions. The elasticity of total cereal supply with respect to a proportional change in the prices of all cereals is found to be 0.26. However, the possibilities of substitutions among cereals cultivated on dry land (durum wheat, bread wheat and barley) are quite important. The elasticities of supply are 1.01 for bread wheat, 4.92 for durum wheat, and 1.43 for barley. These large elasticities are generated mostly by substitutions among cereals. Changing relative prices of cereals can thus generate large adjustments in their respective productions. Yet, the aggregate grain supply response would be minor due to fixed land constraints in the sector. Pricing policy is thus likely to be less effective than policies aimed at stimulating investment in land-substituting technologies that increase wheat and barley production in the long-run.

(16) In the absence of institutional constraints, the possibilities of substitution among irrigated crops (cereals, vegetables, sugar beet and forage) are found to be more important. Although irrigated land is only 30 percent of cultivated public land in the northwest, irrigated crops are highly profitable and can be sensitive to changing market conditions. Increasing the supply of irrigable land would increase the flexibility of the farming system to respond to prices and climatic risk. Further investments in irrigation infrastructure could also represent an efficient use of resources.

(17) The current model provides an illustration of the use of linear programming in economic analysis and policy planning. As the work was done in close collaboration with staff of the MOA, the process helped to strengthen linkages between staff in statistics and planning, and strengthened skills in economic and policy analysis. With the assistance of APIP, the Ministry now has the computers, the software and the skills to operate the model, update it, and use it for further policy analysis. Work is now proceeding on a model for the private sector. Both sets of work will provide model templates for extending work to other regions.

(18) A number of future improvements in the model appear to be desirable. Being static, the model fails to incorporate the dynamic processes that characterize livestock or tree productions. It neglects the issue of risk and uncertainty and the possible effects of climatic variability on management decisions. Also, there is a need to improve the analysis of crop yield response to fertilizers. Incorporating these issues in further refinements of the model would appear to be a good topic for further work.

SOMMAIRE

UN MODELE DE PROGRAMMATION LINAIRE POUR LA PLANIFICATION AGRICOLE EN TUNISIE: CAS DU SECTEUR PUBLIC DANS LE NORD-OUEST

(1) Toute mesure de politique agricole doit nécessairement reposer sur une analyse approfondie des mécanismes de fonctionnement technique et économique du secteur. Une analyse de la profitabilité et de la compétitivité des productions animales ou végétales peut aider à mieux comprendre l'évolution économique du secteur agricole face aux changements de la conjoncture économique. Cette étude examine les activités économiques du secteur agricole public du Nord-Ouest dans le contexte de la réforme de la politique agricole en Tunisie. Les effets de la politique agricole sur les revenus, les cultures, les productions, l'utilisation des intrants et sur le coût d'opportunité des ressources agricoles sont simulés par un modèle de programmation linéaire. Le modèle inclue les activités des Unités de Coopératives de Production, des Agro-Combinats et des Fermes Pilotes dans les gouvernorats de Béja, Jendouba, Le Kef, Siliana et Zaghouan.

(2) Le travail rapporté ici a quatre objectives: 1/ aider le Ministère de l'Agriculture à mieux évaluer la performance économique du secteur public; 2/ illustrer l'utilité des modèles de programmation linéaire comme moyen de gestion des fermes d'tat; 3/ améliorer les compétences du personnel de la DGPDIA en matière d'analyse économique et de planification; et 4/ essayer d'identifier les besoins en données statistiques ainsi que leur utilisation en planification. Ce travail est le résultat d'efforts combinés entre le personnel de la DGPDIA, le département d'économie rurale de l'Institut National Agronomique de Tunisie, et l'International Agricultural Programs de l'Université du Wisconsin.

(3) Le choix de la région (Nord-Ouest) et du secteur (public versus privé) a été influencé par de nombreux facteurs. D'abord, les techniques de production sont mieux comprises et mieux documentées dans le secteur public que dans le secteur privé, ce qui a facilité la collecte des données. Deuxièmement, la région Nord-Ouest est très importante du point de vue de la production agricole, avec 77 pour cent de la production céréalière et 55 pour cent du bétail du secteur public Tunisien.

(4) Les facteurs de production inclus dans le modèle sont: la main-d'oeuvre (temporaire et permanente); la mécanisation; les engrais azotés, phosphoriques et potassiques; l'eau d'irrigation; et les herbicides (tous étant achetés aux prix officiels). La terre est divisée en cinq catégories en fonction de la topographie, de la pente et de la profondeur des terrains.

(5) Le modèle inclus les cultures suivantes (en monoculture ou en assolement): les céréales (blé dur, blé tendre et orge); les légumineuses (fève); les cultures maraîchères (tomates, melons, pomme de terre, poivre); la betterave à sucre; les fourrages verts (vesce avoine, orge, bersim ray-grass et

luzerne); le foin de vesce avoine et la paille; l'ensilage (de mas, de sorgho et d'orge); et la jachère (travaillée ou pturée). Les productions de céréales, de légumineuses et de cultures maraîchères sont vendues aux prix officiels. Les fourrages et les ensilages sont utilisés pour la nourriture du bétail. Les productions animales (la viande, le lait et la laine) sont vendues aux prix de marché. La paille de blé et le foin peuvent être utilisés pour la nourriture du bétail, ou bien vendus sur le marché.

(6) Un cours sur Les Méthodes de Recherche Opérationnelles en Analyse Politiques a été enseigné à la DGPDIA en août - septembre 1989. / la suite de ce cours, l'on a commencé à développer un modèle du secteur public pour la région Nord-Ouest. En Décembre 1989, cinq visites sur des fermes d'tat ont permis d'estimer un certain nombre de coefficients techniques concernant les productions agricoles. En plus, des discussions avec des agronomes, des zootechniciens et des économistes de l'Institut National Agronomique ont permis d'obtenir des renseignements utiles sur les techniques de production utilisées dans le secteur public. Finalement, des données ont été aussi obtenues à partir d'autres études ainsi que des publications officielles du Ministère de l'Agriculture. En Mars 1990, un modèle préliminaire était en place et commenait à être utilisé pour l'analyse de la politique agricole. Le modèle présenté ici inclut de nombreuses améliorations qui ont été incorporées entre Mars et Décembre 1990.

(7) La solution de base du modèle permet d'évaluer sa capacité à expliquer les décisions de production dans le secteur agricole public. La solution de base inclut les productions, l'utilisation de la terre, l'utilisation des intrants, et le coût d'opportunité des ressources fixes (comme la terre, la main-d'oeuvre permanente et le bétail) pour l'année 1986. Les résultats du modèle sont assez proches des données officielles concernant les activités du secteur public. Ceci indique que le modèle donne une bonne représentation des décisions de production dans le secteur public.

(8) Cinq scénarios de la politique agricole sont simulés: 1/ l'élimination des subventions sur les engrais; 2/ l'élimination des subventions sur l'eau d'irrigation; 3/ l'élimination des "quotas" d'eau d'irrigation; 4/ la réduction de la main-d'oeuvre permamente sur les fermes d'tat; et 5/ l'élimination de deux "quotas" qui reflètent la politique du secteur public: une superficie minimum en betterave à sucre; et une superficie maximum en cultures maraîchères.

(9) L'augmentation du prix de l'ammonitre de 118 D/tonne à 128 D/tonne, et du prix du super 45 de 110 D/tonne à 141 D/tonne (Scénario 1) n'a que peu d'effet sur la solution de base. Le revenu net diminue de 1 pour cent. Les superficies culturales aussi bien que l'utilisation des engrais ne changent pas. Ce résultat est consistent avec les études antérieures de l'APIP qui n'ont pas trouvé de relation significative entre l'utilisation des engrais et leur prix dans le Nord-Ouest entre 1975 et 1987. Les prix implicites de la terre diminuent un peu à cause de l'augmentation des coûts de production. La valeur du bétail aussi diminue un peu à cause de la hausse du coût des rations alimentaires.

(10) Avec le scénario 2, le prix de l'eau a été augmenté de 25000 à 60000 D/million m^3. Ce changement crée une diminution importante du revenu, bien qu'il n'affecte pas les productions ni l'utilisation d'eau (parce que la demande en eau demeure supérieure au "quota" d'eau). L'augmentation du prix de l'eau accompagnée de l'élimination du quota d'eau (scénario 3) a un effet profond sur les productions et sur le revenu agricole. Comparé au scénario 2, le revenu net augmente de 19 pour cent. Les superficies irriguées vont de 29865 à 34000 hectares. L'utilisation d'eau augmente de 150 à 171 million m^3. Le prix implicite des terres irrigables double presque, allant de 229 D/ha à 425 D/ha. L'amélioration du profit due aux cultures irriguées (fève, bersim ray-grass, ensilage) est associée à une substitution fourrages - céréales sur terres irriguées. Les coûts d'opportunité du bétail augmentent beaucoup à cause de la diminution du coût de la ration.

(11) Au scénario 4, la main-d'oeuvre permanente est réduite de 50 pour cent dans le secteur public du Nord Ouest. La main-d'oeuvre temporaire est embauchée au besoin. Ceci donne une petite augmentation du revenu net. La diminution du coût de la main-d'oeuvre cependant n'est pas suffisante pour changer les productions ni l'utilisation des intrants. L'emploi de la main-d'oeuvre permanente diminue de moitié alors que la main-d'oeuvre temporaire double presque, le résultat net étant une réduction de 160000 jours de travail par an. Ce scénario est associé à une embauche de travailleurs temporaires tout au long de l'année, et à une diminution du sous-emploi de la main-d'oeuvre permanente.

(12) Les simulations (1) à (4) sont obtenues sous deux "quotas": la superficie en maraîchage ne doit pas dépasser 6490 ha; et un minimum de 1/5 des superficies irriguées doit être planté en betterave à sucre pour satisfaire la politique gouvernementale. Ces deux contraintes sont éliminées au scénario (5), ce qui permet aux fermes d'tat de choisir les activités les plus profitables. Le modèle suggère que les productions maraîchères augmenteraient aux dépens de la betterave à sucre. Le revenu net augmente de 61 pour cent. La substitution maraîchage - ensilage résulte en une diminution de la consommation d'eau et une augmentation des superficies irriguées. La valeur du bétail diminue beaucoup à cause de l'augmentation du coût de la ration.

(13) Les résultats des cinq simulations indiquent que les fermes d'tat pourraient améliorer leur profitabilité en augmentant les productions maraîchères et les superficies irriguées, en diminuant les superficies en betterave à sucre, et en développant des contrats de travail plus flexibles. Même avec des prix d'engrais plus élevés (à cause de l'élimination des subventions), le revenu net pourrait augmenter de 47 pour cent. Etant donnés la technologie, les prix et les rendements actuels, il semble que la betterave à sucre n'ait pas d'avantage comparatif sur les terres d'tat de la région Nord-Ouest. En d'autres termes, de nouvelles technologies qui augmenteraient les rendements et/ou diminueraient les coûts de production devraient être développées avant que l'industrie de la betterave à sucre puisse devenir concurrentielle sur le marché mondial.

(14) La stabilité de la solution du programme linéaire donne des renseignements utiles sur les possibilités d'ajustements structurels. Sur les terres non - irriguées (70 pour cent des superficies cultivées), la région du

Nord-Ouest a un avantage comparatif en production céréalière dans des conditions de marché très variées. Ceci indique la rigidité du système de production dans des conditions agro - climatiques limitatives. Les conjonctures économiques qui diminueraient la profitabilité des céréales auront donc un effet important sur le revenu net, mais seulement peu d'effet sur le niveau des productions céréalières. Donc, des tentatives de diversification de cultures devraient probablement être associées à des technologies nouvelles.

(15) L'offre totale en céréales ainsi que la demande en engrais sont très inélastiques et ne sont que peu influencées par les prix de marché. L'élasticité de l'offre totale en céréales par rapport à une augmentation proportionnelle du prix de toutes les céréales est estimée à 0,26. Cependant, les possibilités de substitution entre céréales cultivées en sec (blé dur, blé tendre, orge) sont très importantes. Les élasticités d'offre sont de 1,01 pour le blé tendre, 4,92 pour le blé dur, et 1,43 pour l'orge. Ces élasticités importantes sont en grande partie le résultat de substitution entre céréales. Donc, un changement des prix relatifs de chaque céréale peut entraîner des effets importants sur leur production respective, bien que la réponse d'offre totale en céréales serait très faible (à cause des contraintes de terre). Du point de vue de leurs effets sur les niveaux de production totale, une politique des prix pourrait donc être moins efficace qu'une politique de recherche et de vulgarisation qui essayerait d'augmenter les rendements de blé et d'orge.

(16) En général, les possibilités de substitution entre les cultures irriguées (céréales, maraîchage, betterave à sucre et fourrages) sont importantes. Bien que les superficies irriguées ne constituent que 30 pour cent des superficies cultivées sur les terres publiques du Nord-Ouest, les cultures irriguées sont très profitables et sont assez sensibles aux changements des prix. Un accroissement des réseaux d'irrigation et des superficies irriguées amélioreraient la flexibilité du système de production et sa capacité à s'adapter aux changements économiques et climatiques.

(17) Le modèle actuel donne une bonne illustration de l'utilisation de la programmation linéaire en analyse économique et en planification. Ce travail a été accompli en collaboration étroite avec le personnel de la DGPDIA. Ceci a contribué à améliorer les compétences en matière d'analyse économique et de planification, ainsi que la coordination entre les statisticiens et les économistes au sein du Ministère de l'Agriculture. Avec l'aide de l'APIP, le Ministère maintenant a les ordinateurs, les logiciels et les compétences qui vont permettre l'utilisation du modèle et son amélioration à des fins d'analyse économique et politique. La spécification d'un modèle du secteur privé pour la région Nord-Ouest est maintenant en progrès. Ceci devrait donner une base de départ pour développer ce genre d'analyse sur d'autres régions.

(18) Il convient de noter plusieurs possibilités d'amélioration du modèle présenté ici. D'abord, le modèle utilisé paraît relativement statique puisqu'il n'intègre pas les processus dynamiques tels que ceux de l'élevage et de l'arboriculture. Il ne tient pas compte non plus du facteur risque lié à la variabilité climatique de la région. Aussi, l'analyse de la réponse des rendements en fonction de l'utilisation des engrais pourrait être améliorée. Donc, de nombreuses modifications pourraient être apportées au modèle. Ceci fera l'objet de travaux de continuation ultérieurs.

A LINEAR PROGRAMMING MODEL FOR AGRICULTURAL PLANNING IN TUNISIA: A STUDY OF THE NORTHWEST PUBLIC SECTOR

I. Introduction

This study examines the profitability and competitiveness of the public sector in Tunisia's northwest region under alternative pricing policies and institutional reforms proposed within the framework of the Tunisian structural adjustment program. Impacts of these policies on net income, cropping patterns, output response, input use, and opportunity cost of owned resources are simulated with a linear programming model developed from primary and secondary data sources. The model covers activities of state farms in the northwest public sector, in particular the Unités Cooperatives de Production, the Agro-Combinats, and the Fermes Pilotes in the gouvernorats of Béja, Jendouba, Le Kef, Siliana and Zaghouan. This work was carried out in the context of the Projet d'Ajustement de la Politique Agricole (Agricultural Policy Adjustment Program) within the Ministry of Agriculture (MOA).

The work leading up to this report had four objectives: (1) to assist the MOA in evaluating the economic performance and impacts of alternative price and institutional policies in the public sector; (2) to illustrate the usefulness of linear programming models for improving the efficiency of state farms; (3) to strengthen the skills of staff in the Direction Générale de la Planification, du Développement et des Investissements Agricoles (Department of Planning, Development and Agricultural Investments) (DGPDIA) in economic modeling and linear programming techniques; and (4) to help focus data needs and strengthen linkages between the bureaus of statistics and planning in the MOA. This work was carried out as a collaborative effort by staff of the DGPDIA/MOA, the Department of Agricultural Economics in the Tunisian National Institute of Agriculture, and the International Agricultural Programs of the University of Wisconsin.

II. Methodology

A. The Model

The model maximizes net income of crop and livestock activities of state farms and production cooperatives in Tunisia's northwest region subject to available land, labor and capital resources. Assuming that income is a linear function of production decisions, and that technological and institutional constraints affecting these decisions are also linear, the maximization of net income can be accomplished using linear programming techniques. The general linear programming model has the form:

$$(1) \quad \text{Max}_x \{c'x : A\,x \leq b,\ x \geq 0\}$$

where $(c'x)$ is the objective function, and $(A\,x \leq b)$ represents the complete range of production possibilities and constraints that influence production decisions, where:

$x = (x_1, x_2, \ldots, x_n)$ is a vector (with a dimension of (nx1)) of decision variables which are assumed to be non-negative $(x \geq 0)$.

$c = (c_1, c_2, \ldots, c_n)$ is a vector (with a dimension of (nx1)) of net income per unit of activity, c_j being the income (if positive) or the cost (if negative) of one unit of the activity x_j, $j = 1, 2, \ldots, n$. Therefore, $c'x = \Sigma_j(c_j\ x_j)$ is the total net income being maximized.

$b = (b_1, b_2, \ldots, b_m)$ is a vector with a dimension of (mx1), where each b_i element represents the maximum amount of resource 'i' available for the production process, $i = 1, 2, \ldots, m$. That is, there are 'm' resources available in limited quantities, each being a potentially limiting factor in production decisions. Certain constraints expressing restrictions on production levels can also be introduced into the model.

$A = \{a_{ij};\ i = 1, 2, \ldots, m;\ j = 1, 2, \ldots, n\}$ is a matrix of technical coefficients with a dimension of (mxn). The coefficient a_{ij} represents the quantity of the i-th resource used per unit of activity x_j. Therefore, $\Sigma_j(a_{ij}\ x_j)$ is the total quantity of the i-th resource that is used by all activities $x = (x_1, x_2, x_3, \ldots, x_n)$. The equation $A\,x \leq b$ simply guarantees that the total quantities of resources used $(A\,x)$ will not exceed the maximum quantities available (b).

The optimization problem in equation (1) can be solved using well-known numerical methods. The SIMPLEX method is employed in this study, using the LINDO software package.

B. Model Coverage

The northwest region is composed of five gouvernorats or administrative regions: Béja, Jendouba, Le Kef, Siliana and Zaghouan. Béja and Jendouba have a sub-humid climate (between 500 and 600 mm of rain per year) while Le Kef and Siliana have a semi-arid climate (between 350 and 500 mm). The model includes the activities of state farms operating within the region--the Cooperative Production Units (Unités Coopératives de Production (UCP)), the Agro-Combinats (AC) and the Pilot Farms (Fermes Pilotes (FP))--as well as the activities of commercial farms in the state controlled irrigated perimeters. The entire region contains 119 state farms that collectively control 146,676 ha of dryland, and 34,000 ha of irrigated perimeters. Cereal crop-animal husbandry associations are the main production systems, contributing about 60% of national cereal production and more than 28% of animal products (private and public sectors combined). The public sector contributes more than 20% of the agricultural output in the northwest region.

C. Objective Function

The objective function measures net income, or gross value of sales of crop and animal products less total variable costs. It is a deterministic function based on input-output relationships for an average year. No allowances are made for variations in output associated with climatic change, or for variations in prices associated with changes in production of agricultural commodities. Prices for products and factors of production correspond to the base year 1986.

D. Activities

The model corresponds to a "representative state farm," but incorporates the aggregate resources of all farms in the northwest public sector. It contains n=293 production and sales activities and m=199 constraints. Activities in the model define the various production possibilities open to state farms subject to availability of resources. These resources include temporary and permanent labor, mechanized traction, mechanized harvesting, Ammonium Nitrate fertilizer, super phosphate fertilizer, potassium fertilizer, irrigation water, and herbicides, all purchased at official prices. Land in the model is sub-divided into five soil types based on differences in moisture, soil depth and topography. Agricultural practices are specified by crop rotation constraints and by technical input-output coefficients associated with individual crop and livestock enterprises.

a. Crop Production

Crop activities in the model include production and sales of crop output and production of forage, specifically:

1. Cereals including durum wheat (BD), bread wheat (BT), barley (OG) and other cereals (AU);
2. Sugar beets (BS);
3. Vegetable cultivation including tomatoes (TM), melons and watermelons (PQ), potatoes (PDT), and peppers (PM);
4. Fava beans and horse beans (FV);
5. Green forage crops including green vetch-oats (FVVA), alfalfa (LZ), green oats (FVOG) and bersim ray-grass (BRG);
6. Ensilage in particular maize ensilage (ENMS), sorghum ensilage (ENSG) and vetch-oats ensilage (ENVA);
7. Hay and straw: vetch-oats hay (FNVA) and straw (PL) as a by-product of durum wheat, bread wheat and barley cultivation; and
8. Fallow: worked fallow (JT) and pasture fallow (JP).

Tree crop activities were not incorporated in the model because they represent only a small area in the northwest region, although they are important in other regions of the country (e.g. Cap-Bon, Sahel).

b. Animal Production

Animal products include meat (VIAND) and milk (LAIT) potentially produced from purebred cattle (BOVP), crossbred cattle (BOVC), and sheep (OVIN). Animals are produced with forage and ensilage derived from cropping activities plus concentrate supplements (CONCTR). Hay or straw can either be fed to livestock or sold at prevailing market prices, depending on where financial returns are highest.

E. Resources

a. Land

Five categories of land are included in the model: irrigable land (I), flat bottom land (1), moderately sloping land (2), steeply sloping shallow soils (3), and pasture (PATUR). These categories appear to capture the principal properties of soils (depth, fertility and water retention capacity) that influence cropping patterns in the region.

b. Labor

Labor use is divided into five periods of the year--(1) October-November, (2) December-February, (3) March-May, (4) June-July, and (5) August-September --to capture seasonal variations in labor availability and labor demands. Labor can either be permanent (TRAVPM) or temporary (TRAVTM). In contrast with temporary labor that is hired on a daily basis, hiring of permanent labor involves longer-term work contracts that impose a certain rigidity on employment patterns.

c. Capital

Capital includes seeds (SEM), herbicides (TOTDESH), mechanized tillage (TRACTN), mechanized harvesting (MOISS), water (EAU) and fertilizer: Ammonium Nitrate fertilizer (AMMON), super phosphate fertilizer or Super 45 (SP45) and potash fertilizer (POTASS). All of these resources are expressed in quantities (kg/ha), except for herbicide, which is measured in value (D/ha).

F. Constraints

A number of constraints have been introduced into the model (i.e. 199) including constraints on resource use, constraints defining crop rotations (i.e. the order in which certain crops follow others from one year to the next), and simple accounting constraints that allow the program to calculate summary variables (e.g. aggregate output summed over individual crop enterprises or over different soil regimes). Although these accounting relationships do not constrain the problem's solution, they have the advantage of providing summary information to facilitate the interpretation of model results. The model also contains certain institutional constraints (minimum quota on sugar beet production, and a maximum quota on vegetables) reflecting agricultural policy priorities being administered by the public sector. The following constraints on resource use are incorporated in the model:

1. **Crop production.** Crop and forage production is computed as cultivated area times yield. Yields vary with land type and crop rotation. Durum wheat can be cultivated with irrigation or by dryland farming on flat bottom land, on moderately sloping land or on steeply sloping soils. Bread wheat can also be irrigated, but under dryland conditions can be grown only on flat bottom land or on moderately sloping land. Barley can be grown on flat bottom land, on moderately sloping land, or on steeply sloping land, but cannot be irrigated in the model. Fava beans are cultivated with irrigation or on flat land. Green forage (vetch-oats and barley) can be cultivated on any kind of land. All other crops (sugar beets, tomatoes, melons and watermelons, potatoes, peppers, alfalfa, ray-grass, maize ensilage, and sorghum ensilage] can only be cultivated on irrigated land.

2. **Forage transfer constraints.** These constraints enable the transfer of ensilage (EN), hay (FN), or straw (PL) from one period to the next throughout the year. Periods are the same as those used for disaggregating labor. Grass on pasture land and green forage are assumed to be non-transferable (i.e. they must be consumed by livestock in the period they are cut).

