A VERTICALLY INTEGRATED PROJECTIONS SYSTEM FOR AGRICULTURAL LAND USE PLANNING *

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During the 1960's, public agencies became increasingly interested in comprehensive planning for the use, management, and development of the nation's water and related land resources. Research conducted by these agencies primarily focused on water due to the interstate character of water resources, existing legislative mandates and the early association of environmental concerns with water-related externalities.[1] The major objectives of this effort were the development of principles and standards for multiple objective planning and evaluation and the development of regional economic projections. These economic projections, their underlying data base, and supporting analytical systems are designed to serve two purposes: "First, they are an essential input for estimating the demands for water and related land. Secondly, they constitute a framework for estimating the economic effects of specified water constraints and of alternative programs for developing and managing the Nation's land and water resources" [Water Resources Council, 1972b, p.5]. Despite the fact that this research has been water-related and that the land use planning problem is institutionally local rather than regional, the principles and standards developed for multiple objective planning and evaluation are sufficiently general that the knowledge gained may be applied to questions of land use.

The purpose of this paper is to synthesize previous agricultural projections research into a single projections and land use information system. The paper presents a conceptual version of such a system and establishes a possible linkage of national projections to small area land use planning problems and benefit-cost analyses.[2]

Some of the current research issues in agricultural land use planning and policy have been identified as:

1. the adequacy of the land resource base to meet future food and fiber requirements;
2. the impact of the conversion of land presently in agricultural use to non-agricultural uses;
3. the need for economic criteria as inputs in agricultural land use planning decisions and policy analysis [Economic Research Service, 1975].

Each of these research issues requires an information system and projections for solution. The information system should include the biophysical and socioeconomic characteristics of the resource base, the current pattern of resource use, the current production of goods and services from that resource base, the future supply of resources without the plan, the future demand for goods and services, the resulting future needs without the plan and the alternative allocations of resources that could meet future needs with and without the plan [McKusick, et al., 1973]. The required projections should be made for the small area,[3] the relevant focus of the land use planning problem. Projections should relate to the "demand" for resources and reflect comparative advantage within the economic system. The effects of interregional competition on prices, efficiency and equity have to be related to the benefits and costs of small area projects, programs, land and water use plans. Thus it is useful to vertically disaggregate the nation into a system of regions within regions. Each of these subsystems of information may then be linked via a mathematical programming model which would generate the "optimal