3. **Livestock nutrition requirements.** These constraints define the nutritional needs of purebred cattle, crossbred cattle, and sheep for forage units (UF), digestible nitrogen (MAD), dry matter (MS) and hay (FN). Also defines quantities of nutrients (UF, MAD, MS, and FN) provided per ton of forage, ensilage, hay and grass (pasture) produced.

4. **Maximum livestock herd size:** 1986 stocks (female units) of purebred cattle, crossbred cattle, and sheep.

5. **Livestock products.** Yields of milk, meat and wool per female unit of purebred cattle, crossbred cattle and sheep.

6. **Seed Use.** Quantity of seeds used per crop activity.

7. **Land Resources.** Hectares of irrigated land (I), flat bottom land (category 1), moderately sloping land (category 2), and steeply sloping land (category 3) in the northwest public sector. Irrigated land is equivalent in quality to flat bottom land, except it is constrained in area by the size or scope of irrigation infrastructure.

8. **Crop rotations.** Although most crops can be cultivated as monocultures (except for sugar beets and vegetables), yields are generally higher with rotations. Most rotations incorporated in the model are two-year rotations including: (1) durum wheat, bread wheat or barley after worked fallow (JT); (2) durum wheat, bread wheat or barley after green fallow (JP); and (3) durum wheat, bread wheat or barley after legumes (vetch-oats hay, green vetch-oats, ensilage vetch-oats, or fava beans). The only exception to the two-year norm is the three-year rotation for sugar beets: sugar beet (BS) after a legume (vetch-oats or fava beans) after wheat (durum or bread).

9. **Labor requirements.** Hours required per hectare of crop activity or per female unit of livestock per agricultural period: (1) October-November; (2) December-February; (3) March-May; (4) June-July; and (5) August-September.

10. **Mechanized tillage requirements:** Hours of mechanization required for tillage per hectare of crop activity.

11. **Mechanized harvesting requirements:** Hours of mechanization required for harvesting per hectare of crop activity.

12. **Fertilizer requirements.** Quantity of Ammonium Nitrate, Super 45, and Potash (in kg) required per hectare of crop activity.

13. **Water requirements.** Amount of water (000 m^3) required per hectare of irrigated crop.

14. **Vegetable production quotas.** Area of vegetables in the model is constrained to not exceed 6,490 ha (mean area in 1986). Some state farm managers expressed an interest in expanding vegetable cultivation but felt compelled to grow sugar beets instead in accordance with government priorities.

15. **Sugar beet production quotas.** Area planted in sugar beets must be at least equal to 20 percent of the area of other irrigated crops. Most state farms in the northwest region consider sugar beet production a Tunisian government priority that must be undertaken to achieve sugar self-sufficiency. Private farmers in the irrigated perimeters are required to grow some sugar beets in return for irrigation water. Effectively these practices impose a quota on sugar beet area.

III. Data

Data on public sector resources and activities are published annually in two documents: the Enquête Agricole de Base [Basic Agricultural Survey, (EAB)] and the Enquête sur les Périmètres Irrigués [Survey of Irrigated Perimeters (EPI)]. However, the composition of farms in the public sector varies from one survey to the other. The EAB reports data on size of land holdings, cropping patterns, use of Ammonium Nitrate and Super 45 fertilizer, livestock holdings, and permanent and temporary labor employment (no output data) for the UCPs, ACs and FPs. The EPI reports data on area and input use on irrigable and irrigated holdings of the same public agencies, but includes as well commercial farmers in the irrigated perimeters. Thus while water delivery is regulated and controlled by the state, management of farming activities in the irrigated perimeters is both publicly and privately managed.

The overlap between the EAB and EPI data series raises two operational problems. First, how should the public sector be defined in terms of available resources, technical input-output coefficients, etc.)? Second, which set of empirical data should be used to calibrate the model? For example, the EAB has very detailed data about land use (pasture, plowed land, worked fallow and waste land); however, within the category of plowed land, it does not distinguish between irrigable and non-irrigable land. The EPI gives detailed

information on the amount of irrigable and irrigated land in the public irrigated perimeters, but does not distinguish between the activities of public and private farms. The model developed here thus includes the public sector as well as private farm activities in the irrigated perimeters, with resource levels based on best judgement and interpretation of available data.

Four categories of resources are considered fixed in the model: land, irrigation water, permanent labor and livestock.

Regarding land, the UCPs, ACs, and FPs in the five northwest gouvernorats collectively controlled 17,250 ha of fallow, 116,309 ha of arable land, and 12,117 ha of pasture in 1985-86 (1986 EAB). Published data from the 1989 EPI on irrigated perimeters indicates that there are 35,600 ha of irrigable land in the public sector, 32,000 ha being actually irrigated. Soil quality (depth and topography) is an important factor in crop production. Bread wheat is usually cultivated on better land (flat land and deep soils) because of its superior yield response to fertility and water. Barley is usually cultivated on poorer land (shallow soils on hillsides) because of its superior drought resistance. It is difficult to subdivide aggregate data on land resources into these soil regimes. However, other divisions that are sometimes used to distinguish soil types (e.g. proportion of sand, clay, or silt, or percentage of area falling within certain gradients of slope) are not reported in official statistics.

Constraints on availability of the different land qualities were determined based on observations of land use reported in the agricultural surveys. Technical coefficients in the model reflect the comparative advantage of each crop for each soil type. Land resources were then adjusted in successive model iterations until its solution conformed to the observed agricultural practices. This iterative procedure resulted in the following endowments: 49,000 ha of steeply sloping land, 25,000 ha of moderately sloping

land, 13,000 ha of flat bottom land, 12,120 ha of pasture, and 34,000 ha of irrigated land. The total area (133,120 ha) more or less corresponds to the land resources in the EAB and EPI data surveys (181,276 ha) reported above, less the area of tree crops (21,479 ha) which was not included in the model, less the overlap (the difference--26,677 ha) between arable land in the EAB, some unknown fraction of which irrigated, and land in the irrigated perimeters. Whether indeed this amount of overlap in irrigated land does exist between the two surveys was impossible to verify. Nevertheless, land endowments in the model can easily be changed should they prove to be inaccurate.

Land classified as flat bottom can potentially be irrigated with investment in irrigation infrastructure for water delivery. The area of irrigable land that remains non-irrigated because of water availability constraints (150 million m^3) is simply treated as non-irrigated flat bottom land (4,135 ha) and is endogenously determined by the model. As long as this constraint is active, the opportunity cost of irrigable land and flat bottom land at the margin will necessarily remain the same. The irrigation water constraint was determined by first obtaining the unconstrained model solution (with abundant water) at the subsidized water price, then iteratively adjusting the water constraint until the ratio of irrigated land to irrigable land equaled 0.87 (1989 EPI). It is possible that factors other than irrigation water are responsible for the lack of irrigation on irrigable land (e.g. sufficient rainfall or unaffordable technology). This constraint could easily be altered to evaluate these possibilities.

The number of cattle (female unit = u.f.) is calculated from data provided in the livestock census (EAB 1986) on numbers of cows, heifers and female calves, and "other cattle" held by the UCPs, ACs and FPs, and the weights 1 u.f. = 1 cow, 0.4 heifer or female calf, and 0.5 "other cattle". The stock of

sheep (female unit = u.f.) is calculated from the number of ewes and "other sheep" inventoried in the UCPs, ACs and FPs, and the weights 1 u.f. = 1 ewe and 0.6 "other sheep". Based on these calculations, livestock on state farms in 1986 amounted to 9,825 purebred cattle (u.f.), 130 crossbred cattle (u.f.), and 95,950 sheep (u.f.). These various categories of livestock are constrained in the model to not exceed these levels. Thus the model can choose to liquidate stock in cases where animal production is not profitable. However, it prevents stock numbers from exceeding 1986 levels in the short-run due to capacity constraints imposed by fixed investments in sheds, milking parlors, and time requirements for herd reproduction.

The amount of permanent labor in the public sector is calculated from data in the 1986 EAB for the UCPs, ACs and FPs on total number of employees working on state farms, and the average number of days worked by permanent workers per year. Based on these data for 1985-86, the public sector in the northwest region employed 4,509 employees who collectively worked roughly 1,367,337 days during the year. The year is divided into five agricultural periods: (1) October-November; (2) December-February; (3) March-May; (4) June-July; and (5) August-September. Permanent labor availability is prorationed among these five periods based on days per period.

Resource endowments for the five land types and the three categories of livestock each have constraints establishing maximum ceilings in the model. The constraint on irrigation water, if active, would imply that only a portion of the irrigable flat bottom would be irrigated; the remainder would revert to dryland farming practices. Permanent labor supply is constant in the model, meaning that their labor services pose fixed salary costs to state farms, whether there is work or not. Depending on the intensity and seasonality of labor demands derived from agricultural activities, this stock of permanent

labor may either be fully- or under-employed during each of the five labor periods. The model permits hiring of temporary labor during periods of excess labor demand. Permanent labor surplus may arise in other periods. All other inputs or resources in the model (fertilizer, herbicide, mechanization, seeds) are determined without explicit constraints.

The data underlying empirical development of the model has thus been obtained from various sources: the EAB and EPI agricultural surveys, expert opinion, and complementary polls of some state farms in the northwest region. Selected data in the model are presented in Annex 1 on prices and yields of marketed output, Annex 2 on fertilizer and capital requirements of alternative crop enterprises, Annex 3 on labor requirements, Annex 4 on forage crop yields, and Annex 5 on the nutritional value of forage and on livestock nutrition requirements. The complete data are contained in the northwest public sector model presented in Annex 6.

The computer model for the northwest public sector (in Annex 6) can be read as an ASCII file by a wide variety of computer packages, but is solved in this study using LINDO (refer to the LINDO technical manual for documentation on the TAKE, ALTER and GO commands needed to execute the model). Parameter changes in the model can either be executed using the LINDO ALTER command, or by using a general word processing package (e.g. Word Perfect). If a general word processor is used, files must be accessed and saved in ASCII format (i.e. the format that LINDO will read the file under the TAKE command). Output from LINDO for the base case solution is presented in Annex 7. The sensitivity of this solution is indicated by the range analysis in Annex 8, i.e. the allowable range in which a variable can be changed without altering the base solution. The interpretation of the base solution and of alternative policy experiments are the focus of the following sections.

IV. Interpretation of the Base Case Solution

The results indicated below refer to a deterministic future, i.e. a future based on the information used in the construction of the model. Net income in the model solution is the value of agricultural output sold at official prices less input costs. It excludes fixed charges associated with management or capital depreciation that would be considered fixed in the short term. A more detailed study of these costs would be necessary to establish definitive conclusions on the financial viability of the public agricultural sector.

A. General Overview

Six policy scenarios, including the base case, are simulated with the northwest public sector model. The base case or base solution (model A) provides estimates of output, land use patterns, input use, and the opportunity cost of owned resources (land, permanent labor, animal units) for the public sector in the base year 1986. Model results from the base solution are first validated with data on area cultivated and input use reported for the public sector in the 1986 EAB and 1989 EPI. The base model is then used to simulate the impact of five policy experiments: (B) eliminating producer input subsidies on fertilizer; (C) eliminating irrigation water subsidies and quotas on water supply; (D) reducing the size of the public sector work force; (E) eliminating output quotas on vegetables and sugar beets; and (F) all policies combined.

B. Base Model Solution

The optimal solution for the base model is presented in Annex 7. It indicates that net income for the public sector is 36 million Dinars for a Useful Agricultural Surface (Surface Agricole Utile (SAU)) of 121,000 ha. This represents an average remuneration of about 300 D/ha of SAU derived from the following cropping activities:

- 20,154 ha of bread wheat, of which 8,567 ha (BT/LG1) is in a rotation with 3,000 ha of fava beans (FV1) and 5,567 ha of vetch-oats ensilage (ENVA1) on flat bottom land; and 11,587 ha (BTI) under irrigation.

- 15,645 ha of barley in rotation with worked fallow (OG/JT3) on steeply sloping land.

- 12,500 ha of durum wheat (BD/LG2) in rotation with 4,299 ha of vetch-oats hay (FNVA2) and 8,201 ha of vetch-oats ensilage (ENVA2) on moderately sloping land.

- 8,855 ha of other cereals (AU/LG3) in rotation with vetch-oats hay (FNVA3) on steeply sloping land.

- 15,645 ha of worked fallow (JT3) on steeply sloping land.

- 33,730 ha of forage crops including 13,154 ha of hay [i.e. 4,299 ha of vetch-oats hay (FNVA2) on moderately sloping land and 8,855 ha of vetch-oats hay (FNVA3) on steeply sloping land], 1,879 ha of green forage [bersim ray-grass (BRGI)], and 18,700 ha of ensilage [i.e. 4,932 ha of irrigated maize ensilage (ENMSI), 5,567 ha of vetch-oats ensliage on flat botton land (ENVA1), and 8,201 ha of vetch-oats ensilage on moderately sloping land (ENVA2)].

- 6,490 ha of irrigated vegetables [all in potatoes (PDTI)], and 4,978 ha of irrigated sugar beets (BSI).

- 3,000 ha of fava beans and horse beans (FV1) on flat bottom land.

- 12,120 ha of pasture (PATUR) used for livestock grazing.

The opportunity cost of land gradually increases from the lowest quality to the highest quality land: 75 D/ha for steeply sloping land, 149 D/ha for moderately sloping land, and 232 D/ha for flat bottom land. These values measure the increase in the sector's annual net income which would result from the availability of one additional hectare of each respective land type. These land values, as expected, are lowest for upland shallow soils and highest for bottom land.

Total animal products are 31,336 tons of milk, 9,728 tons of meat, and 288 tons of wool. Irrigated crops use 150 million m^3 of water, 14,184 tons of Ammonium Nitrate fertilizer (117 kg/ha of SAU), 9,441 tons of Super 45 fertilizer (78 kg/ha of SAU), 3,362 tons of potash (28 kg/ha of SAU), and 2.0

million hours of labor (16.6 hours/ha of SAU), of which 1.36 million hours are permanent labor and 0.64 million hours are temporary labor.

B. Calibration of the Base Model

Results of the base model are first calibrated against actual data reported in the 1986 EAB and 1989 EPI for the purpose of model validation. The base model results are compared with these actual data in Table 1. The model tends to slightly overestimate durum wheat area (12,500 vs 12,305 ha) and bread wheat area (20,154 vs 19,512 ha), and to underestimate the area under barley (15,645 vs 15,811 ha), but the differences are negligible. Model results for forage area (33,733 vs 33,838 ha), worked fallow (15,645 vs 17,250 ha), fava beans (3,000 vs 3,179), and sugar beets (4,978 vs 4,810 ha) are also quite close to reality. Model results and actual figures for vegetable cropping areas are identical (6,490 ha in both cases) due to the quota constraint on vegetable area in the model, although only potatoes are produced to the exclusion of other vegetables.

In general, the base model seems to quite closely approximate cropping patterns in the northwest public sector. Areas of cereals, forages and worked fallow deviate from actual data by less than 5 percent. These crops represent about 90 percent of total crop area excluding perennial tree crops[1]. Some secondary crops have been constrained in the model for various reasons. "Other cereals" which include oats and wheat-rye hybrids (triticale) are constrained to equal the 1986 area (8,855 ha). Data on "other cereals" is less precise than for other crops, yet it was included in the model to avoid over-estimating wheat and barley areas. A minimum of 3,000 ha of fava beans (including minor

1. Tree crops were excluded from the model (and land resource endowments adjusted accordingly) because of data limitations and the need for a more complex model that could capture the dynamic evolution of tree productivity from time of planting to uprooting.

Table 1

Comparison of Base Model Solution with the 1986 Actual Situation

	Actual[a] 1986 Data	Base Model Solution
Cereals (ha):	56,483	57,154
Durum wheat	12,305	12,500
Bread wheat	19,512	20,154
Barley (grain)	15,811	15,645
Other cereals	8,855	8,855
Forage crops (ha):	33,838	33,733
Green forage		1,879
Vetch-oats hay		13,154
Ensilage		18,700
Fava and horse beans (ha)	3,179	3,000
Vegetables (ha)	6,490	6,490
Sugar beets (ha)	4,810	4,978
Worked fallow (ha)	17,250	15,645
Pasture (ha)	12,117	12,120
Arable land (ha)	123,380	121,000
Input use:		
Ammonium Nitrate (tons)	12,305	14,184
Super 45 (tons)	11,277	9,441
Permanent labor (000 dinars)	1,367	1,367
Temporary labor (000 dinars)	634	642

a. The actual situation corresponds to cultivated areas in the public sector of Tunisia's northwest region reported in the 1986 Enquête Agricole de Base and the 1989 Enquête sur les Périmètres Irrigués.

areas of peas, chick peas and other legumes) was imposed in the model solution. Areas planted in vegetables were constrained not to exceed 6,490 ha. This prevents a substantial increase in vegetable production due to their very high profitability and the assumption of a perfectly elastic demand schedule for individual vegetables in the model. The area planted in sugar beets is also constrained to equal one-fifth of the irrigated area. On visits to public and private farms in the irrigated perimeters, farmers repeatedly indicated that they must plant sugar beets in order to have access to irrigation water. The coefficient (one-fifth) is the ratio of sugar beet area to irrigated area in 1989 (EPI).

Potatoes totally dominate vegetable production in the model solution, although in reality the public sector produces a broad mix of vegetables. A number of factors partially explain this result: (a) labor constraints in the model are not sufficiently precise to capture bottlenecks in the seasonal demand for labor on vegetables; (b) the hypothesis of perfectly elastic demand schedules (constant and exogenous prices) for individual vegetable crops is probably unrealistic; (c) input requirements for vegetables are not very precise, which may be causing an over-estimation of net income from potatoes; and (d) agricultural constraints (such as multicropping and rotations to control for diseases or for market timing) are absent in the model.

Two adjustments to data on fertilizer use reported in the EAB and EPI must be made before validating fertilizer use in the model. First, the use of each fertilizer on tree crops must be deducted as they are not included in the model. Second, the amount of fertilizer applied to vegetable crops by commercial farmers in the irrigated perimeters must be added. Data from the 1989 EPI do not distinguish between fertilizer use by commercial farmers and fertilizer use by state farms. However, as the area of vegetables by state farms in the irrigated perimeters is relatively small (348 ha) compared to the

total (6,490 ha), the amount of overlap in state farm fertilizer usage between the EAB and EPI surveys is minimal. Base model results indicate that the use of Ammonium Nitrate fertilizer (14,184 tons) is higher than the adjusted levels reported in the agricultural surveys (12,305 tons), while the use of Super 45 is lower (9,441 tons versus 11,277 tons). These findings suggest either that mean fertilizer rates assumed in the model have been over-estimated for Ammonium Nitrate fertilizer and under-estimated for Super 45, or that some farms in the public sector do not use chemical fertilizers. Insufficient evidence is available at this point to determine which is the more plausible.

Temporary labor demand in the model depends on four key assumptions: (1) the technical coefficients for labor requirements; (2) assumptions on number of hours worked per day (5.2 for permanent labor and 6.5 for temporary labor); (3) salaries (3 Dinars/day for both labor categories); and (4) fixed employment of permanent labor. The labor coefficients under (1) were determined based on visits to state farms, on discussions with INAT agronomists and animal scientists, and on a review of similar studies conducted previously. Wage rates under (3) were computed from raw data collected under the 1986 Enquête Conjoncture and reported in Roth et. al. (1990). Hypothesis (2) is not verifiable because of lack of data. However, the fact that temporary labor in the base case solution (641,749 days) compares remarkably well with actual employment on state farms (633,930 days, 1986 EAB), suggests that the above assumptions are fairly realistic.

In general, these results indicate that the model's solution provides a reasonable approximation of the public sector's technical and economic operations for the period 1986. The analysis now turns to using the model to forecast adjustments in cropping patterns, agricultural production, and resource use resulting from hypothesized changes in market conditions and agricultural policy.

D. Sensitivity of the Base Solution

a. Production

Production figures generated by the model (Annex 7) and price ranges over which the base solution is stable (Annex 8) are summarized below to evaluate the model's stability and its sensitivity to price changes:

- Of the total production of 175,310 tons of cereals, 30,000 tons are durum wheat, 83,588 tons bread wheat, 42,241 tons barley, and 19,481 tons other cereals. This solution is stable for prices varying respectively from 179 to 187 D/ton for durum wheat, from 168 to 173 D/ton for bread wheat, from 116 to 138 D/ton for barley, and below 120 D/ton for other cereals.

- Sugar beet production is 223,990 tons. This solution is stable for a beet price ranging from 21 to 32 D/ton (compared to a price of 27 D/ton in the base model). Only above a price of 32 D/ton would beets start to occupy more land. However, it must be noted that this stability is due in large part to the constraint which imposes on the model the requirement of a minimum area in sugar beets equal to one-fifth of the area of other irrigated crops.

- Potato production is 68,145 tons, as long as potato prices are at least 196 D/ton (the price in the model being 220 D/ton). This indicates that potatoes are a profitable irrigated crop under a wide variety of market conditions. The limited degree of adjustments in vegetables to increases in their prices is largely due to the constraint which confines vegetable cultivation to less than 6,490 ha.

- Total milk production is 31,336 tons, 31,047 from purebred cows and 289 from crossbred cows. This solution is stable for a milk price exceeding 116 D/ton (given a price of 200 D/ton used in the model).

- Total meat production is 9,728 tons: 3,930 of purebred cattle meat, 42 of crossbred cattle meat, and 5,757 of mutton. This solution is stable for a meat price of at least 814 D/ton for beef or 1,251 D/ton for mutton (prices in the base model being 1,400 and 1,800 D/ton respectively).

- Production of wool is 288 tons.

- While most of the forage production is consumed by livestock, some is marketed: 33,779 tons of hay and 66,732 tons of straw are sold during period 2 (December-February) when hay and straw prices are highest. This solution is stable for forage prices ranging from 54 to 56 D/ton for hay and from 28 to 35 D/ton of straw sold during period 2.

These results indicate that small price changes can have a major influence on cereal production. Conversely, animal products are profitable over a wide

range of market conditions, and are rather insensitive to price changes. This stability in livestock production is mainly due to the model's structure, which establishes an upper limit for stock size: 9,825 head of purebred cattle, 130 head of crossbred cattle and 95,950 head of sheep. Once this upper limit is reached, herd size becomes fixed and the model ceases to allow further increases in milk and meat production. Over the short-run this situation is probably realistic, as farms have the option of liquidating herds if prices sharply decline, and as long-term investments in buildings and herds are fixed. In the long term, however, some adjustment in stock size can be anticipated. As the model currently ignores these adjustments, it tends to under-estimate the supply response of milk or meat production to changes in market prices.[2]

Forage crops in this mixed farming system tend to complement both animal and crop production. The cultivation of nitrogen fixing legumes (vetch-oats, bersim) helps to improve crop yields through additions of nitrogen to the soil, and through improved soil structure. Forages in turn are either fed to livestock or sold at market prices. Animal products and cereals are thus complementary outputs and part of an integrated system. It is possible that certain animal production activities which are justified within this mixed farming system (because they enhance cereals productivity) may cease to be profitable as specialized enterprises.

b. Factors of Production

All available land is cultivated in the model. Opportunity costs for land provide an implicit value of its use in agricultural production: 29 D/ha for

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2. An analysis of these adjustments over a longer term would require a significant modification of the model's structure. In particular, this would require a dynamic model which could capture the evolution of the size and composition of stock by various animal age-size categories.

pasture land, 75 D/ha for steeply sloping land, 149 D/ha for moderately sloping land, and 232 D/ha for flat bottom land. As one would expect, these implicit land values increase as soil quality improves.

Fertilizer use is 14,183 tons of Ammonium Nitrate fertilizer for a price ranging from 50 to 186 D/ton (compared to 118 D/ton in the base solution), 9,441 ton of Super 45 for a price ranging from 38 to 177 D/ton (compared to 110 D/ton in the base solution), and 3,361 ton of Potash for a price that does not exceed 1,659 D/ton (compared with 300 D/ton in the base model). These results indicate that fertilizer use is rather insensitive to changes in the price of fertilizer.

A total of 1.85 million Dinars is expended on herbicides in the model. This solution is stable as long as the herbicide price does not increase by more than 41 percent, or does not decrease by more than 32 percent in relation to the base case solution. As with fertilizer, herbicide demand seems to be rather insensitive to changes in the economic situation.

Finally, the model employs 2.0 million work hours. This solution is stable as long as the price of labor stays between 0.8 and 7.8 D/day. These results indicate that employment demand in the public farm sector is not very sensitive to changes in labor costs, primarily due to the high share of permanent labor out of total labor hired on state farms.

VI. Implications for Agricultural Policy

Results of the preceding sections were aimed at validating the base model solution (scenario A). This section uses the base model to evaluate five policy experiments that are central to the analysis of farm efficiency in the northwest public sector: (B) eliminating agricultural subsidies on fertilizers; (C) eliminating subsidies on irrigation water and water quotas; (D) reducing the size of the permanent work force in the public sector; (E) eliminating the

Table 2

Parameter Changes in the Policy Simulations

	1986 Actual Figures	Base Case	Eliminate Fertilizer Subsidies	Eliminate Water Subsidies and Quotas
Model Simulation		A	B	C
Ammonium Nitrate price (D/ton)	118[a]	118	128	118
Super Phosphate price (D/ton)	110[a]	110	141	110
Price of water (D/000 m^3)	25	25	25	60
Water quota (million m^3)	150[b]	150	150	0
Permanent workers (000 days):	1,367.3[c]	1,367.3	1,367.3	1,367.3
October-November		227.9	227.9	227.9
January-February		341.8	341.8	341.8
March-May		341.8	341.8	341.8
June-July		227.9	227.9	227.9
August-September		227.9	227.9	227.9
Sugar beet constraint (ha)	4,810[e]	1/5 Irr. Area	1/5 Irr. Area	1/5 Irr. Area
Vegetable crop quota (ha)	6,490[d]	6,490	6,490	6,490

a. Based on actual prices paid by farmers (calculated from 1986 Enquête Conjoncture primary data).
b. Only 87% of irrigable land is actually irrigated (Ratio = .87 taken from the 1989 Enquête sur les Périmètre Irrigués).
c. Size of permanent work force is calculated as the number of workers times the average number of days worked reported in the 1986 Enquête Agricole de Base, pp. 55, 71, 84.
d. Total area of vegetables in the public sector (Enquête sur les Périmètres Irrigués).
e. Total industrial crops in the irrigated perimeters.

Table 2

Parameter Changes in the Policy Simulations (Continued)

	Base Case	Reduce Size of Permanent Work Force	Eliminate Production Quotas	All Scenarios Combined
Model simulation	A	D	E	F=B+C+D+E
Ammonium Nitrate price (D/ton)	118	118	118	128
Super Phosphate price (D/ton)	110	110	110	141
Price of water (D/000 m^3)	25	25	25	60
Water quota (million m^3)	150	150	150	0
Permanent workers (000 days):	1,367.3	683.5	1,367.3	683.5
October-November	227.9	113.9	227.9	113.9
January-February	341.8	170.9	341.8	170.9
March-May	341.8	170.9	341.8	170.9
June-July	227.9	113.9	227.9	113.9
August-September	227.9	113.9	227.9	113.9
Sugar beet constraint	1/5 Irr. Area	1/5 Irr. Area	0	0
Vegetable crop quota (ha)	6,490	6,490	0	0

production quotas on vegetables and sugar beets; and (F) all of the policies B to E combined.

These policy interventions are simulated by systematically modifying base model parameters according to the changes indicated in Table 2. Results of the simulations concerning production, area, input use and opportunity costs for fixed resources are presented in Tables 3 and 4 for Scenarios A to C, and in Tables 5 and 6 for Scenarios D to F. Annex 9 contains further details on area of specific crop activities selected by the model by land type.

A. The Base Model

The base model results in Tables 3 and 4 represent selected data on production, input use, and the opportunity costs of fixed factors (land, water, permanent labor or livestock) predicted by the model for the public sector for 1986. The base model is consequently used as a reference point for comparing the impacts of the above agricultural policy scenarios.

B. Elimination of Fertilizer Subsidies

This scenario evaluates the impact of higher prices of Ammonium Nitrate fertilizer and Super 45 fertilizer in the public sector. Prices are set at import parity levels thus eliminating all fertilizer subsidies (AIRD, 1987). The Ammonium Nitrate fertilizer price is increased by 8.5 percent, from 118 to 128 D/ton. The price for Super 45 is increased by 28.2 percent, from 110 to 141 D/ton. All other prices and technical coefficients remain the same as in the base case.

Results of the simulation indicate that net income in the northwest public sector would decrease by about 1 percent, from 36,183 to 35,748 thousand Dinars. Agricultural production would remain the same, implying that the reduction in profitability would not be important enough to justify an

Table 3:

Impacts of Alternative Price Policy on Crop Area and Output, North West Public Sector

	1986 Actual Figures	Base Case	Eliminate Fertilizer Subsidies	Eliminate Water Subsidies and Quotas
		A	B	C
Net public sector income (000 Dinars)		36,183	35,748	36,831
Crop sales (tons):				
Durum wheat		30,000	30,000	30,000
Bread wheat		83,588	83,588	76,509
Barley		42,242	42,242	42,242
Other cereals		19,481	19,481	19,481
Fava beans		2,100	2,100	3,690
Sugar beets		223,990	223,990	255,000
Potatoes		68,145	68,145	68,145
Hay		33,779	33,779	71,703
Straw		66,732	66,732	57,678
Animal sales/output (tons):				
Milk		31,337	31,337	31,337
Meat (beef)		3,972	3,972	3,972
Meat (mutton)		5,757	5,757	5,757
Wool		288	288	288
Crop area:				
Cereals	56,483[a]	57,154	57,154	55,076
Durum wheat	12,305	12,500	12,500	12,500
Bread wheat	19,512	20,154	20,154	18,076
Barley	15,811	15,645	15,645	15,645
Other cereals	8,855	8,855	8,855	8,855
Fava beans	3,179[b]	3,000	3,000	5,272
Sugar beets	4,810	4,978	4,978	5,667
Vegetables	6,490[c]	6,490	6,490	6,490
Forages	33,838[a]	33,733	33,733	33,733
Green forage		1,879	1,879	1,890
Hay (vetch-oats)		13,154	13,154	21,355
Ensilage		18,700	18,700	9,605
Worked fallow	17,250[a]	15,645	15,645	15,645
Pasture	12,117[a]	12,120	12,120	12,120

a/ Area of forages, worked fallow and pasture by the UCPs, Agro-combinats and Fermes Pilots (1986 Enquête Agricole de Base). b/ Includes areas in fava beans, horse beans, peas, chick peas and other legumes (1986 Enquête Agricole de Base). c/ Total area of vegetables grown in the public sector includes private farms in the irrigated perimeters as well as the UCPs, Agro-Combinats, and Fermes Pilotes.

Table 4:

Impacts of Alternative Price Policy on Resource Use and Prices of Owned Resources, North West Public Sector

	Actual Figures	Base Case	Eliminate Fertilizer Subsidies	Eliminate Water Subsidies and Quotas
		A	B	C
Fertilizer (tons):				
Ammonium Nitrate	12,305[a]	14,184	14,184	14,523
Triple Super Phosphate	11,277[a]	9,441	9,441	9,824
Potash		3,362	3,362	3,669
Water (000,000 m^3)	150[b]	150	150	174
Permanent labor (000 days)	1,367[d]	1,367	1,367	1,367
Temporary labor (000 days)	634[d]	642	642	778
October-November		207	207	220
January-February		191	191	217
March-May		95	95	125
June-July		149	149	199
August-September		0	0	0
Mechanization (000 hours)		2,071	2,071	2,094
Cultivated land:	123,380[e]	121,000		
Flat		49,000	49,000	49,000
Moderately sloping		25,000	25,000	25,000
Steeply sloping		13,000	13,000	13,000
Irrigated perimeter		34,000	34,000	34,000
Irrigable land in dryland crops[c]		4,135	4,135	0
Pasture	12,117[c]	12,120	12,120	12,120
Cost of owned resources (D/ha):				
Pasture		29	29	25
Steeply sloping land		75	75	75
Moderately sloping land		149	145	145
Flat land		232	229	224
Irrigated land		232	229	425
Water (000,000 m^3)		50,739	50,230	0
Livestock (D/u.f.):				
Purebred cattle		286	285	358
Crossbred cattle		188	187	228
Sheep		33	33	43

Footnotes for Table 4

a/ Total fertilizer use (10,894 tons Ammonium Nitrate and 9,716 tons Super 45) less fertilizer applied to tree crops by state farms (399 tons and 139 tons respectively) plus fertilizer applied mainly by commercial vegetable growers in the irrigated perimeters (1,810 tons Ammonium Nitrate and 1,700 tons Super 45) (1986 Enquête Agricole de Base (EAB) and 1989 Enquête sur les Périmètre Irriqués (EPI). b/ The constraint on irrigation water supply (150 million m^3) was chosen to achieve the ratio of .87 between the area of irrigated to irrigable land (1989 EPI). c/ Irrigable land in dryland crops is the area of land in the irrigated perimeters used for dryland cultivation because of limited water supply. d/ Permanent and temporary labor hired by state farms (1986 EAB). e/ Arable land (133,559 ha) less tree crops (21,479 ha) on land held by state farms (1986 EAB), plus vegetable crops (6,490 ha) and sugar beets (4,810 ha) in the irrigated perimeters (1989 EPI); Data on pasture taken from 1986 EAB.

adjustment towards less fertilizer intensive crops (barley or legume rotations instead of wheat rotations, or cereals instead of vegetables or forage crops). Fertilizer use would also remain the same. Opportunity costs of fixed land resources decline marginally due to higher production costs. The value of livestock also decreases slightly due to the higher implicit costs of forage in animal rations. These results confirm those obtained in the econometric study by Kristjanson et al. (1990) which found no significant relationship between fertilizer prices and fertilizer use in the northwest region over the period 1975 to 1987.

C. Elimination of Water Subsidies and Water Quotas

The work by Bloch et. al. (1991) indicates that water lifting and delivery in the public sector is subsidized by as much as 58 percent, although results vary considerably among farms and regions. Land use efficiency in the irrigated perimeters (irrigated to irrigable land) of .87 further suggests that some form of water rationing is evident. This scenario examines the impact, first separately and then jointly, of (a) removing subsidies on irrigation water by increasing the price from 25 to 60 Dinars per thousand m^3; and (b) eliminating the constraint on water supply which could be accomplished by either increasing the efficiency of water allocation and use, or through additional investment in irrigation infrastructure. If irrigation is profitable, these investments could be financed by the savings generated from reducing water subsidies.

Increasing the water price without changing water quotas (scenario not shown in Tables 3 and 4) would substantially diminish the public sector's net income, but would not alter production, cropping patterns or input use. Net income would decrease by 14.5 percent, from 36,183 to 30,933 thousand Dinars. However, the price of water is not sufficiently high to reduce water demand to

below quota levels. Consequently, water still retains a positive opportunity cost (15.7 Dinars per thousand m^3) and water use and allocation among crops remain the same.

Increasing the water price while simultaneously eliminating water quotas would have a profound impact on public sector production and income. Compared with the water subsidies scenario alone, net income increases from 30,933 to 36,831 thousand Dinars, slightly higher than base case levels (36,183 thousand Dinars). The irrigated area expands from 29,865 ha to 34,000 ha, while crops under dryland cultivation on flat bottom land decrease from 17,135 ha to 13,000 ha. Water use increases from 150 to 171 million m^3. The opportunity cost for irrigated land almost doubles (from 229 to 425 D/ha). The supply of irrigated land, rather than water, becomes the important factor constraining crop production. The opportunity cost of livestock increases noticeably from 286 to 358 D/u.f. of purebred cattle and from 33 to 43 D/u.f. of sheep, because of lower implicit forage costs.

Rather dramatic changes would be experienced with respect to crop production. The area of bread wheat would decline slightly from 83,588 ha to 76,509 ha, largely because of the reduction of dryland crops on flat bottom land (Annex 9). Improved profitability of relatively water-intensive crops (fava beans, bersim ray-grass, ensilage) would result in the substitution of ensilage for cereals on irrigated land. The higher yields and the expanded area of maize and sorghum ensilage on irrigated land enables a reduction in the total area of ensilage by almost half (vetch-oats ensilage on flat bottom and moderately sloping land is displaced). It also enables greater production and sales of vetch-oats hay. Forage animal feed is therefore produced on a smaller area through more intensive forage production on irrigated land. Sugar beet profitability also improves, but its expanded area is due to the increase in

irrigated area and to the constraint that beets must be cultivated in fixed proportions in relation to the irrigated surface.

D. Reduction in Size of Permanent Work Force

A number of important questions arise concerning employment in the public sector: (1) does current staffing levels of permanent labor result in idle or under-utilized labor during certain periods of the year creating inefficiency; (2) does the presence of a large and constant permanent labor supply tend to shift agricultural production toward more labor intensive activities; and (3) what would be the impacts of a reduction of permanent employment in the public sector? A comparison of scenarios A to C indicates that temporary labor is needed in periods 1-4 of the year. Only in the 5-th period, August-September, is there no employment of temporary labor and a surplus of permanent labor.

Aside from the technical coefficients for labor requirements, two key assumptions have an important bearing on the answers to questions (2) and (3) above. The first is the assumption that the minimum wage rate (3 D/day) is constant throughout the year for permanent and temporary labor. The second is the assumption that temporary workers work more hours per day (6.5) compared with permanent workers (5.2). There was no available source of data to confirm these suppositions. However, discussions with agricultural experts seem to indicate that temporary workers are on average more efficient than permanent workers. This observation is implicitly incorporated in the model by assigning temporary workers higher ratios of work per unit of pay compared with permanent workers (i.e. given that salaries are the same, temporary workers are assumed to be 25 percent more efficient than permanent workers based on their higher rate of work intensity per day (6.5 vs 5.2 hours).

The size of the permanent work force is reduced in the model by 50 percent to represent a reduction of permanent employment in the public sector for sake

of budgetary restraint, while maintaining a critical mass of labor for supervisory purposes and for critical day to day farm operations. This policy would be equivalent to laying off 50 percent of the permanent work force, or about 2,255 workers in the northwest public sector.

The results presented in Tables 5 and 6 indicate that a reduction of permanent labor would slightly increase net income from 36,183 to 36,667 thousand Dinars, due to savings in labor costs. These changes are not sufficiently large to influence production, cropping patterns, or fertilizer use. The impacts on employment are nevertheless quite clear. Employment of permanent labor would decline from 1,367 to 684 thousand days. Temporary labor would increase from 642 to 1,165 thousand days, resulting in a net reduction of 160 thousand days overall. In general, reducing the size of the permanent work force (by half) would not greatly influence public sector activities or income. These results are explained by the fairly steady hiring of temporary workers throughout the year, and the absence of strong seasonal under-utilization of permanent labor.

E. Elimination of Production Quotas

The simulations thus far have been examined with two output quotas in effect. Vegetable production has been constrained not to exceed 6,490 ha. Also, the area under sugar beets has been constrained to equal one-fifth of the irrigated area as a precondition for access to irrigation water, a condition motivated by the government's efforts to ensure sufficient supplies for its state-run sugar factories. This scenario examines the impact of the elimination of these two quotas, thus allowing growers in the public sector complete freedom to choose cropping patterns.

The results of this scenario indicate that producers would discontinue sugar beet cultivation and would sharply expand vegetable production. The area

Table 5

Impacts of Alternative Institutional Reforms on Crop Area and Production, North West Public Sector

	Base Case	Reduce Size of Permanent Work Force	Eliminate Production Quotas	Ensemble
	A	D	E	F=B+C+D+E
Net public sector income (000 D)	36,183	36,667	58,143	53,319
Crop sales (tons):				
Durum wheat	30,000	30,000	30,000	30,000
Bread wheat	83,588	83,588	22,100	22,100
Barley	42,242	42,242	22,145	21,217
Other cereals	19,481	19,481	19,481	19,481
Fava beans	2,100	2,100	2,100	2,100
Sugar beets	223,990	223,990	0	0
Potatoes	68,145	68,145	322,226	340,223
Peppers	0	0	2,459	0
Hay	33,779	33,779	0	0
Straw	66,732	66,732	24,613	28,245
Animal sales/output (tons):				
Milk	31,337	31,337	31,337	31,337
Meat (beef)	3,972	3,972	3,972	3,972
Meat (mutton)	5,757	5,757	5,757	4,188
Wool	288	288	288	209
Crop area:				
Cereals	57,154	57,154	37,921	37,499
Durum wheat	12,500	12,500	12,500	12,500
Bread wheat	20,154	20,154	6,500	6,500
Barley	15,645	15,645	10,066	9,644
Other cereals	8,855	8,855	8,855	8,855
Fava beans	3,000	3,000	3,000	3,000
Sugar beets	4,978	4,978	0	0
Vegetables	6,490	6,490	30,688	32,402
Forages	33,733	33,733	49,039	48,099
Green forages	1,879	1,879	11,158	12,002
Vetch-oats hay	13,154	13,154	13,046	18,499
Ensilage	18,700	18,700	24,835	17,598
Worked fallow	15,645	15,645	0	0
Pasture	12,120	12,120	12,120	12,120

Table 6

Impacts of Alternative Institutional Reforms on Resource Use and Prices of Owned Resources, North West Public Sector

	Base Case	Reduce Size of Permanent Work Force	Eliminate Production Quotas	Ensemble
	A	D	E	F=B+C+D+E
Fertilizer use (tons):				
Ammonium Nitrate	14,184	14,184	16,801	16,766
Triple Super Phosphate	9,441	9,441	12,993	13,045
Potash	3,362	3,362	11,107	11,501
Water (000,000 m^3)	150	150	149	142
Permanent labor (000 days)	1,367	684	1,367	684
Temporary labor (000 days)	642	1,165	1,015	1,376
October-November	207	298	554	661
January-February	191	328	461	614
March-May	95	232	0	26
June-July	149	240	0	30
August-September	0	67	0	45
Mechanization (000 hours)	2,071	2,071	2,822	2,856
Cultivated land:	131,000	131,000	131,000	131,000
Steeply sloping	49,000	49,000	49,000	49,000
Moderately sloping	25,000	25,000	25,000	25,000
Flat land	13,000	13,000	13,000	13,000
Irrigated perimeter	34,000	34,000	34,000	34,000
Irrigated land in dryland crops[d]	4,135	4,135	0	0
Pasture	12,120	12,120	12,120	12,120
Cost of owned resources (D/ha):				
Steeply sloping land	75	75	84	85
Moderately sloping land	149	147	190	192
Flat land	232	230	286	289
Irrigated land	232	230	1,341	1,191
Pasture	29	29	40	42
Water (000,000 m^3)	50,739	50,769	0	0
Livestock (D/u.f.)				
Purebred cattle	286	269	131	38
Crossbred cattle	188	171	103	28
Sheep	33	32	10	0

in vegetables would increase from 6,490 ha to 30,688 ha, and the implicit value of one hectare of irrigated land would increase from 232 to 1,341 D/ha. The substitution of vegetables for ensilage would result in a net reduction of water use to such an extent that the water constraint would cease to be active, and the amount of irrigable land that is irrigated would expand accordingly. Sugar beet production would totally disappear.

Other substitution impacts are also apparent. Cultivation of durum wheat would decrease from 20,154 to 6,500 ha due to the substitution of vegetables for wheat on irrigated land. The area in barley would decline and worked fallow would disappear on steep slopes; green forage and dryland ensilage would simultaneously increase to compensate for the reduction of ensilage on irrigated land (Annex 9). The value of livestock, measured by its opportunity cost, would decrease significantly from 269 to 131 D/u.f. of purebred cattle and from 33 to 10 D/u.f. of sheep, due to a sharp increase in the implicit cost of forage. Use of Ammonium Nitrate fertilizer would rise from 14,184 to 16,801 tons, and the use of Super 45 would rise from 9,441 to 12,993 tons due to the relatively higher fertilizer requirements of vegetables. Temporary labor demand would also increase from 642 to 1,015 thousand days, because of increased labor requirements, especially for harvesting of vegetables.

Strictly from the perspective of economic efficiency, model results indicate that the public sector could improve its profitability by expanding vegetable cultivation and by eliminating the sugar beet production quotas. Also employment opportunities for temporary labor would expand rather dramatically, an important point given the current state of high unemployment and underemployment in the private sector. Further simulations with the model (based on the non-quota scenario) indicate that sugar beet prices would have to rise from 27 to 46.5 D/ton before farmers would profit from their cultivation.

It seems rather unlikely that sugar demand, and the value of sugar beets derived from sugar beet processing, would reach that price level in the short to intermediate run. Thus, sugar beets, given current technology, prices and yields, do not appear to represent an optimal use of resources. Further investment in yield increasing or cost-reducing technology would be necessary if the sugar beet industry is to remain competitive with imported sugar.

F. All Scenarios Combined

Scenario F examines the combined impacts of all previous Scenarios B to E. The price of Ammonium Nitrate fertilizer is increased from 118 to 128 D/ton and the price of Super 45 is increased from 110 to 141 D/ton, thereby eliminating fertilizer subsidies. The price of irrigation water is increased from 25 to 60 Dinars per thousand m^3 and constraints on irrigation water availability are eliminated. The size of the permanent labor force is reduced by half. And, production quotas on vegetables and sugar beets are eliminated.

As with Scenario C, the impact of reducing quotas seems to dominate the model solution. Production of vegetables would increase from 6,490 to 32,402 ha. Water use would decrease from 150 to 142 million m^3 because of the substitution of potatoes for irrigated ensilage, which has high water requirements. As with Scenario E, the areas of bread wheat and barley would substantially decline. However, the area in barley would experience additional reduction due to the expansion of vetch-oats hay and green barley forage, which compensate for the loss of irrigated ensilage (Annex 9). The employment of temporary labor would increase dramatically from 642 to 1,376 thousand days/year, reflecting both the high labor requirements of vegetable cultivation as well as the impacts of reductions in the size of the permanent work force. The marginal value of one u.f. of purebred cattle would decline to 38 D, while the value of one u.f. of sheep drops to zero and sheep numbers decline from

95,950 to 69,796 u.f., because of higher costs of feedstuffs. In general, net income for the public sector would be 53,319 thousand Dinars, 47 percent higher than under the base case. The majority of this increase would be due to the elimination of production quotas.

VI. Elasticities of Supply

Sensitivity analysis is employed in this section to examine the relative effectiveness of price policy in achieving broader goals of agricultural development. The influence of prices on output supply and input demand are analyzed with the model under alternative market conditions. In particular, prices in the base model were doubled one at a time, and the resulting solution then compared to the base solution.[3] This procedure permits the evaluation of the sensitivity of production decisions to changes in market prices, measured in relative terms by the elasticities reported in Table 7.[4] These elasticities can be interpreted as the average percentage change in the dependent variable caused by a price increase of one percent. Dependent variables reported in Table 7 include net income; the opportunity cost of land; production of durum wheat, bread wheat and barley; cereal production (defined as the total tonnage

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3. The supply and demand functions derived from the linear program are typically "stepped" functions where each change of the base solution produces a jump from one step to the next. The emphasis in this section is on the average slope of the steps, and not in their shape. The choice of doubling each price implies that the average slopes of the steps are measured in the corresponding interval.

4. The elasticities reported in Table 7 are calculated as follows:

$$E = [(y_1-y_0)/y_0]/[(p_1-p_0)/p_0]$$

where p is the price and y is the variable influenced by the change in price p, and 0 and 1 respectively correspond to the situations before and after the change of p. In the case where $p_1 = 2\ p_0$ (i.e. where the price is doubled), the formula for calculating the elasticities would be:

$$E = (y_1-y_0)/y_0.$$

of cereals); the demand for Ammonium Nitrate fertilizer, Super 45 and Potash; the demand for fertilizers (defined as total tonnage of the three types of fertilizer); and herbicide use.[5]. Adjustments in these variables were examine in response to respective changes in the price of durum wheat, bread wheat, barley, cereals (defined as a proportional increase in prices of all cereals), potatoes, fava beans and sugar beets.

As indicated in Table 7, changes in the prices of individual cereals have an important effect on the dependent variables. For example, the increase in the price of durum wheat has a large positive impact on net income (with an elasticity of 0.59) and on land values (with elasticities varying from 1.37 to 2.59). Similar results are obtained for the price of bread wheat, except that the elasticity on steeply sloping soils is much smaller, but still positive.[6] This reflects the fact that durum wheat is better adapted to steeply sloping land than is bread wheat. The impact of the price of barley on net income is positive with an elasticity of 0.22. Also, the elasticities with respect to the price of barley are higher on steeply sloping land (2.22) than on moderately sloping land (0.82) or on flat bottom land (0.40), indicating that barley is better suited to steep slopes than bread wheat. In general, the price of cereals does not have much impact on the quantity demanded of fertilizer or herbicides. This is partially explained by the fact that cereal crops do not use these inputs intensively.

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5. The impacts of prices on animal products (milk, meat and wool), on the use of concentrates, and on vegetables are not reported in Table 7 because the linear program's solution for these activities proved to be insensitive to price changes.

6. The low price elasticity of bread wheat with respect to steeply sloping land is due mainly to the fact that no option has been included in the model for its cultivation on this soil type.

Table 7:

Elasticities With Respect to Commodity Prices

	Price of Durum Wheat	Price of Bread Wheat	Price of Barley	Price of Cereals
Net income	0.59	0.53	0.22	0.70
Opportunity cost of land:				
Flat bottom	1.37	1.48	0.40	1.51
Moderately sloping	1.86	1.74	0.82	1.86
Steeply sloping	2.59	0.18	2.22	2.59
Outputs:				
Cereals	0.14	0.18	-0.08	0.26
Durum wheat	4.92	-1.00	-1.00	1.30
Bread wheat	-1.00	1.01	-0.55	0.58
Barley	-1.00	-0.51	1.43	-1.00
Factors of production:				
Fertilizer:	-0.07	-0.11	-0.08	-0.08
Ammonium Nitrate	-0.09	-0.05	-0.02	-0.11
Super 45	-0.02	0.01	-0.19	-0.03
Potash	-0.15	-0.15	0.03	-0.15
Herbicide	0.12	0.28	-0.17	0.28

Table 7:

Elasticities in Relation to Prices (Continued)

	Price of Potatoes	Price of Fava Beans	Price of Sugar Beets
Net income	0.24	0.16	0.18
Opportunity cost of land:			
Flat bottom	0.02	1.06	0.08
Moderate slope	0.02	0.22	0.10
Steep slope	0.01	0.00	0.04
Outputs:			
Cereals	0.07	-0.10	-0.25
Durum Wheat	0.00	0.00	0.00
Bread Wheat	0.16	-1.00	-0.42
Barley	0.00	-0.42	-0.25
Factors of Production:			
Fertilizer	0.09	-0.10	0.15
Ammonium Nitrate	0.10	-0.32	0.11
Super 45	-0.01	0.17	0.18
Potash	0.46	-0.31	0.24
Herbicides	0.09	-0.51	0.10

The influence of cereal prices on cereal production is particularly interesting. First, the supply elasticity of each type of cereal is positive and quite high: 4.9 for durum wheat, 1.0 for bread wheat and 1.4 for barley. A'so, cross elasticities are generally negative and high, suggesting strong competition among cereals for available resources. For example, the elasticity of durum wheat production in relation to the price of bread wheat or barley is -1.0. Thus pricing policy that alters the relative output price ratios of these cereals (e.g. the price of durum wheat is raised relative to the prices of bread wheat and barley) would engender important substitution impacts. For example, a 10 percent increase in the price of durum wheat would allow a 49 percent increase in durum wheat production and a 10 percent decrease each in bread wheat and barley production.

These results might suggest good possibilities for expanding cereal production by changing individual cereal prices. However, as indicated in Table 7, the <u>total</u> cereal production response to a proportional price change for all cereals is very inelastic (0.26). This indicates that the important substitution possibilities mentioned above are substitutions among cereals, while substitution possibilities between cereals and other crops are limited. Changing the relative prices of cereals can thus generate large adjustments in their respective productions. Yet, the aggregate grain supply response would be small due to fixed land constraints in the sector. Pricing policy is thus likely to be less effective than policies aimed at stimulating investment in land-substituting technologies (i.e. development and adoption of new high-yielding varieties, increased fertilizer use, and expansion of the irrigation network) that increase wheat and barley production in the long-run.

The fact that total dryland cereal areas are insensitive to changes in the cereals price further indicates that cereals (in association with forage crops

and animal husbandry), in the northwest region, have a significant comparative advantage over other crops.[7] Price policy would thus have only a minor influence on total cereal production or on the use of factors of production (e.g. fertilizer and herbicides). It is this marked comparative advantage of dryland cereal crops (in association with forage crops and animal husbandry) combined with land constraints that contribute to the low substitution possibilities between cereals and non-cereal crops. As indicated in Table 7, cereal price changes will generally have much more impact on net income than on production decisions.

While dryland areas are mainly devoted to cereals in the northwest region, this is not the case for irrigated land. Indeed, with irrigation, the substitution possibilities among crops increase markedly. Forage crops, cereals, sugar beets and vegetables are all candidates for irrigated land use. Model results indicate that, in the absence of agricultural policy considerations, vegetables seem to have a comparative advantage over other crops on irrigated land. Irrigated land is only 28 percent of cultivated land in the northwest public sector. Irrigated vegetables and forages are highly profitable and provide viable options for crop diversification. Increasing the supply of irrigable land would increase the flexibility of the farming system to respond to prices and climatic risk. Further investments in irrigation infrastructure would appear to represent an efficient use of resources as indicated by the high opportunity cost of irrigated land in the model. State farms should thus consider expanding vegetable production. However, without investment in irrigation infrastructure, any expansion in vegetable area would come at the expense of sugar beets and cereals.

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7. This result should not be surprising given the fact that this region was already a cereals exporting region 2000 years ago and was part of the Roman Empire's "granary."

VII. Conclusion

The linear programming model developed for the public agricultural sector of northwest Tunisia is first and foremost an economic analysis tool. In order for this analysis to be effective, the model must accurately represent agricultural activities in the sector. In general, the base model seems to quite closely approximate cropping patterns; areas of cereals, forages and worked fallow deviate from actual data by less than 5 percent. Deviations between the predicted and actual usages of fertilizer are larger but not unreasonable. Further simulations of policy experiments with the model indicate that state farms in the northwest region could improve their profitability by: (1) increasing vegetable cultivation on irrigated land; (2) reducing sugar beet cultivation; (3) further developing the irrigation infrastructure in the region; and (4) granting more flexible labor contracts on state farms.

The model was also used to simulate the impacts of pricing policy on output supply and input demand response by systematically doubling prices in the base solution. The results, presented in the form of elasticities, indicate that important substitution possibilities are apparent among cereals (i.e. among durum wheat, bread wheat and barley), but only limited substitution possibilities are apparent between cereals and non-cereals under dryland agriculture. The production system in fact appears to be quite rigid, and cereal-legume rotations are quite robust in the model. The impact of input prices on production decisions seems to be rather limited. In contrast, the competition among cereals, forage crops, vegetables and sugar beets on irrigated land is keen. The aggregate output supply response and input demand response thus appear to be highly inelastic. Policy considerations to increase aggregate output will need to emphasize non-price interventions and options for

stimulating investment in land-substituting technologies (i.e. institutional reform, development and adoption of new high-yielding varieties, increased fertilizer use, expansion of the irrigation network) if accelerated growth in aggregate agricultural output is to be achieved in the long run.

The current model provides an illustration of the use of linear programming in economic analysis and policy planning. As the work was done in close collaboration with staff of the MOA, the process helped to strengthen linkages between staff in statistics and planning, and strengthened skills in economic and policy analysis. With the assistance of APIP, the Ministry now has the computers, the software and the skills to operate the model, update it, and use it for further policy analysis. Work is now proceeding on a model for the private sector. Both sets of work will provide model templates for extending work to other regions.

In its present form, the model is relatively static. It does not integrate dynamic processes such as those of animal husbandry or tree crops, or more complex rotations sometimes found within the region. It also does not account for risk stemming from the region's climatic variability. However, the linear programming tool is sufficiently flexible to include multi- periodic processes and to account for risk within the objective function of the current model. These modifications represent the next stages of the modeling effort.

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ANNEXES

Annex 1

Crop Prices and Yields

No.	Activity	Price (D/ton) (1)	Output (Ton/Ha) (2)	Straw (Ton/Ha) (3)	Seeds (Kg/Ha) (4)	Price of Seeds (D/Kg) (5)
	BD	185				.3
1	BDI		4.0	3.0	120	
2	BD/JT1		3.3	2.0	115	
3	BD/JT2		2.9	1.7	110	
4	BD/JT3		2.1	1.3	105	
5	BD/JP1		2.4	2.0	115	
6	BD/JP2		2.0	1.7	110	
7	BD/JP3		1.3	1.3	105	
8	BD/LG1		2.9	2.0	115	
9	BD/LG2		2.4	1.7	110	
10	BD/LG3		1.6	1.3	105	
11	BD/LGI		4.3	3.0	120	
12	BD/BSI		4.0	3.0	120	
	BT	170				.3
13	BTI		4.7	3.0	125	
14	BT/JT1		3.9	2.0	120	
15	BT/JT2		3.1	1.7	115	
16	BT/JP1		2.8	2.0	120	
17	BT/JP2		1.9	1.7	115	
18	BT/LG1		3.4	2.0	120	
19	BT/LG2		2.6	1.7	115	
20	BT/BSI		4.7	3.0	125	
21	BT/LGI		4.8	3.0	125	
	OG	120				.2
22	OG/JT1		3.1	2.0	105	
23	OG/JT2		2.9	1.7	100	
24	OG/JT3		2.7	1.3	105	
25	OG/JP1		2.4	2.0	100	
26	OG/JP2		2.1	1.7	95	
27	OG/JP3		1.8	1.3	105	
28	OG/LG1		2.8	2.0	100	
29	OG/LG2		2.5	1.7	95	
30	OG/LG3		2.2	1.3	95	
31	FV1	530	0.7		120	.7
32	FVI		1.1		140	
33	FV/BSI		1.1		140	
34	BSI	27	45.0		15	3.5
35	TMI	100	20.0		per ha	100
36	PQI	150	12.0		2	10
37	PDTI	220	10.5		2,000	.12
38	PMI	300	7.0		per ha	120

Crop Prices and Yields (Continued)

No.	Activity	Price (D/ton) (1)	Output (Ton/Ha) (2)	Straw (Ton/Ha) (3)	Seeds (Kg/Ha) (4)	Price of Seeds (D/Kg) (5)
39	FVVA1		22		110	.25
40	FVVA2		17		105	
41	FVVA3		10		100	
42	FVVAI		27		120	
43	FVVA/BSI		27		120	
44	FNVA1		5.5		110	.15
45	FNVA2		4.5		105	
46	FNVA3		3.0		100	
47	FNVAI		7.0		120	
48	FVOG1		26		105	.2
49	FVOG2		21		100	
50	FVOG3		16		95	
51	FVOGI		32		115	
52	ENVA1		22		110	
53	ENVA2		17		105	
54	ENVA3		10		100	
55	ENAVI		27		120	.2
56	ENMSI		60		35	
57	ENSGI		70		25	
58	BRGI		60		25	
59	LZI		60		25	
60	PATUR		3.2			
61	JP1		7.5			
62	JP2		6.4			
63	JP3		4.9			
64	JT1					
65	JT2					
66	JT3					
67	FOIN1	50				
68	FOIN2	55				
69	FOIN5	50				
70	PAILLE1	25				
71	PAILLE2	30				
72	PAILLE5	20				
73	LAITBP	200	3.16			
74	LAITBC	200	2.23			
75	VIANDBP	1,400	0.4			
76	VIANDBC	1,400	0.32			
77	VIANDOV	1,800	0.06			
78	LAINE	1,700	.003			
79	BOVP					
80	BOVC					
81	OVIN					

Annex 2

Fertilizer and Capital Requirements

No.	Activity	Ammonium Nitrate (kg) (6)	Super 45 (kg) (7)	Potash (kg) (8)	Mechan-zation (hour) (9)	Mechanical Harvesting (hour) (10)	Water ($000m^3$) (11)
Input Price (D)		.118	.110	.3	7.0	17.0	25
	BD						
1	BDI	150	100		19	2.3	3
2	BD/JT1	130	85		17	1.9	
3	BD/JT2	115	75		17	1.7	
4	BD/JT3	100	65		17	1.5	
5	BD/JP1	130	85		17	1.9	
6	BD/JP2	115	75		17	1.7	
7	BD/JP3	100	65		17	1.5	
8	BD/LG1	105	85		17	1.9	
9	BD/LG2	90	75		17	1.7	
10	BD/LG3	80	65		17	1.5	
11	BD/LGI	120	100		19	2.3	3
12	BD/BSI	150	100		10	2.3	3
	BT						
13	BTI	150	100		19	2.3	3
14	BT/JT1	130	85		17	1.9	
15	BT/JT2	115	75		17	1.7	
16	BT/JP1	130	85		17	1.9	
17	BT/JP2	115	75		17	1.7	
18	BT/LG1	105	85		17	1.9	
19	BT/LG2	90	75		17	1.7	
20	BT/BSI	120	100		19	2.3	3
21	BT/LGI	150	100		19	2.3	3
	OG						
22	OG/JT1	115			12	1	
23	OG/JT2	95			12	0.9	
24	OG/JT3	80			12	0.8	
25	OG/JP1	115			12	1.0	
26	OG/JP2	90			12	0.9	
27	OG/JP3	80			12	0.8	
28	OG/LG1	90			12	1	
29	OG/LG2	75			12	0.9	
30	OG/LG3	65			12	0.8	
31	FV1		125		17	1	
32	FVI		150		19	1.5	3.5
33	FV/BSI		150		19	1.5	4.5
34	BSI	350	250	120	30		8.5
35	TMI	500	170	200	58		7.5
36	PQI	150	300	200	52		7.5
37	PDTI	300	250	350	50		4
38	PMI	200	200	200	25		7.5

Fertilizer and Capital Requirements (Continued)

No.	Activity	Ammonium Nitrate (kg) (6)	Super 45 (kg) (7)	Potash (kg) (8)	Mechan-zation (hour) (9)	Mechanical Harvesting (hour) (10)	Water ($000m^3$) (11)
39	FVVA1	150	100		15		
40	FVVA2	115	80		12		
41	FVVA3	100	80		10		
42	FVVAI	175	125		20		1.5
43	FVVA/BSI	175	125		20		1.5
44	FNVA1	150	100		20		
45	FNVA2	115	80		16		
46	FNVA3	100	80		13		
47	FNVAI	175	125		30		3
48	FVOG1	150	100		8		
49	FVOG2	115	80		8		
50	FVOG3	100	80		8		
51	FVOGI	175	125		12		3
52	ENVA1	120	80		18		
53	ENVA2	110	80		16		
54	ENVA3	100	80		14		
55	ENAVI	200	150	75	21		7
56	ENMSI	300	200	100	25		8
57	ENSGI	250	150	75	23		6
58	BRGI	300	125		22		4
59	LZI	0	150	100	28		10
60	PATUR						
61	JP1				0		
62	JP2				0		
63	JP3				0		
64	JT1				6		
65	JT2				6		
66	JT3				6		
67	FOIN1						
68	FOIN2						
69	FOIN5						
70	PAILLE1						
71	PAILLE2						
72	PAILLE5						
73	LAITBP						
74	LAITBC						
75	VIANDBP						
76	VIANDBC						
77	VIANDOV						
78	LAINE						
79	BOVP						
80	BOVC						

Annex 3

Labor Requirements

No.	Activity	Work1 (hours) (12)	Work2 (Hours) (13)	Work3 (Hours) (14)	Work4 (Hours) (15)	Work5 (Hours) (16)	Herbicide (D/Ha) (17)
Salary (D/day)		3	3	3	3	3	
	BD						
1	BDI	9.9	3.9	2.4	4.5	5.2	35.00
2	BD/JT1	6.6	2.6	1.6	3.0	3.5	25.00
3	BD/JT2	5.9	2.3	1.4	2.7	3.2	25.00
4	BD/JT3	5.3	2.1	1.3	2.4	2.8	25.00
5	BD/JP1	7.3	2.9	1.8	3.3	3.9	30.00
6	BD/JP2	6.5	2.5	1.5	3.0	3.5	30.00
7	BD/JP3	5.8	1.9	1.4	2.6	3.1	30.00
8	BD/LG1	6.6	2.6	1.6	3.0	3.5	30.00
9	BD/LG2	5.9	2.3	1.4	2.7	3.2	30.00
10	BD/LG3	5.3	2.1	1.3	2.4	2.8	30.00
11	BD/LGI	9.9	3.9	2.4	4.5	5.2	30.00
12	BD/BSI	9.9	3.9	2.4	4.5	5.2	30.00
	BT						
13	BTI	9.9	3.9	2.4	4.5	5.2	45.00
14	BT/JT1	6.6	2.6	1.6	3.0	3.5	35.00
15	BT/JT2	5.9	2.3	1.4	2.7	3.2	35.00
16	BT/JP1	7.3	2.9	1.8	3.3	3.9	40.00
17	BT/JP2	6.5	2.5	1.5	3.0	3.5	40.00
18	BT/LG1	6.6	2.6	1.6	3.0	3.5	40.00
19	BT/LG2	5.9	2.3	1.4	2.7	3.2	40.00
20	BT/BSI	9.9	3.9	2.4	4.5	5.2	45.00
21	BT/LGI	9.9	3.9	2.4	4.5	5.2	45.00
	OG						
22	OG/JT1	3.2	2.0	1.0	3.5	3.0	20.00
23	OG/JT2	2.9	1.8	0.9	3.2	2.7	20.00
24	OG/JT3	2.6	1.6	0.8	2.8	2.4	20.00
25	OG/JP3	3.2	1.8	0.9	3.9	2.1	25.00
26	OG/JP1	3.5	2.2	1.1	3.5	3.3	25.00
27	OG/JP2	3.2	2.0	1.0	3.1	3.0	25.00
28	OG/LG1	3.2	2.0	1.0	3.5	3.0	25.00
29	OG/LG2	2.9	1.8	0.9	3.2	2.7	25.00
30	OG/LG3	2.6	1.6	0.8	2.8	2.4	25.00
31	FV1	30	15	23	2	4	
32	FVI	40	20	30	2	5	
33	FV/BSI	40	20	30	2	5	
34	BSI	125	225	225	200	0	60.00
35	TMI	90	96	150	375	580	
36	PQI	0	48	102	240	128	
37	PDTI	120	120	0	0	0	
38	PMI	80	0	124	336	584	

Labor Requirements (Continued)

No.	Activity	Work1 (hours) (12)	Work2 (Hours) (13)	Work3 (Hours) (14)	Work4 (Hours) (15)	Work5 (Hours) (16)	Herbicide (D/Ha) (17)
39	FVVA1	5	3.5	5	0	6	
40	FVVA2	4.5	3.2	4.5	0	5.4	
41	FVVA3	4.1	2.8	4.1	0	4.9	
42	FVVAI	9	4.5	7.5	0	9	
43	FVVA/BSI	9	4.5	7.5	0	9	
44	FNVA1	5	2.5	3.5	0	6	
45	FNVA2	4.5	2.3	3.2	0	5.4	
46	FNVA3	4.1	2	2.8	0	4.9	
47	FNVAI	9	3.4	5.3	0	9	
48	FVOG1	5.2	2.8	3	0	3	
49	FVOG2	4.7	2.5	2.7	0	2.7	
50	FVOG3	4.2	2.3	2.4	0	2.4	
51	FVOGI	9.4	3.1	4.5	0	4.5	
52	ENVA1	8	3	3	0	8	
53	ENVA2	7	2.7	2.7	0	7.2	
54	ENVA3	6	2.4	2.4	0	6.5	
55	ENVAI	12	4	4.5	0	12	
56	ENMSI		0	37	27	15	
57	ENSGI		0	10	50	15	
58	BRGI		6	3	4	6.5	
59	LZI	5	4	18	26	22	
60	PATUR						
61	JP1						
62	JP2						
63	JP3						
64	JT1						
65	JT2						
66	JT3						
67	FOIN1						
68	FOIN2						
69	FOIN5						
70	PAILLE1						
71	PAILLE2						
72	PAILLE5						
73	LAITBP						
74	LAITBC						
75	VIANDBP						
76	VIANDBC						
77	VIANDOV						
78	LAINE						
79	BOVP	33	50	50	33	33	
80	BOVC	33	50	50	33	33	
81	OVIN	2.5	3.8	3.8	2.5	2.5	

Annex 4

Forage Crop Yields

		Period1	Period2	Period3	Period4	Period5	Total
Green Forage Crops:							
1	FVVA1	0	0	22	0	0	22
2	FVVA2	0	0	17	0	0	17
3	FVVA3	0	0	10	0	0	10
4	FVVAI	0	0	27	0	0	27
5	FVVA/BSI	0	0	27	0	0	27
6	FOG1	0	26	0	0	0	26
7	FOG2	0	21	0	0	0	21
8	FOG3	0	16	0	0	0	16
9	FOGI	0	32	0	0	0	32
10	BRGI	0	35	25	0	0	60
11	LZI	0	0	30	30	0	60
Hay, Ensilage and Pasture:							
1	FNVA1	0	0	5.5	0	0	5.5
2	FNVA2	0	0	4.5	0	0	4.5
3	FNVA3	0	0	3	0	0	3
4	FNVAI	0	0	7	0	0	7
5	ENVA1	0	0	22	0	0	27
6	ENVA2	0	0	17	0	0	17
7	ENVA3	0	0	10	0	0	10
8	ENSAVI	0	0	27	0	0	27
10	ENSMSI	0	0	0	60	0	60
11	ENSG	0	0	0	70	0	70
12	PATUR	0.3	1.2	1.2	0.5	0	2.2
13	JP1	1.0	2.5	2.5	1.5	0	7.5
14	JP2	0.8	2.2	2.2	1.2	0	6.4
15	JP3	0.5	1.8	1.8	0.8	0	4.9

Annex 5

Nutritional Values of Forage Crops

		Period1	Period2	Period3	Period4	Period5	Total
Forage Units (UF):							
1	FVVA	60	60	60	60	60	300
2	FNVA	380	380	380	380	380	1,900
3	FVOG	60	60	60	60	60	300
4	FVPAT	75	75	75	75	75	375
5	ENVA	100	100	100	100	100	500
6	ENMS	200	200	200	200	200	1,000
7	ENSG	120	120	120	120	120	600
8	FVBRG	90	90	90	90	90	450
9	FVLZ	85	85	85	85	85	425
10	FNPAL	150	150	150	150	150	750
11	BESOIN-BP	700	1,050	1,050	700	700	4,200
12	BESOIN-BC	450	675	675	450	450	2,700
13	BESOIN-OV	100	150	150	80	80	430
Digestible Nitrogen (MAD):							
1	FVVA	10	10	10	10	10	50
2	FNVA	17	17	17	17	17	85
3	FVOG	9	9	9	9	9	45
4	FVPT	7.5	7.5	7.5	7.5	7.5	37.5
5	ENVA	16	16	16	16	16	80
6	ENMS	12	12	12	12	12	60
7	ENSG	14	14	14	14	14	70
8	FVBRG	20	20	20	20	20	100
9	FVLZ	19	19	19	19	19	95
10	FNPAL	0	0	0	0	0	0
11	BESOIN-BP	70	105	105	70	70	423
12	BESOIN-BC	52	78	78	52	52	302
13	BESOIN-OV	10	15	15	10	10	41

Annex 5

Nutritional Values of Forage Crops (Continued)

		Period1	Period2	Period3	Period4	Period5	Total
Dry Matter (MS):							
1	FVVA	150	150	150	150	150	750
2	FNVA	850	850	850	850	850	4,270
3	FVOG	150	150	150	150	150	750
4	FVPT	200	200	200	200	200	1,000
5	ENVA	200	200	200	200	200	1,000
6	ENMS	270	270	270	270	270	1,350
7	ENSG	200	200	200	200	200	1,000
8	FVBRG	150	150	150	150	150	750
9	FVLZ	170	170	170	170	170	850
10	FNPAL	900	900	900	900	900	4,500
11	BESOIN-BP	700	1,050	1,050	700	700	4,200
12	BESOIN-BC	500	750	750	500	500	3,000
13	BESOIN-OV	50	75	75	50	50	300
Hay:							
1	FNAV						
2	FNPAL						
1	BESOIN-BP	0.122	0.183	0.183	0.122	0.122	.732
2	BESOIN-BC	0.122	0.183	0.183	0.122	0.122	.732
3	BESOIN-OV	0	0	0	0	0	0
Concentrate (kg per year) (price = 150 D/Kg)							
1	BES/BP	2					2
2	BES/BC	1.8					1.8
3	BES/OV	0					0

Annex 6

Northwest Public Sector Model

```
WIDTH 80
!                                                    Base Case Model
!                                                    24 December 1990
!
!
!
!                    SECTEUR PUBLIC -- REGION DU NORD-OUEST
!
!
!I.  Produits
!
!  A. Cereales:                          B. Cultures Maricheres:
!
!     BD = Blé Dur            (Tn)        BS = Betterave à Sucre   (Tn)
!     BT = Blé Tendre         (Tn)        TM = Tomate              (Tn)
!     OG = Orge               (Tn)        PQ = Pastèque et Melons  (Tn)
!     AU = Autres Céreales    (Tn)        PDT= Pomme de Terre      (Tn)
!                                         PM = Piment              (Tn)
!
!  C. Fourrages en Vert:                 D. Ensilage:
!
!     FVVA = Vesce A. en Vert (Tn)        ENMS = Ensilage Mais     (Tn)
!     FVOG = Orge en Vert     (Tn)        ENSG = Ensilage Sorgho   (Tn)
!     BRG  = Bersim Ray-Gras  (Tn)        ENVA = Ensilage Avoine   (Tn)
!     LZ   = Luzerne          (Tn)
!
!  E. Foin:                              F. Jachère:
!
!     FNVA = Vesce Avoine     (Tn)        JT = Jachère Travaillée  (Ha)
!     PAL  = Paille           (Tn)        JP = Jachère Paturée     (Ha)
!
!  G. Legumineuses:
!
!     FV = Fève et Fèveroles  (Tn)
!
!  H. Elevage:
!
!     BOVP = Bovins Race Pure (Unité Femelle)
!
!              VIANDBP = Viande          (Tn)
!              LAIT    = Lait            (Tn)
!
!     BOVC = Bovins Race Croisée (Unité Femelle)
!
!              VIANDBC = Viande          (Tn)
!              LAIT    = Lait            (Tn)
!
!     OVIN = Ovins (Unité Femelle)
!
!              VIANDOV = Viande Ovin     (Tn)
!              LAINE   = Laine           (Tn)
!
!
```

```
!II.  Ressources
!
!  A. Main d'Ouevre:
!
!     TRAVPM = Travail Permanent   (Jours=Heures/5.2)
!     TRAVTM = Travail Temporaire  (Jours=Heures/6.5)
!
!     TRACTN = Traction            ('000 Heures)
!     MOISS  = Moisson             (Heures)
!
!     Périodes :   1 = Oct - Nov
!                  2 = Dec - Fev
!                  3 = Mars - Mai
!                  4 = Juin - Juillet
!                  5 = Aout - Sept
!
!  B. Terre:                          C. Autres Ressources:
!
!    3 = Pente Forte       (Ha)          EAU      = Eau          ('000,000 m3)
!    2 = Pente Moyenne     (Ha)          AMMON    = Ammonitre    (Tn)
!    1 = Pente Faible      (Ha)          SUP45    = Super 45%    (Tn)
!    I = Irriguée          (Ha)          POTASS   = Potasse      (Tn)
!                                        TOTDESH  = Desherbant   ('000 Dinars)
!
```

```
!*****************************************************************************
!
!          Fonction Objectif
!
!*****************************************************************************
!
 MAX
    185 PRODBD  +   170 PRODBT  +   120 PRODOG  +  110 PRODAU  +  530 PRODFV
 +   27 PRODBS  +   100 PRODTM  +   150 PRODPQ  +  220 PRODPDT +  300 PRODPM
 +   50 FOIN1   +    55 FOIN2   +    50 FOIN5   +   25 PAILLE1 +   30 PAILLE2
 +   20 PAILLE5 +   200 LAITBP  +   200 LAITBC  + 1400 VIANDBP + 1400 VIANDBC
 + 1800 VIANDOV +  1700 LAINE
 -  300 SEMBD   -   300 SEMBT   -   200 SEMOG   -  700 SEMFV   - 3500 SEMBS
 -  100 TMI     - 10000 SEMPQ   -   120 SEMPDT  -  120 PMI     -  250 SEMVT
 -  150 SEMFN   -   200 SEMEN   - 25000 EAU     -  118 AMMON   -  110 SP45
 -  300 POTASS  -  7000 TRACTN  -    17 MOISS   -    3 TRAVPM1 -    3 TRAVTM1
 -    3 TRAVPM2 -     3 TRAVTM2 -     3 TRAVPM3 -    3 TRAVTM3 -    3 TRAVPM4
 -    3 TRAVTM4 -     3 TRAVPM5 -     3 TRAVTM5 -  150 CONCTR  - 1000 TOTDESH
!
SUBJECT TO
!
!*****************************************************************************
!
!    Production des Céréales, Légumineuses et Cultures Maraichères
!
!*****************************************************************************
!
  BLEDUR)       PRODBD - 4.0 BDI    -  3.3 BD/JT1  -  2.9 BD/JT2  -  2.1 BD/JT3
        - 2.4 BD/JP1 - 2.0 BD/JP2 -  1.3 BD/JP3  -  2.9 BD/LG1  -  2.4 BD/LG2
        - 1.6 BD/LG3 - 4.3 BD/LGI -  4.0 BD/BSI                 =    0
  BLETDR)       PRODBT - 4.7 BTI    -  3.9 BT/JT1  -  3.1 BT/JT2  -  2.8 BT/JP1
        - 1.9 BT/JP2 - 3.4 BT/LG1 -  2.6 BT/LG2  -  4.7 BT/BSI  -  4.8 BT/LGI
                                                                =    0
  ORGE)         PRODOG - 3.1 OG/JT1 -  2.9 OG/JT2  -  2.7 OG/JT3  -  2.4 OG/JP1
        - 2.1 OG/JP2 - 1.8 OG/JP3 -  2.8 OG/LG1  -  2.5 OG/LG2  -  2.2 OG/LG3
                                                                =    0
  AUTCER)       PRODAU - 2.7 AU/JT3 -  2.2 AU/LG3               =    0
  FEVE)         PRODFV -  .7 FV1    -  1.1 FVI     -  1.1 FV/BSI =    0
  BETTERAV)     PRODBS              -   45 BSI                  =    0
  TOMATE)       PRODTM              -   20 TMI                  =    0
  PASTEQUE)     PRODPQ              -   12 PQI                  =    0
  POMTERRE)     PRODPDT             - 10.5 PDTI                 =    0
  PIMENT)       PRODPM              -    7 PMI                  =    0
!
```

```
!
!*************************************************************************
!
!          Superficies
!
!*************************************************************************
!
 SUPERBD)  SUPBD  - BDI    - BD/JT1 - BD/JT2 - BD/JT3 - BD/JP1   - BD/JP2
                  - BD/JP3 - BD/LG1 - BD/LG2 - BD/LG3 - BD/BSI   - BD/LGI  = 0
 SUPERBT)  SUPBT  - BTI    - BT/JT1 - BT/JT2 - BT/JP1 - BT/JP2   - BT/LG1
                  - BT/LG2 - BT/BSI - BT/LGI                              = 0
 SUPEROG)  SUPOG  - OG/JT1 - OG/JT2 - OG/JT3 - OG/JP1 - OG/JP2   - OG/JP3
                  - OG/LG1 - OG/LG2 - OG/LG3                              = 0
 SUPERAU)  SUPAU  - AU/JT3 - AU/LG3                                       = 0
 SUPERFV)  SUPFV  - FV1             - FVI    - FV/BSI                     = 0
 SUPERBS)  SUPBS  - BSI                                                   = 0
 SUPERTM)  SUPTM  - TMI                                                   = 0
 SUPERPQ)  SUPPQ  - PQI                                                   = 0
 SUPERPDT) SUPPDT - PDTI                                                  = 0
 SUPERPM)  SUPPM  - PMI                                                   = 0
 SUPRVRT)  SUPFVT - FVVA1  - FVVA2  - FVVA3  - FVVAI  - FVVA/BSI - FVOG1
                  - FVOG2  - FVOG3  - FVOGI  - BRGI   - LZI               = 0
 SUPERFN)  SUPFN  - FNVA1  - FNVA2  - FNVA3  - FNVAI                      = 0
 SUPEREN)  SUPEN  - ENMSI  - ENSGI  - ENVAI  - ENVA1  - ENVA2    - ENVA3  = 0
 SUPERPAT) SUPPAT - JP1    - JP2    - JP3                                 = 0
!
!*************************************************************************
!
!         Production de Fourrages
!
!*************************************************************************
!
  RFVVA1) PRDFVVA1 -   0 FVVA/BSI -   0 FVVAI  -   0 FVVA1  -   0 FVVA2
                   -   0 FVVA3                                          <= 0
  RFVVA2) PRDFVVA2 -   0 FVVA/BSI -   0 FVVAI  -   0 FVVA1  -   0 FVVA2
                   -   0 FVVA3                                          <= 0
  RFVVA3) PRDFVVA3 -  27 FVVA/BSI -  27 FVVAI  -  22 FVVA1  -  17 FVVA2
                   -  10 FVVA3                                          <= 0
  RFVVA4) PRDFVVA4 -   0 FVVA/BSI -   0 FVVAI  -   0 FVVA1  -   0 FVVA2
                   -   0 FVVA3                                          <= 0
  RFVVA5) PRDFVVA5 -   0 FVVA/BSI -   0 FVVAI  -   0 FVVA1  -   0 FVVA2
                   -   0 FVVA3                                          <= 0
!
  RFNVA1) PRDFNVA1 -   0 FNVAI    -   0 FNVA1  -   0 FNVA2  -   0 FNVA3  <= 0
  RFNVA2) PRDFNVA2 -   0 FNVAI    -   0 FNVA1  -   0 FNVA2  -   0 FNVA3  <= 0
  RFNVA3) PRDFNVA3 -   7 FNVAI    - 5.5 FNVA1  - 4.5 FNVA2  -   3 FNVA3  <= 0
  RFNVA4) PRDFNVA4 -   0 FNVAI    -   0 FNVA1  -   0 FNVA2  -   0 FNVA3  <= 0
  RFNVA5) PRDFNVA5 -   0 FNVAI    -   0 FNVA1  -   0 FNVA2  -   0 FNVA3  <= 0
!
  RFVOG1) PRDFVOG1 -   0 FVOGI    -   0 FVOG1  -   0 FVOG2  -   0 FVOG3  <= 0
  RFVOG2) PRDFVOG2 -  32 FVOGI    -  26 FVOG1  -  21 FVOG2  -  16 FVOG3  <= 0
  RFVOG3) PRDFVOG3 -   0 FVOGI    -   0 FVOG1  -   0 FVOG2  -   0 FVOG3  <= 0
  RFVOG4) PRDFVOG4 -   0 FVOGI    -   0 FVOG1  -   0 FVOG2  -   0 FVOG3  <= 0
  RFVOG5) PRDFVOG5 -   0 FVOGI    -   0 FVOG1  -   0 FVOG2  -   0 FVOG3  <= 0
!
```

```
  RFVPAT1) PRDPAT1 -   1 JP1      -  .8 JP2    -  .5 JP3    -  .3 PATUR   <= 0
  RFVPAT2) PRDPAT2 - 2.5 JP1      - 2.2 JP2    - 1.8 JP3    - 1.2 PATUR   <= 0
  RFVPAT3) PRDPAT3 - 2.5 JP1      - 2.2 JP2    - 1.8 JP3    - 1.2 PATUR   <= 0
  RFVPAT4) PRDPAT4 - 1.5 JP1      - 1.2 JP2    -  .8 JP3    -  .5 PATUR   <= 0
  RFVPAT5) PRDPAT5 -   0 JP1      -   0 JP2    -   0 JP3    -   0 PATUR   <= 0
!
  RENVA1) PRDENVA1 -   0 ENVAI    -   0 ENVA1  -   0 ENVA2  -   0 ENVA3   <= 0
  RENVA2) PRDENVA2 -   0 ENVAI    -   0 ENVA1  -   0 ENVA2  -   0 ENVA3   <= 0
  RENVA3) PRDENVA3 -  27 ENVAI    -  22 ENVA1  -  17 ENVA2  -  10 ENVA3   <= 0
  RENVA4) PRDENVA4 -   0 ENVAI    -   0 ENVA1  -   0 ENVA2  -   0 ENVA3   <= 0
  RENVA5) PRDENVA5 -   0 ENVAI    -   0 ENVA1  -   0 ENVA2  -   0 ENVA3   <= 0
!
  RENMS1) PRDENMS1 -   0 ENMSI                                            <= 0
  RENMS2) PRDENMS2 -   0 ENMSI                                            <= 0
  RENMS3) PRDENMS3 -   0 ENMSI                                            <= 0
  RENMS4) PRDENMS4 -  60 ENMSI                                            <= 0
  RENMS5) PRDENMS5 -   0 ENMSI                                            <= 0
!
  RENSG1) PRDENSG1 -   0 ENSGI                                            <= 0
  RENSG2) PRDENSG2 -   0 ENSGI                                            <= 0
  RENSG3) PRDENSG3 -   0 ENSGI                                            <= 0
  RENSG4) PRDENSG4 -  70 ENSGI                                            <= 0
  RENSG5) PRDENSG5 -   0 ENSGI                                            <= 0
!
 RFVBRG1) PRDBRG1  -   0 BRGI                                             <= 0
 RFVBRG2) PRDBRG2  -  35 BRGI                                             <= 0
 RFVBRG3) PRDBRG3  -  25 BRGI                                             <= 0
 RFVBRG4) PRDBRG4  -   0 BRGI                                             <= 0
 RFVBRG5) PRDBRG5  -   0 BRGI                                             <= 0
!
  RFVLZ1) PRDLUZ1   -  0 LZI                                              <= 0
  RFVLZ2) PRDLUZ2   -  0 LZI                                              <= 0
  RFVLZ3) PRDLUZ3   - 30 LZI                                              <= 0
  RFVLZ4) PRDLUZ4   - 30 LZI                                              <= 0
  RFVLZ5) PRDLUZ5   -  0 LZI                                              <= 0
!
 RPAILL1) PRDPAL1                                                         <= 0
 RPAILL2) PRDPAL2                                                         <= 0
 RPAILL3) PRDPAL3                                                         <= 0
 RPAILL4) PRDPAL4  -   3 BDI      -   2 BD/JT1 - 1.7 BD/JT2 - 1.3 BD/JT3
                   -   2 BD/JP1   - 1.7 BD/JP2 - 1.3 BD/JP3 -   2 BD/LG1
                   - 1.7 BD/LG2   - 1.3 BD/LG3 -   3 BD/LGI -   3 BD/BSI
                   -   3 BTI      -   2 BT/JT1 - 1.7 BT/JT2 -   2 BT/JP1
                   - 1.7 BT/JP2   -   2 BT/LG1 - 1.7 BT/LG2 -   3 BT/LGI
                   -   3 BT/BSI   -   2 OG/JT1 - 1.7 OG/JT2 - 1.3 OG/JT3
                   -   2 OG/JP1   - 1.7 OG/JP2 - 1.3 OG/JP3 -   2 OG/LG1
                   - 1.7 OG/LG2   - 1.3 OG/LG3                             <= 0
 RPAILL5) PRDPAL5                                                         <= 0
!
```

```
!*****************************************************************************
!
!     Transfert de Fourrage Vert
!
!*****************************************************************************
!
   FVVA1)   PRDFVVA1   +      0 TFVVA51   -  CFVVA1   -  TFVVA12  >= 0
   FVVA2)   PRDFVVA2   +      0 TFVVA12   -  CFVVA2   -  TFVVA23  >= 0
   FVVA3)   PRDFVVA3   +      0 TFVVA23   -  CFVVA3   -  TFVVA34  >= 0
   FVVA4)   PRDFVVA4   +      0 TFVVA34   -  CFVVA4   -  TFVVA45  >= 0
   FVVA5)   PRDFVVA5   +      0 TFVVA45   -  CFVVA5   -  TFVVA51  >= 0
!
   FNVA1)   PRDFNVA1   +   0.97 TFNVA51   -  CFNVA1   -  TFNVA12
                                          -  FOIN1                >= 0
   FNVA2)   PRDFNVA2   +   0.97 TFNVA12   -  CFNVA2   -  TFNVA23
                                          -  FOIN2                >= 0
   FNVA3)   PRDFNVA3   +   1.00 TFNVA23   -  CFNVA3   -  TFNVA34  >= 0
   FNVA4)   PRDFNVA4   +   0.97 TFNVA34   -  CFNVA4   -  TFNVA45  >= 0
   FNVA5)   PRDFNVA5   +   0.97 TFNVA45   -  CFNVA5   -  TFNVA51
                                          -  FOIN5                >= 0
!
   FVOG1)   PRDFVOG1   +      0 TFVOG51   -  CFVOG1   -  TFVOG12  >= 0
   FVOG2)   PRDFVOG2   +      0 TFVOG12   -  CFVOG2   -  TFVOG23  >= 0
   FVOG3)   PRDFVOG3   +      0 TFVOG23   -  CFVOG3   -  TFVOG34  >= 0
   FVOG4)   PRDFVOG4   +      0 TFVOG34   -  CFVOG4   -  TFVOG45  >= 0
   FVOG5)   PRDFVOG5   +      0 TFVOG45   -  CFVOG5   -  TFVOG51  >= 0
!
   FVPAT1)  PRDPAT1    +      0 TPAT51    -  CFVPAT1  -  TPAT12   >= 0
   FVPAT2)  PRDPAT2    +      0 TPAT12    -  CFVPAT2  -  TPAT23   >= 0
   FVPAT3)  PRDPAT3    +      0 TPAT23    -  CFVPAT3  -  TPAT34   >= 0
   FVPAT4)  PRDPAT4    +      0 TPAT34    -  CFVPAT4  -  TPAT45   >= 0
   FVPAT5)  PRDPAT5    +      0 TPAT45    -  CFVPAT5  -  TPAT51   >= 0
!
   ENVA1)   PRDENVA1   +   0.97 TENVA51   -  CENVA1   -  TENVA12  >= 0
   ENVA2)   PRDENVA2   +   0.97 TENVA12   -  CENVA2   -  TENVA23  >= 0
   ENVA3)   PRDENVA3   +   1.00 TENVA23   -  CENVA3   -  TENVA34  >= 0
   ENVA4)   PRDENVA4   +   0.97 TENVA34   -  CENVA4   -  TENVA45  >= 0
   ENVA5)   PRDENVA5   +   0.97 TENVA45   -  CENVA5   -  TENVA51  >= 0
!
   ENMS1)   PRDENMS1   +   0.97 TMS51     -  CENMS1   -  TMS12    >= 0
   ENMS2)   PRDENMS2   +   0.97 TMS12     -  CENMS2   -  TMS23    >= 0
   ENMS3)   PRDENMS3   +   0.97 TMS23     -  CENMS3   -  TMS34    >= 0
   ENMS4)   PRDENMS4   +   1.00 TMS34     -  CENMS4   -  TMS45    >= 0
   ENMS5)   PRDENMS5   +   0.97 TMS45     -  CENMS5   -  TMS51    >= 0
!
   ENSG1)   PRDENSG1   +   0.97 TSG51     -  CENSG1   -  TSG12    >= 0
   ENSG2)   PRDENSG2   +   0.97 TSG12     -  CENSG2   -  TSG23    >= 0
   ENSG3)   PRDENSG3   +   0.97 TSG23     -  CENSG3   -  TSG34    >= 0
   ENSG4)   PRDENSG4   +   1.00 TSG34     -  CENSG4   -  TSG45    >= 0
   ENSG5)   PRDENSG5   +   0.97 TSG45     -  CENSG5   -  TSG51    >= 0
!
```

```
!
   FVBRG1)  PRDBRG1     +      0 TBRG51     -   CFVBRG1  -   TBRG12   >= 0
   FVBRG2)  PRDBRG2     +      0 TBRG12     -   CFVBRG2  -   TBRG23   >= 0
   FVBRG3)  PRDBRG3     +      0 TBRG23     -   CFVBRG3  -   TBRG34   >= 0
   FVBRG4)  PRDBRG4     +      0 TBRG34     -   CFVBRG4  -   TBRG45   >= 0
   FVBRG5)  PRDBRG5     +      0 TBRG45     -   CFVBRG5  -   TBRG51   >= 0
!
   FVLZ1)   PRDLUZ1     +      0 TLZ51      -   CFVLZ1   -   TLZ12    >= 0
   FVLZ2)   PRDLUZ2     +      0 TLZ12      -   CFVLZ2   -   TLZ23    >= 0
   FVLZ3)   PRDLUZ3     +      0 TLZ23      -   CFVLZ3   -   TLZ34    >= 0
   FVLZ4)   PRDLUZ4     +      0 TLZ34      -   CFVLZ4   -   TLZ45    >= 0
   FVLZ5)   PRDLUZ5     +      0 TLZ45      -   CFVLZ5   -   TLZ51    >= 0
!
   FNPAL1)  PRDPAL1     +    .97 TPAL51     -   CFNPAL1  -   TPAL12
                                            -   CLTPAL1  -   PAILLE1  >= 0
   FNPAL2)  PRDPAL2     +    .97 TPAL12     -   CFNPAL2  -   TPAL23
                                            -   CLTPAL2  -   PAILLE2  >= 0
   FNPAL3)  PRDPAL3     +    .97 TPAL23     -   CFNPAL3  -   TPAL34
                                            -   CLTPAL3              >= 0
   FNPAL4)  PRDPAL4     +   1.00 TPAL34     -   CFNPAL4  -   TPAL45
                                            -   CLTPAL4              >= 0
   FNPAL5)  PRDPAL5     +    .97 TPAL45     -   CFNPAL5  -   TPAL51
                                            -   CLTPAL5  -   PAILLE5  >= 0
!
!*****************************************************************************
!
!          Besoins de l'Elevage
!
!*****************************************************************************
!
   UF1)  60 CFVVA1  +  380 CFNVA1  +   60 CFVOG1  +   75 CFVPAT1 +  100 CENVA1
     +  200 CENMS1  +  120 CENSG1  +   90 CFVBRG1 +   85 CFVLZ1  +  150 CFNPAL1
     -  700 BOVP    -  450 BOVC    -  100 OVIN                    >=   0
  MAD1)  10 CFVVA1  +   17 CFNVA1  +    9 CFVOG1  +  7.5 CFVPAT1 +   16 CENVA1
     +   12 CENMS1  +   14 CENSG1  +   20 CFVBRG1 +   19 CFVLZ1  +    0 CFNPAL1
     -   70 BOVP    -   52 BOVC    -   10 OVIN                    >=   0
   MS1) 150 CFVVA1  +  850 CFNVA1  +  150 CFVOG1  +  200 CFVPAT1 +  200 CENVA1
     +  270 CENMS1  +  200 CENSG1  +  150 CFVBRG1 +  170 CFVLZ1  +  900 CFNPAL1
     -  700 BOVP    -  500 BOVC    -   50 OVIN                    >=   0
 FOIN1)      CFNVA1  +      CFNPAL1 - .122 BOVP    - .122 BOVC    >=   0
 LITIER1)    CLTPAL1 -  .02 OVIN    -  .05 BOVP    -  .05 BOVC    >=   0
!
   UF2)  60 CFVVA2  +  380 CFNVA2  +   60 CFVOG2  +   75 CFVPAT2 +  100 CENVA2
     +  200 CENMS2  +  120 CENSG2  +   90 CFVBRG2 +   85 CFVLZ2  +  150 CFNPAL2
     - 1050 BOVP    -  675 BOVC    -  150 OVIN                    >=   0
  MAD2)  10 CFVVA2  +   17 CFNVA2  +    9 CFVOG2  +  7.5 CFVPAT2 +   16 CENVA2
     +   12 CENMS2  +   14 CENSG2  +   20 CFVBRG2 +   19 CFVLZ2  +    0 CFNPAL2
     -  105 BOVP    -   78 BOVC    -   15 OVIN                    >=   0
   MS2) 150 CFVVA2  +  850 CFNVA2  +  150 CFVOG2  +  200 CFVPAT2 +  200 CENVA2
     +  270 CENMS2  +  200 CENSG2  +  150 CFVBRG2 +  170 CFVLZ2  +  900 CFNPAL2
     - 1050 BOVP    -  750 BOVC    -   75 OVIN                    >=   0
 FOIN2)      CFNVA2  +      CFNPAL2 - .183 BOVP    - .183 BOVC    >=   0
 LITIER2)    CLTPAL2 -  .05 OVIN    -  .10 BOVP    -  .10 BOVC    >=   0
!
```

```
  UF3)    60 CFVVA3  +  380 CFNVA3  +   60 CFVOG3  +   75 CFVPAT3 +  100 CENVA3
     +   200 CENMS3  +  120 CENSG3  +   90 CFVBRG3 +   85 CFVLZ3  +  150 CFNPAL3
     - 1050 BOVP     -  675 BOVC    -  150 OVIN                    >=   0
  MAD3)   10 CFVVA3  +   17 CFNVA3  +    9 CFVOG3  +  7.5 CFVPAT3 +   16 CENVA3
     +    12 CENMS3  +   14 CENSG3  +   20 CFVBRG3 +   19 CFVLZ3  +    0 CFNPAL3
     -   105 BOVP     -   78 BOVC    -   15 OVIN                    >=   0
   MS3) 150 CFVVA3  +  850 CFNVA3  +  150 CFVOG3  +  200 CFVPAT3 +  200 CENVA3
     +   270 CENMS3  +  200 CENSG3  +  150 CFVBRG3 +  170 CFVLZ3  +  900 CFNPAL3
     - 1050 BOVP     -  750 BOVC    -   75 OVIN                    >=   0
 FOIN3)      CFNVA3  +      CFNPAL3 - .183 BOVP    - .183 BOVC    >=   0
 LITIER3)    CLTPAL3 -  .05 OVIN    -  .10 BOVP    -  .10 BOVC    >=   0
!
   UF4)    60 CFVVA4  +  380 CFNVA4  +   60 CFVOG4  +   75 CFVPAT4 +  100 CENVA4
     +   200 CENMS4  +  120 CENSG4  +   90 CFVBRG4 +   85 CFVLZ4  +  150 CFNPAL4
     -   700 BOVP     -  450 BOVC    -   80 OVIN                    >=   0
  MAD4)   10 CFVVA4  +   17 CFNVA4  +    9 CFVOG4  +  7.5 CFVPAT4 +   16 CENVA4
     +    12 CENMS4  +   14 CENSG4  +   20 CFVBRG4 +   19 CFVLZ4  +    0 CFNPAL4
     -    70 BOVP     -   52 BOVC    -   10 OVIN                    >=   0
   MS4) 150 CFVVA4  +  850 CFNVA4  +  150 CFVOG4  +  200 CFVPAT4 +  200 CENVA4
     +   270 CENMS4  +  200 CENSG4  +  150 CFVBRG4 +  170 CFVLZ4  +  900 CFNPAL4
     -   700 BOVP     -  500 BOVC    -   50 OVIN                    >=   0
 FOIN4)      CFNVA4  +      CFNPAL4 - .122 BOVP    - .122 BOVC    >=   0
 LITIER4)    CLTPAL4 -  .02 OVIN    -  .05 BOVP    -  .05 BOVC    >=   0
!
   UF5)    60 CFVVA5  +  380 CFNVA5  +   60 CFVOG5  +   75 CFVPAT5 +  100 CENVA5
     +   200 CENMS5  +  120 CENSG5  +   90 CFVBRG5 +   85 CFVLZ5  +  150 CFNPAL5
     -   700 BOVP     -  450 BOVC    -   80 OVIN                    >=   0
  MAD5)   10 CFVVA5  +   17 CFNVA5  +    9 CFVOG5  +  7.5 CFVPAT5 +   16 CENVA5
     +    12 CENMS5  +   14 CENSG5  +   20 CFVBRG5 +   19 CFVLZ5  +    0 CFNPAL5
     -    70 BOVP     -   52 BOVC    -   10 OVIN                    >=   0
   MS5) 150 CFVVA5  +  850 CFNVA5  +  150 CFVOG5  +  200 CFVPAT5 +  200 CENVA5
     +   270 CENMS5  +  200 CENSG5  +  150 CFVBRG5 +  170 CFVLZ5  +  900 CFNPAL5
     -   700 BOVP     -  500 BOVC    -   50 OVIN                    >=   0
 FOIN5)      CFNVA5  +      CFNPAL5 - .122 BOVP    - .122 BOVC    >=   0
 LITIER5)    CLTPAL5 -  .02 OVIN    -  .05 BOVP    -  .05 BOVC    >=   0
!
!*****************************************************************************
!
!          Besoins Animaux en Concentre/Unite Femelle
!                              (Tn/An)
!*****************************************************************************
!
 Conctr)    2 BOVP   +  1.8 BOVC    +  0.0 OVIN    -      CONCTR  <=   0
!
!*****************************************************************************
!
!         Nombre Maximum D'Animaux dans le Court Terme
!
!*****************************************************************************
!
  MAXBOVP)       BOVP      <=      9825
  MAXBOVC)       BOVC      <=       130
  MAXOVIN)       OVIN      <=     95950
```

```
!*****************************************************************************
!
!          Production Laitiere et de Viande
!                        (Tn)
!*****************************************************************************
!
   LAITBP)      3.16 BOVP   -  LAITBP    >=   0
   LAITBC)      2.23 BOVC   -  LAITBC    >=   0
   LAINOV)      .003 OVIN   -  LAINE     >=   0
   VIANDBP)      0.4 BOVP   -  VIANDBP   >=   0
   VIANDBC)      .32 BOVC   -  VIANDBC   >=   0
   VIANDOV)      .06 OVIN   -  VIANDOV   >=   0
!
!*****************************************************************************
!
!          Semences Selectionnees
!
!*****************************************************************************
!
 SEMENCBD)     SEMBD  - .120 BDI    - .115 BD/JT1 - .110 BD/JT2 - .105 BD/JT3
        - .115 BD/JP1 - .110 BD/JP2 - .105 BD/JP3 - .115 BD/LG1 - .110 BD/LG2
        - .105 BD/LG3 - .120 BD/LGI - .120 BD/BSI               >=   0
 SEMENCBT)     SEMBT  - .125 BTI    - .120 BT/JT1 - .115 BT/JT2 - .120 BT/JP1
        - .115 BT/JP2 - .120 BT/LG1 - .115 BT/LG2 - .125 BT/BSI - .125 BT/LGI
                                                                >=   0
 SEMENCOG)     SEMOG  - .105 OG/JT1 - .100 OG/JT2 - .105 OG/JP1 - .100 OG/JP2
        - .095 OG/JP3 - .105 OG/LG1 - .100 OG/LG2 - .095 OG/LG3 - .095 OG/JT3
                                                                >=   0
 SEMENCFV)     SEMFV  - .120 FV1    - .140 FVI    - .140 FV/BSI >=   0
 SEMENCBS)     SEMBS  - .015 BSI                                >=   0
 SEMENCPQ)     SEMPQ  - .002 PQI                                >=   0
 SEMENCPT)     SEMPDT -    2 PDTI                               >=   0
 SEMECVT)      SEMVT  - .110 FVVA1  - .105 FVVA2  - .100 FVVA3  - .120 FVVA/BSI
        - .120 FVVAI  - .025 BRGI   - .025 LZI    - .105 FVOG1  - .100 FVOG2
        - .095 FVOG3  - .115 FVOGI                               >=   0
 SEMENCEN)     SEMEN  - .035 ENMSI  - .025 ENSGI  - .110 ENVA1  - .105 ENVA2
        - .100 ENVA3  - .120 ENVAI                               >=   0
 SEMENCFN)     SEMFN  - .110 FNVA1  - .105 FNVA2  - .100 FNVA3  - .120 FNVAI
                                                                >=   0
!
```

```
!*************************************************************************
!
!          Contrainte Terre
!
!*************************************************************************
!
 TERREPF)   BD/JP3    + BD/LG3   + OG/JP3   + OG/LG3   + FVVA3    + FVOG3
          + JP3       + BD/JT3   + OG/JT3   + JT3      + FNVA3    + ENVA3
          + AU/JT3    + AU/LG3                                              <= 49000
 TERREPM)   BD/JT2    + BT/JT2   + OG/JT2   + BD/JP2   + BT/JP2   + OG/JP2
          + BD/LG2    + BT/LG2   + OG/LG2   + FVVA2    + FNVA2    + FVOG2
          + JT2       + JP2      + ENVA2                                    <= 25000
 TERREPO) + BD/JT1    + BD/JP1   + BD/LG1   + BT/JT1   + BT/JP1   + BT/LG1
          + OG/JT1    + OG/JP1   + OG/LG1   + FV1      + FVVA1    + FNVA1
          + FVOG1     + JT1      + JP1      + ENVA1    - IRRSEC             <= 13000
 IRRIGUEE)  BDI       + BTI      + BSI      + TMI      + PQI      + PDTI
          + PMI       + ENVAI    + ENMSI    + ENSGI    + BRGI     + LZI
          + BD/LGI    + BT/LGI   + FVVAI    + FVI      + BD/BSI   + BT/BSI
          + FVVA/BSI  + FV/BSI   + FNVAI    + FVOGI    + IRRSEC             <= 34000
 PATURAGE)  PATUR                                                           <= 12120
!
   LEGUME)  FV1       + FVI      + FV/BSI                                   >=  3000
 AUTCERLS)  SUPAU                                                            =  8855
 CULTMARI)  TMI       + PQI      + PDTI     + PMI                           <=  6490
!
!*************************************************************************
!
!          Rotations des Cultures Céréalières
!
!*************************************************************************
!
  CERJCT1)  BD/JT1    + BT/JT1   + OG/JT1   - JT1                            <= 0
  CERJCP1)  BD/JP1    + BT/JP1   + OG/JP1   - JP1                            <= 0
  CERLEG1)  BD/LG1    + BT/LG1   + OG/LG1   - FVVA1    - FNVA1    -   FV1
                                            - ENVA1                          <= 0
  CERJCT2)  BD/JT2    + BT/JT2   + OG/JT2   - JT2                            <= 0
  CERJCP2)  BD/JP2    + BT/JP2   + OG/JP2   - JP2                            <= 0
  CERLEG2)  BD/LG2    + BT/LG2   + OG/LG2   - FVVA2    - FNVA2    -   ENVA2 <= 0
  CERJCT3)  BD/JT3    + OG/JT3   + AU/JT3   - JT3                            <= 0
  CERJCP3)  BD/JP3    + OG/JP3   - JP3                                       <= 0
  CERLEG3)  OG/LG3    + BD/LG3   + AU/LG3   - FVVA3    - FNVA3    -   ENVA3 <= 0
  BRCERLGA) BD/BSI    + BT/BSI   + FVVA/BSI + FV/BSI             - 2 BSI   <= 0
  BRCERLGB) BD/BSI    + BT/BSI   - FVVA/BSI - FV/BSI                       <= 0
  CERLEGMI) BD/LGI    + BT/LGI   - FVVAI    - FNVAI    -  ENVAI   -   FVI  <= 0
!
```

```
!*****************************************************************************
!
!          Main d'Oeuvre Agricole par Période
!
!*****************************************************************************
!
 TRAV1) 9.9 BDI     + 6.6 BD/JT1 + 5.9 BD/JT2 + 5.3 BD/JT3    + 7.3 BD/JP1
      + 6.5 BD/JP2 + 6.6 BD/LG1 + 5.9 BD/LG2 + 5.3 BD/LG3    + 5.8 BD/JP3
      + 9.9 BD/LGI + 9.9 BD/BSI + 9.9 BTI    + 6.6 BT/JT1    + 5.9 BT/JT2
      + 7.3 BT/JP1 + 6.5 BT/JP2 + 6.6 BT/LG1 + 5.9 BT/LG2    + 9.9 BT/BSI
      + 9.9 BT/LGI + 3.2 OG/JT1 + 2.9 OG/JT2 + 2.6 OG/JT3    + 3.5 OG/JP1
      + 3.2 OG/JP2 + 3.2 OG/JP3 + 3.2 OG/LG1 + 2.9 OG/LG2    + 2.6 OG/LG3
      + 2.6 AU/JT3 + 2.6 AU/LG3 +  30 FV1    +  40 FVI       +  40 FV/BSI
      + 125 BSI    +  90 TMI    + 120 PDTI   +  80 PMI       +   5 FVVA1
      + 4.5 FVVA2  + 4.1 FVVA3  +   9 FVVAI  +   9 FVVA/BSI  + 5.0 FNVA1
      + 4.5 FNVA2  + 4.1 FNVA3  +   9 FNVAI  + 5.2 FVOG1     + 4.7 FVOG2
      + 4.2 FVOG3  + 9.4 FVOGI  +  12 ENVAI  +   8 ENVA1     +   7 ENVA2
      +   6 ENVA3  +   0 ENMSI  +   0 ENSGI  +   2 BRGI      +   5 LZI
      +  33 BOVP   +  33 BOVC   + 2.5 OVIN   - 5.2 TRAVPM1   - 6.5 TRAVTM1 <=  0
!
 TRAV2) 3.9 BDI     + 2.6 BD/JT1 + 2.3 BD/JT2 + 2.1 BD/JT3    + 2.9 BD/JP1
      + 2.5 BD/JP2 + 1.9 BD/JP3 + 2.6 BD/LG1 + 2.3 BD/LG2    + 2.1 BD/LG3
      + 3.9 BD/LGI + 3.9 BD/BSI + 3.9 BTI    + 2.6 BT/JT1    + 2.3 BT/JT2
      + 2.9 BT/JP1 + 2.5 BT/JP2 + 2.6 BT/LG1 + 2.3 BT/LG2    + 3.9 BT/BSI
      + 3.9 BT/LGI + 2.0 OG/JT1 + 1.8 OG/JT2 + 1.6 OG/JT3    + 2.2 OG/JP1
      + 2.0 OG/JP2 + 1.8 OG/JP3 + 2.0 OG/LG1 + 1.8 OG/LG2    + 1.6 OG/LG3
      + 1.6 AU/JT3 + 1.6 AU/LG3 +  15 FV1    +  20 FVI       +  20 FV/BSI
      + 225 BSI    +  96 TMI    +  48 PQI    + 120 PDTI      + 3.5 FVVA1
      + 3.2 FVVA2  + 2.8 FVVA3  + 4.5 FVVAI  + 4.5 FVVA/BSI  + 2.5 FNVA1
      + 2.3 FNVA2  +   2 FNVA3  + 3.4 FNVAI  + 2.8 FVOG1     + 2.5 FVOG2
      + 2.3 FVOG3  + 3.1 FVOGI  +   4 ENVAI  +   3 ENVA1     + 2.7 ENVA2
      + 2.4 ENVA3  +   0 ENMSI  +   0 ENSGI  + 6.0 BRGI      +   4 LZI
      +  50 BOVP   +  50 BOVC   + 3.8 OVIN   - 5.2 TRAVPM2   - 6.5 TRAVTM2 <=  0
!
 TRAV3) 2.4 BDI     + 1.6 BD/JT1 + 1.4 BD/JT2 + 1.3 BD/JT3    + 1.8 BD/JP1
      + 1.5 BD/JP2 + 1.4 BD/JP3 + 1.6 BD/LG1 + 1.4 BD/LG2    + 1.3 BD/LG3
      + 2.4 BD/LGI + 2.4 BD/BSI + 2.4 BTI    + 1.6 BT/JT1    + 1.4 BT/JT2
      + 1.8 BT/JP1 + 1.5 BT/JP2 + 1.6 BT/LG1 + 1.4 BT/LG2    + 2.4 BT/BSI
      + 2.4 BT/LGI + 1.0 OG/JT1 +  .9 OG/JT2 + 0.8 OG/JT3    + 1.1 OG/JP1
      + 1.0 OG/JP2 + 0.9 OG/JP3 + 1.0 OG/LG1 + 0.9 OG/LG2    + 0.8 OG/LG3
      +  .8 AU/JT3 +  .8 AU/LG3 +  23 FV1    +  30 FVI       +  30 FV/BSI
      + 225 BSI    + 150 TMI    + 102 PQI    + 124 PMI       +   5 FVVA1
      + 4.5 FVVA2  + 4.1 FVVA3  + 7.5 FVVAI  + 7.5 FVVA/BSI  + 3.5 FNVA1
      + 3.2 FNVA2  + 2.8 FNVA3  + 5.3 FNVAI  + 3.0 FVOG1     + 2.7 FVOG2
      + 2.4 FVOG3  + 4.5 FVOGI  + 4.5 ENVAI  +   3 ENVA1     + 2.7 ENVA2
      + 2.4 ENVA3  +  37 ENMSI  +  10 ENSGI  +   3 BRGI      +  18 LZI
      +  50 BOVP   +  50 BOVC   + 3.8 OVIN   - 5.2 TRAVPM3   - 6.5 TRAVTM3 <=  0
!
```

```
 TRAV4) 4.5 BDI     +   3 BD/JT1 + 2.7 BD/JT2 + 2.4 BD/JT3    + 3.3 BD/JP1
      +   3 BD/JP2 + 2.6 BD/JP3 +   3 BD/LG1 + 2.7 BD/LG2    + 2.4 BD/LG3
      + 4.5 BD/LGI + 4.5 BD/BSI + 4.5 BTI    +   3 BT/JT1    + 2.7 BT/JT2
      + 3.3 BT/JP1 +   3 BT/JP2 +   3 BT/LG1 + 2.7 BT/LG2    + 4.5 BT/BSI
      + 4.5 BT/LGI + 3.5 OG/JT1 + 3.2 OG/JT2 + 2.8 OG/JT3    + 3.9 OG/JP1
      + 3.5 OG/JP2 + 3.1 OG/JP3 + 3.5 OG/LG1 + 3.2 OG/LG2    + 2.8 OG/LG3
      + 2.8 AU/JT3 + 2.8 AU/LG3 +   2 FV1    +   2 FVI       +   2 FV/BSI
      + 200 BSI    + 375 TMI    + 240 PQI    + 336 PMI       +   0 FVVA1
      +   0 FVVA2  +   0 FVVA3  +   0 FVVAI  +   0 FVVA/BSI  +   0 FNVA1
      +   0 FNVA2  +   0 FNVA3  +   0 FNVAI  +   0 FVOG1     +   0 FVOG2
      +   0 FVOG3  +   0 FVOGI  +   0 EVVAI  +   0 ENVA1     +   0 ENVA2
      +   0 ENVA3  +  27 ENMSI  +  50 ENSGI  +   4 BRGI      +  26 LZI
      +  33 BOVP   +  33 BOVC   + 2.5 OVIN   - 5.2 TRAVPM4   - 6.5 TRAVTM4
      + 2.8 PRDPAL4                                          <=  0
!
 TRAV5) 5.2 BDI     + 3.5 BD/JT1 + 3.2 BD/JT2 + 2.8 BD/JT3    + 3.9 BD/JP1
      + 3.5 BD/JP2 + 3.1 BD/JP3 + 3.5 BD/LG1 + 3.2 BD/LG2    + 2.8 BD/LG3
      + 5.2 BD/LGI + 5.2 BD/BSI + 5.2 BTI    + 3.5 BT/JT1    + 3.2 BT/JT2
      + 3.9 BT/JP1 + 3.5 BT/JP2 + 3.5 BT/LG1 + 3.2 BT/LG2    + 5.2 BT/BSI
      + 5.2 BT/LGI +   3 OG/JT1 + 2.7 OG/JT2 + 2.4 OG/JT3    + 3.3 OG/JP1
      +   3 OG/JP2 + 2.1 OG/JP3 +   3 OG/LG1 + 2.7 OG/LG2    + 2.4 OG/LG3
      + 2.4 AU/JT3 + 2.4 AU/LG3 +   4 FV1    +   5 FVI       +   5 FV/BSI
      +   0 BSI    + 580 TMI    + 128 PQI    + 584 PMI       +   6 FVVA1
      + 5.4 FVVA2  + 4.9 FVVA3  +   9 FVVAI  +   9 FVVA/BSI  +   6 FNVA1
      + 5.4 FNVA2  + 4.9 FNVA3  +   9 FNVAI  +   3 FVOG1     + 2.7 FVOG2
      + 2.4 FVOG3  + 4.5 FVOGI  +   8 ENVA1  + 7.2 ENVA2     + 6.5 ENVA3
      +  12 ENVAI  +  15 ENMSI  +  15 ENSGI  + 6.5 BRGI      +  22 LZI
      +  33 BOVP   +  33 BOVC   + 2.5 OVIN   - 5.2 TRAVPM5   - 6.5 TRAVTM5 <=  0
!
!*****************************************************************************
!
!                 Disponibilite du Travail
!
!*****************************************************************************
!
 PERMAIN1)      TRAVPM1            =    227890
 PERMAIN2)      TRAVPM2            =    341834
 PERMAIN3)      TRAVPM3            =    341834
 PERMAIN4)      TRAVPM4            =    227890
 PERMAIN5)      TRAVPM5            =    227890
!
!*****************************************************************************
!
!          Mecanisation
!
!*****************************************************************************
!
```

```
 TRACTION)
       + 19 BDI      + 17 BD/JT1   + 17 BD/JT2   + 17 BD/JT3   +   17 BD/JP1
       + 17 BD/JP2   + 17 BD/JP3   + 17 BD/LG1   + 17 BD/LG2   +   17 BD/LG3
       + 19 BD/LGI   + 10 BD/BSI   + 19 BTI      + 17 BT/JT1   +   17 BT/JT2
       + 17 BT/JP1   + 17 BT/JP2   + 17 BT/LG1   + 17 BT/LG2   +   19 BT/LGI
       + 19 BT/BSI   + 12 OG/JT1   + 12 OG/JT2   + 12 OG/JT3   +   12 OG/JP1
       + 12 OG/JP2   + 12 OG/JP3   + 12 OG/LG1   + 12 OG/LG2   +   12 OG/LG3
       + 12 AU/JT3   + 12 AU/LG3   + 17 FV1      + 19 FVI      +   19 FV/BSI
       + 30 BSI      + 58 TMI      + 52 PQI      + 50 PDTI     +   25 PMI
       + 15 FVVA1    + 12 FVVA2    + 10 FVVA3    + 20 FVVAI    +   20 FVVA/BSI
       + 20 FNVA1    + 16 FNVA2    + 13 FNVA3    + 30 FNVAI    +    8 FVOG1
       +  8 FVOG2    +  8 FVOG3    + 12 FVOGI    + 18 ENVA1    +   16 ENVA2
       + 14 ENVA3    + 21 ENAVI    + 25 ENMSI    + 23 ENSGI    +   22 BRGI
       + 28 LZI      +  6 JT1      +  6 JT2      +  6 JT3      - 1000 TRACTN   <= 0
!
!*****************************************************************************
!
!          Moisson
!
!*****************************************************************************
!
 MOISS)
     + 2.3 BDI     + 1.9 BD/JT1  + 1.7 BD/JT2   + 1.5 BD/JT3  + 1.9 BD/JP1
     + 1.7 BD/JP2  + 1.5 BD/JP3  + 1.9 BD/LG1   + 1.7 BD/LG2  + 1.5 BD/LG3
     + 2.3 BD/LGI  + 2.3 BD/BSI  + 2.3 BTI      + 1.9 BT/JT1  + 1.7 BT/JT2
     + 1.9 BT/JP1  + 1.7 BT/JP2  + 1.9 BT/LG1   + 1.7 BT/LG2  + 2.3 BT/LGI
     + 2.3 BT/BSI  + 1.0 OG/JT1  +  .9 OG/JT2   +  .8 OG/JT3  + 1.0 OG/JP1
     +  .9 OG/JP2  +  .8 OG/JP3  + 1.0 OG/LG1   +  .9 OG/LG2  +  .8 OG/LG3
     +  .8 AU/JT3  +  .8 AU/LG3  + 1.0 FV1      + 1.5 FVI     + 1.5 FV/BSI
     +  .7 PRDPAL4                                            -     MOISS  <= 0
!
!*****************************************************************************
!
!          Engrais
!
!*****************************************************************************
!
 AMMONITR)
     + 150 BDI    + 130 BD/JT1   + 115 BD/JT2 + 100 BD/JT3   +  130 BD/JP1
     + 115 BD/JP2 + 100 BD/JP3   + 105 BD/LG1 +  90 BD/LG2   +   80 BD/LG3
     + 120 BD/LGI + 150 BD/BSI   + 150 BTI    + 130 BT/JT1   +  115 BT/JT2
     + 130 BT/JP1 + 115 BT/JP2   + 105 BT/LG1 +  90 BT/LG2   +  120 BT/LGI
     + 150 BT/BSI + 115 OG/JT1   +  95 OG/JT2 +  80 OG/JT3   +  115 OG/JP1
     +  90 OG/JP2 +  80 OG/JP3   +  90 OG/LG1 +  75 OG/LG2   +   65 OG/LG3
     +  80 AU/JT3 +  55 AU/LG3   + 350 BSI    + 500 TMI      +  150 PQI
     + 300 PDTI   + 200 PMI      + 150 FVVA1  + 115 FVVA2    +  100 FVVA3
     + 175 FVVAI  + 175 FVVA/BSI + 150 FNVA1  + 115 FNVA2    +  100 FNVA3
     + 175 FNVAI  + 150 FVOG1    + 115 FVOG2  + 175 FVOGI    +  120 ENVA1
     + 110 ENVA2  + 100 ENVA3    + 200 ENVAI  + 300 ENMSI    +  250 ENSGI
     + 300 BRGI                                             - 1000 AMMON  <=0
!
```

```
 SUP45) 100 BDI     +  85 BD/JT1    +  75 BD/JT2 +  65 BD/JT3    +   85 BD/JP1
      +  75 BD/JP2 +  65 BD/JP3    +  85 BD/LG1 +  75 BD/LG2    +   65 BD/LG3
      + 100 BD/LGI + 100 BD/BSI    + 100 BTI    +  85 BT/JT1    +   75 BT/JT2
      +  85 BT/JP1 +  75 BT/JP2    +  85 BT/LG1 +  75 BT/LG2    +  100 BT/LGI
      + 100 BT/BSI + 125 FV1       + 150 FVI    + 150 FV/BSI    +  250 BSI
      + 170 TMI    + 300 PQI       + 250 PDTI   + 200 PMI       +  100 FVVA1
      +  80 FVVA2  +  80 FVVA3     + 125 FVVAI  + 125 FVVA/BSI  +  100 FNVA1
      +  80 FNVA2  +  80 FNVA3     + 125 FNVAI  + 100 FVOG1     +   80 FVOG2
      + 125 FVOGI  +  80 ENVA1     +  80 ENVA2  +  80 ENVA3     +  150 ENVAI
      + 200 ENMSI  + 150 ENSGI     + 125 BRGI   + 150 LZI       - 1000 SP45   <=0
!
 POTASSE)
      + 120 BSI    + 200 TMI       + 200 PQI    + 350 PDTI      +  200 PMI
      +  75 ENAVI  + 100 ENMSI     +  75 ENSGI  + 100 LZI       - 1000 POTASS <=0
!
 DESHERB).035 BDI    + .025 BD/JT1 + .025 BD/JT2 + .025 BD/JT3  + .030 BD/JP1
       + .030 BD/JP2 + .030 BD/JP3 + .030 BD/LG1 + .030 BD/LG2  + .030 BD/LG3
       + .035 BD/BSI + .035 BD/LGI + .045 BTI    + .035 BT/JT1  + .035 BT/JT2
       + .040 BT/JP1 + .040 BT/JP2 + .040 BT/LG1 + .040 BT/LG2  + .045 BT/BSI
       + .045 BT/LGI + .020 OG/JT1 + .020 OG/JT2 + .020 OG/JT3  + .025 OG/JP1
       + .025 OG/JP2 + .025 OG/JP3 + .025 OG/LG1 + .025 OG/LG2  + .025 OG/LG3
       + .060 BSI                                -      TOTDESH <=   0
!
!*************************************************************************
!
!          Utilisation de l'Eau
!
!*************************************************************************
!
  EAU)   3.0 BDI    + 3.0 BD/LGI + 3.0 BD/BSI +  3.0 BTI    +  3.0 BT/LGI
      + 3.0 BT/BSI + 3.5 FVI    + 4.5 FV/BSI +  8.5 BSI    +  7.5 TMI
      + 7.5 PQI    +   4 PDTI   + 7.5 PMI    +  1.5 FVVAI +  1.5 FVVA/BSI
      +   3 FVOGI  +   3 FNVAI  + 7.0 ENVAI  +    8 ENMSI +    6 ENSGI
      +   4 BRGI   +  10 LZI                 - 1000 EAU    <=   0
 EAUC)                                             EAU    <= 150
!
!*************************************************************************
!
!          Superficie minimum de betterave à Sucre
!          = 1/5 superficie irriguée.
!*************************************************************************
!
SUPERBET)
          BDI    +  BD/LGI   +  BD/BSI   +  BTI     +  BT/LGI   +  BT/BSI
      +   FVI    +  FV/BSI   +  TMI      +  PQI     +  PDTI     +  PMI
      +   FVVAI  +  FVVA/BSI +  FNVAI    +  FVOGI   +  ENVAI    +  ENMSI
      +   ENSGI  +  BRGI     +  LZI      -  5.0 BSI             <= 0
!
 END
 LEAVE
```

Annex 7

Base Model Optimal Solution

OBJECTIVE FUNCTION VALUE
1) 36182960.0

VARIABLE	VALUE	REDUCED COST
PRODBD	30000.000000	.000000
PRODBT	83588.110000	.000000
PRODOG	42241.500000	.000000
PRODAU	19481.000000	.000000
PRODFV	2100.000000	.000000
PRODBS	223989.700000	.000000
PRODPDT	68145.000000	.000000
FOIN2	33778.870000	.000000
PAILLE2	66731.610000	.000000
LAITBP	31047.000000	.000000
LAITBC	289.900000	.000000
VIANDBP	3930.000000	.000000
VIANDBC	41.600000	.000000
VIANDOV	5757.000000	.000000
LAINE	287.850000	.000000
SEMBD	1375.000000	.000000
SEMBT	2476.463000	.000000
SEMOG	1486.275000	.000000
SEMFV	360.000000	.000000
SEMBS	74.663250	.000000
SEMPDT	12980.000000	.000000
SEMVT	46.974520	.000000
SEMFN	1336.854000	.000000
SEMEN	1646.165000	.000000
EAU	150.000000	.000000
AMMON	14183.680000	.000000
SP45	9441.321000	.000000
POTASS	3361.978000	.000000
TRACTN	2070.953000	.000000
MOISS	152217.200000	.000000
TRAVPM1	227890.000000	.000000
TRAVTM1	206833.500000	.000000
TRAVPM2	341834.000000	.000000
TRAVTM2	191031.200000	.000000
TRAVPM3	341834.000000	.000000
TRAVTM3	95060.700000	.000000
TRAVPM4	227890.000000	.000000
TRAVTM4	148845.300000	.000000
TRAVPM5	227890.000000	.000000
CONCTR	19884.000000	.000000
TOTDESH	1850.664000	.000000
BD/LG2	12500.000000	.000000
BTI	11587.050000	.000000
BT/LG1	8567.351000	.000000
OG/JT3	15645.000000	.000000
AU/LG3	8855.000000	.000000
FV1	3000.000000	.000000
BSI	4977.550000	.000000
PDTI	6490.000000	.000000
SUPBD	12500.000000	.000000
SUPBT	20154.400000	.000000

SUPOG	15645.000000	.000000
SUPAU	8855.000000	.000000
SUPFV	3000.000000	.000000
SUPBS	4977.550000	.000000
SUPPDT	6490.000000	.000000
SUPFVT	1878.981000	.000000
BRGI	1878.981000	.000000
SUPFN	13153.610000	.000000
FNVA2	4298.611000	.000000
FNVA3	8855.000000	.000000
SUPEN	18700.460000	.000000
ENMSI	4931.720000	.000000
ENVA1	5567.351000	.000000
ENVA2	8201.390000	.000000
PRDFNVA3	45908.750000	.000000
PRDPAT1	3636.000000	.000000
PATUR	12120.000000	.000000
PRDPAT2	14544.000000	.000000
PRDPAT3	14544.000000	.000000
PRDPAT4	6060.000000	.000000
PRDENVA3	261905.300000	.000000
PRDENMS4	295903.200000	.000000
PRDBRG2	65764.330000	.000000
PRDBRG3	46974.520000	.000000
PRDPAL4	93484.340000	.000000
TFNVA51	39088.860000	.000000
CFNVA1	1214.510000	.000000
TFNVA12	36701.690000	.000000
CFNVA2	1821.765000	.000000
CFNVA3	1821.765000	.000000
TFNVA34	44086.980000	.000000
CFNVA4	1214.510000	.000000
TFNVA45	41549.870000	.000000
CFNVA5	1214.510000	.000000
CFVPAT1	3636.000000	.000000
CFVPAT2	14544.000000	.000000
CFVPAT3	14544.000000	.000000
CFVPAT4	6060.000000	.000000
TENVA51	67864.550000	.000000
CENVA1	65828.620000	.000000
CENVA3	27433.120000	.000000
TENVA34	234472.200000	.000000
CENVA4	76615.410000	.000000
TENVA45	150822.600000	.000000
CENVA5	78433.410000	.000000
TMS51	226223.400000	.000000
CENMS1	46069.620000	.000000
TMS12	173367.000000	.000000
CENMS2	85473.200000	.000000
TMS23	82692.840000	.000000
CENMS3	80212.050000	.000000
CENMS4	30172.220000	.000000
TMS45	265731.000000	.000000
CENMS5	31535.720000	.000000
CFVBRG2	65764.330000	.000000

CFVBRG3	46974.520000	.000000
TPAL51	85918.820000	.000000
TPAL12	80924.510000	.000000
CLTPAL1	2416.750000	.000000
TPAL23	5972.165000	.000000
CLTPAL2	5793.000000	.000000
CLTPAL3	5793.000000	.000000
TPAL45	91067.590000	.000000
CLTPAL4	2416.750000	.000000
CLTPAL5	2416.750000	.000000
BOVP	9825.000000	.000000
BOVC	130.000000	.000000
OVIN	95950.000000	.000000
JT3	15645.000000	.000000
IRRSEC	4134.702000	.000000

ROW	SLACK OR SURPLUS	DUAL PRICES
BLEDUR)	.000000	185.000000
BLETDR)	.000000	170.000000
ORGE)	.000000	120.000000
AUTCER)	.000000	110.000000
FEVE)	.000000	530.000000
BETTERAV)	.000000	27.000000
TOMATE)	.000000	100.000000
PASTEQUE)	.000000	198.426400
POMTERRE)	.000000	220.000000
PIMENT)	.000000	336.606900
SUPERAU)	.000000	1.128582
RFVVA1)	.000000	8.841574
RFVVA2)	.000000	8.808006
RFVVA3)	.000000	9.743261
RFVVA4)	.000000	8.319036
RFVVA5)	.000000	8.576325
RFNVA1)	.000000	53.350000
RFNVA2)	.000000	55.000000
RFNVA3)	.000000	48.691110
RFNVA4)	.000000	50.197020
RFNVA5)	.000000	51.749500
RFVOG1)	.000000	8.478337
RFVOG2)	.000000	9.953737
RFVOG3)	.000000	7.835794
RFVOG4)	.000000	7.977268
RFVOG5)	.000000	8.223987
RFVPAT1)	.000000	9.235786
RFVPAT2)	.000000	9.377515
RFVPAT3)	.000000	9.163031
RFVPAT4)	.000000	8.689952
RFVPAT5)	.000000	8.958713
RENVA1)	.000000	14.493800
RENVA2)	.000000	14.462340
RENVA3)	.000000	13.226100
RENVA4)	.000000	13.637220
RENVA5)	.000000	14.058980
RENMS1)	.000000	21.722880

RENMS2)	.000000	22.394720
RENMS3)	.000000	23.087340
RENMS4)	.000000	20.439060
RENMS5)	.000000	21.071190
RENSG1)	.000000	15.503730
RENSG2)	.000000	15.657020
RENSG3)	.000000	14.997820
RENSG4)	.000000	14.830270
RENSG5)	.000000	15.038620
RFVBRG1)	.000000	15.078540
RFVBRG2)	.000000	14.844500
RFVBRG3)	.000000	12.848570
RFVBRG4)	.000000	14.187400
RFVBRG5)	.000000	14.626180
RFVLZ1)	.000000	14.281200
RFVLZ2)	.000000	14.056080
RFVLZ3)	.000000	12.153480
RFVLZ4)	.000000	32.916340
RFVLZ5)	.000000	13.852770
RPAILL1)	.000000	29.100000
RPAILL2)	.000000	30.000000
RPAILL3)	.000000	30.927830
RPAILL4)	.000000	14.187890
RPAILL5)	.000000	28.227000
FVVA1)	.000000	-8.841574
FVVA2)	.000000	-8.808006
FVVA3)	.000000	-8.004237
FVVA4)	.000000	-8.319036
FVVA5)	.000000	-8.576325
FNVA1)	.000000	-53.350000
FNVA2)	.000000	-55.000000
FNVA3)	.000000	-48.691110
FNVA4)	.000000	-50.197020
FNVA5)	.000000	-51.749500
FVOG1)	.000000	-8.478337
FVOG2)	.000000	-8.481507
FVOG3)	.000000	-7.835794
FVOG4)	.000000	-7.977268
FVOG5)	.000000	-8.223987
FVPAT1)	.000000	-9.235786
FVPAT2)	.000000	-9.377515
FVPAT3)	.000000	-9.163081
FVPAT4)	.000000	-8.689952
FVPAT5)	.000000	-8.958713
ENVA1)	.000000	-14.493800
ENVA2)	.000000	-14.462340
ENVA3)	.000000	-13.228100
ENVA4)	.000000	-13.637220
ENVA5)	.000000	-14.058980
ENMS1)	.000000	-21.722880
ENMS2)	.000000	-22.394720
ENMS3)	.000000	-23.087340
ENMS4)	.000000	-20.439060
ENMS5)	.000000	-21.071190

ENSG1)	.000000	-15.503730
ENSG2)	.000000	-15.657020
ENSG3)	.000000	-14.997820
ENSG4)	.000000	-14.587460
ENSG5)	.000000	-15.038620
FVBRG1)	.000000	-15.078540
FVBRG2)	.000000	-14.844500
FVBRG3)	.000000	-12.848570
FVBRG4)	.000000	-14.187400
FVBRG5)	.000000	-14.626180
FVLZ1)	.000000	-14.281200
FVLZ2)	.000000	-14.056080
FVLZ3)	.000000	-12.153480
FVLZ4)	.000000	-13.437180
FVLZ5)	.000000	-13.852770
FNPAL1)	.000000	-29.100000
FNPAL2)	.000000	-30.000000
FNPAL3)	.000000	-30.927830
FNPAL4)	.000000	-27.380190
FNPAL5)	.000000	-28.227000
UF1)	.000000	-.086820
MAD1)	.000000	-.363236
FOIN1)	.000000	-14.183300
LITIER1)	.000000	-29.100000
UF2)	.000000	-.092384
MAD2)	.000000	-.326498
FOIN2)	.000000	-14.343730
LITIER2)	.000000	-30.000000
UF3)	.000000	-.105330
MAD3)	.000000	-.168443
FOIN3)	.000000	-5.802140
LITIER3)	.000000	-30.927830
UF4)	.000000	-.081689
MAD4)	.000000	-.341769
FOIN4)	.000000	-13.345070
LITIER4)	.000000	-27.380190
UF5)	.000000	-.084216
MAD5)	.000000	-.352339
FOIN5)	.000000	-13.757810
LITIER5)	.000000	-28.227000
CONCTR)	.000000	150.000000
MAXBOVP)	.000000	285.842900
MAXBOVC)	.000000	187.562400
MAXOVIN)	.000000	32.935050
LAITBP)	.000000	-200.000000
LAITBC)	.000000	-200.000000
LAINOV)	.000000	-1700.000000
VIANDBP)	.000000	-1400.000000
VIANDBC)	.000000	-1400.000000
VIANDOV)	.000000	-1800.000000
SEMENCBD)	.000000	-300.000000
SEMENCBT)	.000000	-300.000000
SEMENCOG)	.000000	-200.000000
SEMENCFV)	.000000	-700.000000

SEMENCBS)	.000000	-3500.000000
SEMENCPQ)	.000000	-10000.000000
SEMENCPT)	.000000	-120.000000
SEMECVT)	.000000	-250.000000
SEMENCEN)	.000000	-200.000000
SEMENCFN)	.000000	-150.000000
TERREPF)	.000000	75.402110
TERREPM)	.000000	148.523600
TERREPO)	.000000	232.281600
IRRIGUEE)	.000000	232.281600
PATURAGE)	.000000	29.364430
LEGUME)	.000000	-8.654358
AUTCERLS)	.000000	-1.128582
CULTMARI)	.000000	816.881900
CERJCT1)	.000000	274.281600
CERJCP1)	.000000	13.042650
CERLEG1)	.000000	118.684900
CERJCT2)	.000000	190.523600
CERJCP2)	.000000	6.645066
CERLEG2)	.000000	84.148960
CERJCT3)	.000000	117.402100
CERJCP3)	.000000	30.459190
CERLEG3)	.000000	60.036470
BRCERLGB)	.000000	386.125500
CERLEGMI)	.000000	20.540150
TRAV1)	.000000	.461538
TRAV2)	.000000	.461538
TRAV3)	.000000	.461538
TRAV4)	.000000	.461538
PERMAIN1)	.000000	-.600000
PERMAIN2)	.000000	-.600000
PERMAIN3)	.000000	-.600000
PERMAIN4)	.000000	-.600000
PERMAIN5)	.000000	-3.600000
TRACTION)	.000000	7.000000
MOISS)	.000000	17.000000
AMMONITR)	.000000	.118000
SUP45)	.000000	.110000
POTASSE)	.000000	.300000
DESHERB)	.000000	1000.000000
EAU)	.000000	75.739020
EAUC)	.000000	50739.020000
SUPERBET)	.000000	89.211110

NO. ITERATIONS= 371

Annex 8

Right-Hand Side Sensitivity Analysis of the Base Model Solution

RANGES IN WHICH THE BASIS IS UNCHANGED:

OBJ COEFFICIENT RANGES

VARIABLE	CURRENT COEF	ALLOWABLE INCREASE	ALLOWABLE DECREASE
PRODBD	185.000000	2.093027	5.625036
PRODBT	170.000000	3.222987	1.875003
PRODOG	120.000000	18.307720	4.049294
PRODAU	110.000000	10.631320	INFINITY
PRODFV	530.000000	12.363370	117.384100
PRODBS	27.000000	5.012852	5.983911
PRODTM	100.000000	33.913560	INFINITY
PRODPQ	150.000000	48.426440	INFINITY
PRODPDT	220.000000	INFINITY	24.404580
PRODPM	300.000000	36.606870	INFINITY
FOIN1	50.000000	3.350002	INFINITY
FOIN2	55.000000	1.362370	1.031678
FOIN5	50.000000	1.749504	INFINITY
PAILLE1	25.000000	4.100000	INFINITY
PAILLE2	30.000000	5.469959	1.621697
PAILLE5	20.000000	8.227001	INFINITY
LAITBP	200.000000	INFINITY	90.456620
LAITBC	200.000000	INFINITY	84.108700
VIANDBP	1400.000000	INFINITY	714.607300
VIANDBC	1400.000000	INFINITY	586.132600
VIANDOV	1800.000000	INFINITY	548.917500
LAINE	1700.000000	INFINITY	1700.000000
SEMBD	-300.000000	75.000130	120.819400
SEMBT	-300.000000	117.392100	72.000130
SEMOG	-200.000000	200.000000	115.085200
SEMFV	-700.000000	72.119650	2347.682000
SEMBS	-3500.000000	3500.000000	17951.730000
TMI	-100.000000	678.271100	INFINITY
SEMPQ	-10000.000000	10000.000000	INFINITY
SEMPDT	-120.000000	120.000000	128.124100
PMI	-120.000000	256.248100	INFINITY
SEMVT	-250.000000	250.000000	980.535800
SEMFN	-150.000000	51.689860	39.143020
SEMEN	-200.000000	42.299840	57.889100
EAU	-25000.000000	INFINITY	50739.020000
AMMON	-118.000000	68.992220	68.429800
SP45	-110.000000	73.304220	66.445720
POTASS	-300.000000	300.000000	1359.274000
TRACTN	-7000.000000	837.762400	759.379500
MOISS	-17.000000	3.461282	4.438871
TRAVPM1	-3.000000	INFINITY	INFINITY
TRAVTM1	-3.000000	2.229153	4.808475
TRAVPM2	-3.000000	INFINITY	INFINITY
TRAVTM2	-3.000000	3.000000	6.023237
TRAVPM3	-3.000000	INFINITY	INFINITY
TRAVTM3	-3.000000	2.906707	7.165612
TRAVPM4	-3.000000	INFINITY	INFINITY

TRAVTM4	-3.000000	3.000000	10.717850
TRAVPM5	-3.000000	INFINITY	INFINITY
TRAVTM5	-3.000000	3.000000	INFINITY
CONCTR	-150.000000	150.000000	104.201300
TOTDESH	-1000.000000	318.712100	406.965000
BDI	.000000	47.499950	INFINITY
BD/JT1	.000000	109.546600	INFINITY
BD/JT2	.000000	11.824720	INFINITY
BD/JT3	.000000	10.933090	INFINITY
BD/JP1	.000000	20.499960	INFINITY
BD/JP2	.000000	83.272640	6.645066
BD/JP3	.000000	77.267050	INFINITY
BD/LG1	.000000	29.999960	INFINITY
BD/LG2	.000000	13.290130	11.824720
BD/LG3	.000000	48.707430	INFINITY
BD/LGI	.000000	9.000015	INFINITY
BD/BSI	.000000	370.625400	INFINITY
BTI	.000000	13.221250	16.790840
BT/JT1	.000000	68.546610	INFINITY
BT/JT2	.000000	32.824720	INFINITY
BT/JP1	.000000	150.616700	13.042650
BT/JP2	.000000	58.500000	INFINITY
BT/LG1	.000000	26.085310	29.999960
BT/LG2	.000000	13.500090	INFINITY
BT/BSI	.000000	386.125500	INFINITY
BT/LGI	.000000	289.846300	9.000015
OG/JT1	.000000	266.234300	INFINITY
OG/JT2	.000000	121.499300	INFINITY
OG/JT3	.000000	72.280890	5.864338
OG/JP1	.000000	94.456930	INFINITY
OG/JP2	.000000	38.446200	INFINITY
OG/JP3	.000000	26.610900	INFINITY
OG/LG1	.000000	148.687700	INFINITY
OG/LG2	.000000	65.764680	INFINITY
OG/LG3	.000000	5.864338	INFINITY
AU/JT3	.000000	5.315658	INFINITY
AU/LG3	.000000	INFINITY	5.315658
FV1	.000000	8.654358	58.748740
FVI	.000000	289.846300	INFINITY
FV/BSI	.000000	58.748740	46.953650
BSI	.000000	225.578400	269.276000
PQI	.000000	581.117200	INFINITY
PDTI	.000000	INFINITY	256.248100
SUPBD	.000000	9.000015	13.290130
SUPBT	.000000	13.500090	9.000015
SUPOG	.000000	38.446200	10.933090
SUPAU	.000000	INFINITY	INFINITY
SUPFV	.000000	8.654358	INFINITY
SUPBS	.000000	225.578400	269.276000
SUPTM	.000000	678.271100	INFINITY
SUPPQ	.000000	581.117200	INFINITY
SUPPDT	.000000	INFINITY	256.248100
SUPPM	.000000	256.248100	INFINITY
SUPFVT	.000000	28.348920	24.513390

FVVA1	.000000	66.675680	INFINITY
FVVA2	.000000	36.989950	INFINITY
FVVA3	.000000	38.609950	INFINITY
FVVAI	.000000	365.585300	INFINITY
FVVA/BSI	.000000	46.953650	58.748740
FVOG1	.000000	89.511330	INFINITY
FVOG2	.000000	47.434330	INFINITY
FVOG3	.000000	23.555680	36.140450
FVOGI	.000000	385.186300	INFINITY
BRGI	.000000	63.069840	24.513390
LZI	.000000	584.374600	INFINITY
SUPFN	.000000	5.427435	4.110017
FNVA1	.000000	36.072450	INFINITY
FNVA2	.000000	5.427435	4.110017
FNVA3	.000000	5.864338	5.315658
FNVAI	.000000	457.901100	INFINITY
SUPEN	.000000	4.601249	7.568871
ENMSI	.000000	89.825050	56.033570
ENSGI	.000000	16.996850	INFINITY
ENVAI	.000000	547.528600	INFINITY
ENVA1	.000000	26.085310	8.654358
ENVA2	.000000	4.110017	5.427435
ENVA3	.000000	26.669250	INFINITY
SUPPAT	.000000	26.610900	INFINITY
JP1	.000000	150.616700	INFINITY
JP2	.000000	83.272640	INFINITY
JP3	.000000	26.610900	INFINITY
PRDFVVA1	.000000	INFINITY	8.841574
PRDFVVA2	.000000	INFINITY	8.808006
PRDFVVA3	.000000	1.739024	INFINITY
PRDFVVA4	.000000	INFINITY	8.319036
PRDFVVA5	.000000	INFINITY	8.576325
PRDFNVA1	.000000	INFINITY	53.350000
PRDFNVA2	.000000	INFINITY	55.000000
PRDFNVA3	.000000	1.206097	.913337
PRDFNVA4	.000000	INFINITY	50.197020
PRDFNVA5	.000000	INFINITY	51.749500
PRDFVOG1	.000000	INFINITY	8.478337
PRDFVOG2	.000000	1.472230	INFINITY
PRDFVOG3	.000000	INFINITY	7.835794
PRDFVOG4	.000000	INFINITY	7.977268
PRDFVOG5	.000000	INFINITY	8.223987
PRDPAT1	.000000	53.221800	9.235786
PATUR	.000000	INFINITY	29.364430
PRDPAT2	.000000	14.783830	9.377515
PRDPAT3	.000000	14.783830	9.163081
PRDPAT4	.000000	33.263630	8.689952
PRDPAT5	.000000	INFINITY	8.958713
PRDENVA1	.000000	INFINITY	14.493800
PRDENVA2	.000000	INFINITY	14.462340
PRDENVA3	.000000	.260169	.346364
PRDENVA4	.000000	INFINITY	13.637220
PRDENVA5	.000000	INFINITY	14.058980

PRDENMS1	.000000	INFINITY	21.722880
PRDENMS2	.000000	INFINITY	22.394720
PRDENMS3	.000000	INFINITY	23.087340
PRDENMS4	.000000	1.497084	.933893
PRDENMS5	.000000	INFINITY	21.071190
PRDENSG1	.000000	INFINITY	15.503730
PRDENSG2	.000000	INFINITY	15.657020
PRDENSG3	.000000	INFINITY	14.997820
PRDENSG4	.000000	.242812	INFINITY
PRDENSG5	.000000	INFINITY	15.038620
PRDBRG1	.000000	INFINITY	15.078540
PRDBRG2	.000000	1.801995	.700383
PRDBRG3	.000000	2.522794	.980536
PRDBRG4	.000000	INFINITY	14.187400
PRDBRG5	.000000	INFINITY	14.626180
PRDLUZ1	.000000	INFINITY	14.281200
PRDLUZ2	.000000	INFINITY	14.056080
PRDLUZ3	.000000	19.479150	12.153480
PRDLUZ4	.000000	19.479150	INFINITY
PRDLUZ5	.000000	INFINITY	13.852770
PRDPAL1	.000000	INFINITY	29.100000
PRDPAL2	.000000	INFINITY	30.000000
PRDPAL3	.000000	INFINITY	30.927830
PRDPAL4	.000000	4.992285	6.394397
PRDPAL5	.000000	INFINITY	28.227000
CFVVA1	.000000	INFINITY	8.841574
TFVVA12	.000000	8.841574	INFINITY
CFVVA2	.000000	INFINITY	8.808006
TFVVA23	.000000	8.808006	INFINITY
CFVVA3	.000000	1.739024	8.004237
TFVVA34	.000000	8.004237	INFINITY
CFVVA4	.000000	INFINITY	8.319036
TFVVA45	.000000	8.319036	INFINITY
CFVVA5	.000000	INFINITY	8.576325
TFVVA51	.000000	8.576325	INFINITY
TFNVA51	.000000	1.281854	.970706
CFNVA1	.000000	14.183300	1.893661
TFNVA12	.000000	1.321499	1.000728
CFNVA2	.000000	14.343730	1.798721
TFNVA23	.000000	6.308887	INFINITY
CFNVA3	.000000	5.802140	9.326178
TFNVA34	.000000	1.206097	.913337
CFNVA4	.000000	13.345070	1.781745
TFNVA45	.000000	1.243399	.941585
CFNVA5	.000000	13.757810	1.836852
CFVOG1	.000000	INFINITY	8.478337
TFVOG12	.000000	8.478337	INFINITY
CFVOG2	.000000	1.472230	8.481507
TFVOG23	.000000	8.481507	INFINITY
CFVOG3	.000000	INFINITY	7.835794
TFVOG34	.000000	7.835794	INFINITY
CFVOG4	.000000	INFINITY	7.977268
TFVOG45	.000000	7.977268	INFINITY
CFVOG5	.000000	INFINITY	8.223987

TFVOG51	.000000	8.223987	INFINITY
CFVPAT1	.000000	53.221800	9.235786
TPAT12	.000000	9.235786	INFINITY
CFVPAT2	.000000	14.783830	9.377515
TPAT23	.000000	9.377515	INFINITY
CFVPAT3	.000000	14.783830	9.163081
TPAT34	.000000	9.163081	INFINITY
CFVPAT4	.000000	33.263630	8.689952
TPAT45	.000000	8.689952	INFINITY
CFVPAT5	.000000	INFINITY	8.958713
TPAT51	.000000	8.958713	INFINITY
TENVA51	.000000	.000001	.000001
CENVA1	.000000	.000001	.000001
TENVA12	.000000	.465325	INFINITY
CENVA2	.000000	.479716	1.234243
TENVA23	.000000	1.234243	INFINITY
CENVA3	.000000	.603463	.968415
TENVA34	.000000	.424688	.346364
CENVA4	.000000	.000001	.357077
TENVA45	.000000	.437822	.000001
CENVA5	.000000	3.523389	.000001
TMS51	.000000	.000003	.000002
CENMS1	.000000	.000003	.000002
TMS12	.000000	1.485011	.650476
CENMS2	.000000	1.710836	.835544
TMS23	.000000	1.530938	2.569898
CENMS3	.000000	1.578287	2.649379
TMS34	.000000	2.648281	INFINITY
CENMS4	.000000	.000002	.933893
TMS45	.000000	1.397246	.000002
CENMS5	.000000	1.855406	.000003
TSG51	.000000	.000001	.000001
CENSG1	.000000	.000001	.000001
TSG12	.000000	.316419	INFINITY
CENSG2	.000000	.326206	1.109139
TSG23	.000000	1.109139	INFINITY
CENSG3	.000000	1.143443	.410355
TSG34	.000000	.410355	INFINITY
CENSG4	.000000	.242812	.000001
TSG45	.000000	.000001	INFINITY
CENSG5	.000000	.000001	INFINITY
CFVBRG1	.000000	INFINITY	15.078540
TBRG12	.000000	15.078540	INFINITY
CFVBRG2	.000000	1.801995	.700383
TBRG23	.000000	14.844500	INFINITY
CFVBRG3	.000000	2.522794	.980536
TBRG34	.000000	12.848570	INFINITY
CFVBRG4	.000000	INFINITY	14.187400
TBRG45	.000000	14.187400	INFINITY
CFVBRG5	.000000	INFINITY	14.626180
TBRG51	.000000	14.626180	INFINITY
CFVLZ1	.000000	INFINITY	14.281200
TLZ12	.000000	14.281200	INFINITY
CFVLZ2	.000000	INFINITY	14.056080

TLZ23	.000000	14.056080	INFINITY
CFVLZ3	.000000	19.479150	12.153480
TLZ34	.000000	12.153480	INFINITY
CFVLZ4	.000000	19.479150	13.437180
TLZ45	.000000	13.437180	INFINITY
CFVLZ5	.000000	INFINITY	13.852770
TLZ51	.000000	13.852770	INFINITY
TPAL51	.000000	3.657362	1.699064
CFNPAL1	.000000	1.893661	INFINITY
TPAL12	.000000	3.770477	1.751612
CLTPAL1	.000000	29.100000	1646.752000
CFNPAL2	.000000	1.798721	INFINITY
TPAL23	.000000	3.441213	638.939900
CLTPAL2	.000000	30.000000	658.700900
CFNPAL3	.000000	9.326178	INFINITY
TPAL34	.000000	3.547642	INFINITY
CLTPAL3	.000000	30.927830	658.700900
CFNPAL4	.000000	1.781745	INFINITY
TPAL45	.000000	3.547642	1.648092
CLTPAL4	.000000	27.380190	1646.752000
CFNPAL5	.000000	1.836852	INFINITY
CLTPAL5	.000000	28.227000	1646.752000
BOVP	.000000	INFINITY	285.842900
BOVC	.000000	INFINITY	187.562400
OVIN	.000000	INFINITY	32.935050
JT3	.000000	5.315658	5.864338
JT2	.000000	11.824720	INFINITY
JT1	.000000	68.546610	INFINITY
IRRSEC	.000000	44.879330	37.596400
ENAVI	.000000	169.500000	INFINITY

RIGHTHAND SIDE RANGES

ROW	CURRENT RHS	ALLOWABLE INCREASE	ALLOWABLE DECREASE
BLEDUR	.000000	INFINITY	30000.000000
BLETDR	.000000	INFINITY	83588.110000
ORGE	.000000	INFINITY	42241.500000
AUTCER	.000000	INFINITY	19481.000000
FEVE	.000000	INFINITY	2100.000000
BETTERAV	.000000	INFINITY	223989.700000
TOMATE	.000000	INFINITY	.000000
PASTEQUE	.000000	.000000	14900.630000
POMTERRE	.000000	INFINITY	68145.000000
PIMENT	.000000	.000000	1907.719000
SUPERBD	.000000	INFINITY	12500.000000
SUPERBT	.000000	INFINITY	20154.400000
SUPEROG	.000000	INFINITY	15645.000000
SUPERAU	.000000	8855.000000	15645.000000
SUPERFV	.000000	INFINITY	3000.000000
SUPERBS	.000000	INFINITY	4977.550000
SUPERTM	.000000	INFINITY	.000000
SUPERPQ	.000000	INFINITY	.000000
SUPERPDT	.000000	INFINITY	6490.000000
SUPERPM	.000000	INFINITY	.000000

SUPRVRT	.000000	INFINITY	1878.981000
SUPERFN	.000000	INFINITY	13153.610000
SUPEREN	.000000	INFINITY	18700.460000
SUPERPAT	.000000	INFINITY	.000000
RFVVA1	.000000	102857.200000	.000000
RFVVA2	.000000	134866.700000	.000000
RFVVA3	.000000	.000000	.000000
RFVVA4	.000000	119711.600000	.000000
RFVVA5	.000000	122552.200000	.000000
RFNVA1	.000000	INFINITY	.000000
RFNVA2	.000000	INFINITY	.000000
RFNVA3	.000000	INFINITY	38155.590000
RFNVA4	.000000	INFINITY	.000000
RFNVA5	.000000	INFINITY	.000000
RFVOG1	.000000	121904.800000	.000000
RFVOG2	.000000	.000000	500640.000000
RFVOG3	.000000	50802.070000	.000000
RFVOG4	.000000	141880.400000	.000000
RFVOG5	.000000	145247.100000	.000000
RFVPAT1	.000000	204753.900000	3636.000000
RFVPAT2	.000000	232660.300000	14544.000000
RFVPAT3	.000000	91443.730000	14544.000000
RFVPAT4	.000000	134098.800000	6060.000000
RFVPAT5	.000000	140158.800000	.000000
RENVA1	.000000	65828.620000	.000000
RENVA2	.000000	85505.350000	.000000
RENVA3	.000000	139423.600000	73076.380000
RENVA4	.000000	135240.900000	.000000
RENVA5	.000000	131183.700000	.000000
RENMS1	.000000	182846.000000	.000000
RENMS2	.000000	168166.000000	.000000
RENMS3	.000000	80212.050000	.000000
RENMS4	.000000	194331.000000	336860.500000
RENMS5	.000000	188501.100000	.000000
RENSG1	.000000	96806.780000	.000000
RENSG2	.000000	112801.900000	.000000
RENSG3	.000000	40342.820000	.000000
RENSG4	.000000	.000000	495082.900000
RENSG5	.000000	99800.800000	.000000
RFVBRG1	.000000	45088.090000	.000000
RFVBRG2	.000000	62141.170000	26305.730000
RFVBRG3	.000000	18789.810000	46974.520000
RFVBRG4	.000000	52476.310000	.000000
RFVBRG5	.000000	53721.520000	.000000
RFVLZ1	.000000	47358.710000	.000000
RFVLZ2	.000000	65321.820000	.000000
RFVLZ3	.000000	19736.060000	.000000
RFVLZ4	.000000	.000000	19736.060000
RFVLZ5	.000000	56426.920000	.000000
RPAILL1	.000000	INFINITY	.000000
RPAILL2	.000000	INFINITY	.000000
RPAILL3	.000000	5793.000000	.000000
RPAILL4	.000000	INFINITY	73116.660000
RPAILL5	.000000	INFINITY	.000000

FVVA1	.000000	.000000	102857.200000
FVVA2	.000000	.000000	134866.700000
FVVA3	.000000	.000000	42864.250000
FVVA4	.000000	.000000	119711.600000
FVVA5	.000000	.000000	122552.200000
FNVA1	.000000	34823.580000	INFINITY
FNVA2	.000000	33778.870000	INFINITY
FNVA3	.000000	38155.590000	INFINITY
FNVA4	.000000	37010.920000	INFINITY
FNVA5	.000000	35900.590000	INFINITY
FVOG1	.000000	.000000	121904.800000
FVOG2	.000000	.000000	155747.000000
FVOG3	.000000	.000000	50802.070000
FVOG4	.000000	.000000	141880.400000
FVOG5	.000000	.000000	145247.100000
FVPAT1	.000000	3636.000000	204753.900000
FVPAT2	.000000	14544.000000	232660.300000
FVPAT3	.000000	14544.000000	91443.730000
FVPAT4	.000000	6060.000000	134098.800000
FVPAT5	.000000	.000000	140158.800000
ENVA1	.000000	66694.840000	65828.620000
ENVA2	.000000	.000000	85505.350000
ENVA3	.000000	73076.380000	139423.600000
ENVA4	.000000	70884.090000	135240.900000
ENVA5	.000000	68757.580000	131183.700000
ENMS1	.000000	316952.100000	182846.000000
ENMS2	.000000	307443.600000	168166.000000
ENMS3	.000000	298220.300000	80212.050000
ENMS4	.000000	336860.500000	194331.000000
ENMS5	.000000	326754.700000	188501.100000
ENSG1	.000000	.000000	96806.780000
ENSG2	.000000	.000000	112801.900000
ENSG3	.000000	.000000	40342.820000
ENSG4	.000000	.000000	112669.700000
ENSG5	.000000	.000000	99800.800000
FVBRG1	.000000	.000000	45088.090000
FVBRG2	.000000	26305.730000	62141.170000
FVBRG3	.000000	46974.520000	18789.810000
FVBRG4	.000000	.000000	52476.310000
FVBRG5	.000000	.000000	53721.520000
FVLZ1	.000000	.000000	47358.710000
FVLZ2	.000000	.000000	65321.820000
FVLZ3	.000000	.000000	19736.060000
FVLZ4	.000000	.000000	55119.000000
FVLZ5	.000000	.000000	56426.920000
FNPAL1	.000000	68795.470000	INFINITY
FNPAL2	.000000	66731.610000	INFINITY
FNPAL3	.000000	64729.660000	5793.000000
FNPAL4	.000000	73116.660000	INFINITY
FNPAL5	.000000	70923.160000	INFINITY
UF1	.000000	10971440.000000	5758703.000000
MAD1	.000000	598960.100000	658286.100000
MS1	.000000	15624060.000000	INFINITY
FOIN1	.000000	21036.360000	1214.510000

LITIER1	.000000	68795.470000	2416.750000
UF2	.000000	16002650.000000	6401062.000000
MAD2	.000000	384063.700000	960159.200000
MS2	.000000	19789710.000000	INFINITY
FOIN2	.000000	33265.130000	1821.765000
LITIER2	.000000	66731.610000	5793.000000
UF3	.000000	4572187.000000	9005167.000000
MAD3	.000000	645446.400000	274331.200000
MS3	.000000	21037360.000000	INFINITY
FOIN3	.000000	29198.070000	1821.765000
LITIER3	.000000	64729.660000	5793.000000
UF4	.000000	12769240.000000	3771528.000000
MAD4	.000000	603444.400000	766154.100000
MS4	.000000	13973920.000000	INFINITY
FOIN4	.000000	13777.270000	1214.510000
LITIER4	.000000	73116.660000	2416.750000
UF5	.000000	13072240.000000	3941965.000000
MAD5	.000000	617484.700000	784334.100000
MS5	.000000	13493660.000000	INFINITY
FOIN5	.000000	14399.870000	1214.510000
LITIER5	.000000	70923.160000	2416.750000
CONCTR	.000000	19884.000000	INFINITY
MAXBOVP	9825.000000	4365.970000	9825.000000
MAXBOVC	130.000000	4533.561000	130.000000
MAXOVIN	95950.000000	53012.030000	95950.000000
LAITBP	.000000	31047.000000	INFINITY
LAITBC	.000000	289.900000	INFINITY
LAINOV	.000000	287.850000	INFINITY
VIANDBP	.000000	3930.000000	INFINITY
VIANDBC	.000000	41.600000	INFINITY
VIANDOV	.000000	5757.000000	INFINITY
SEMENCBD	.000000	INFINITY	1375.000000
SEMENCBT	.000000	INFINITY	2476.463000
SEMENCOG	.000000	INFINITY	1486.275000
SEMENCFV	.000000	INFINITY	360.000000
SEMENCBS	.000000	INFINITY	74.663250
SEMENCPQ	.000000	INFINITY	.000000
SEMENCPT	.000000	INFINITY	12980.000000
SEMECVT	.000000	INFINITY	46.974520
SEMENCEN	.000000	INFINITY	1646.165000
SEMENCFN	.000000	INFINITY	1336.854000
TERREPF	49000.000000	132683.000000	31290.000000
TERREPM	25000.000000	37027.810000	8597.222000
TERREPO	13000.000000	12674.870000	6643.308000
IRRIGUEE	34000.000000	12674.870000	4134.702000
PATURAGE	12120.000000	194146.600000	12120.000000
LEGUME	3000.000000	3321.654000	3000.000000
AUTCERLS	8855.000000	15645.000000	8855.000000
CULTMARI	6490.000000	9554.231000	6490.000000
CERJCT1	.000000	.000000	6643.308000
CERJCP1	.000000	6643.308000	.000000
CERLEG1	.000000	6643.308000	12674.870000
CERJCT2	.000000	.000000	8597.222000
CERJCP2	.000000	8597.222000	.000000

CERLEG2	.000000	8597.222000	25000.000000
CERJCT3	.000000	31290.000000	31290.000000
CERJCP3	.000000	.000000	31290.000000
CERLEG3	.000000	8855.000000	31290.000000
BRCERLGA	.000000	INFINITY	9955.100000
BRCERLGB	.000000	.000000	3000.000000
CERLEGMI	.000000	11587.050000	.000000
TRAV1	.000000	1344418.000000	INFINITY
TRAV2	.000000	1241703.000000	INFINITY
TRAV3	.000000	617894.600000	INFINITY
TRAV4	.000000	967494.200000	INFINITY
TRAV5	.000000	INFINITY	159219.600000
PERMAIN1	227890.000000	258541.900000	227890.000000
PERMAIN2	341834.000000	238789.100000	341834.000000
PERMAIN3	341834.000000	118825.900000	341834.000000
PERMAIN4	227890.000000	186056.600000	227890.000000
PERMAIN5	227890.000000	INFINITY	30619.150000
TRACTION	.000000	2070953.000000	INFINITY
MOISS	.000000	152217.200000	INFINITY
AMMONITR	.000000	14183580.000000	INFINITY
SUP45	.000000	9441321.000000	INFINITY
POTASSE	.000000	3361978.000000	INFINITY
DESHERB	.000000	1850.664000	INFINITY
EAU	.000000	16194.250000	49643.260000
EAUC	150.000000	16.194250	49.643260
SUPERBET	.000000	17666.460000	32034.780000

Annex 9:

Impacts of Alternative Policies on Cultivated Area by Crop and Land Type, North West Public Sector

	Base Case	Eliminate Fertilizer Subsidies	Eliminate Water Subsidies and Quotas
Model simulated	A	B	C
Irrigated land:			
Bread wheat	11,587	11,587	11,576
Sugar beets	4,978	4,978	5,667
Potatoes	6,490	6,490	6,490
Bersim ray-grass	1,879	1,879	1,890
Maize ensilage	4,932	4,932	3,573
Sorghum ensilage	-	-	4,803
Flat bottom land:			
Bread wheat/legume[a]	8,567	8,567	6,500
Fava beans	3,000	3,000	5,272
Vetch-oats ensilage	5,567	5,567	1,228
Moderately sloping land:			
Durum wheat/legume	12,500	12,500	12,500
Vetch-oats hay	4,299	4,299	12,500
Vetch-oats ensilage	8,201	8,201	-
Steeply sloping land:			
Barley/worked fallow	15,645	15,645	15,645
Other cereals/legume	8,855	8,855	8,855
Vetch-oats hay	8,855	8,855	8,855
Worked fallow	15,645	15,645	15,645

a. Cereal/legume corresponds to a two-year rotation of a cereal after a legume. Thus, in the base case on flat bottom land, 8,567 ha of bread wheat must be accompanied by 3,000 ha of fava beans and 5,567 ha of vetch-oats ensilage. The location of the respective crops are reversed the following year.

Annex 9:

Impacts of Alternative Policies on Cultivated Area by Crop and Land Type, North West Public Sector (Continued)

	Base Case	Reduce Size of Permanent Work Force	Eliminate Production Quotas	All Scenarios Combined
Model simulated	A	D	E	F=B+C+D+E
Irrigated land:				
Bread wheat	11,587	11,587	0	
Sugar beets	4,978	4,978	0	
Potatoes	6,490	6,490	30,688	32,402
Peppers	0	0	351	0
Bersim ray-grass	1,879	1,879	0	0
Maize ensilage	4,932	4,932	2,961	1,598
Sorghum ensilage	0	0	0	0
Flat bottom land:				
Bread wheat/legume[a]	8,567	8,567	6,500	6,500
Fava beans	3,000	3,000	3,000	3,000
Vetch-oats ensilage	5,567	5,567	3,500	3,500
Moderately sloping land:				
Durum wheat/legume	12,500	12,500	12,500	12,500
Vetch-oats hay	4,299	4,299	0	0
Vetch-oats ensilage	8,201	8,201	12,500	12,500
Steeply sloping land:				
Barley/worked fallow	15,645	15,645	0	0
Barley/legume	0	0	10,066	9,644
Other cereals/legume	8,855	8,855	8,855	8,855
Vetch-oats hay	8,855	8,855	13,046	18,499
Vetch-oats ensilage	0	0	5,875	0
Barley green forage	0	0	11,158	12,002
Worked fallow	15,645	15,645	0	0

a. Cereal/legume corresponds to a two-year rotation of a cereal after a legume. Thus, in the base case on flat bottom land, 8,567 ha of bread wheat must be accompanied by 3,000 ha of fava beans and 5,567 ha of vetch-oats ensilage. The location of the respective crops are reversed the following year.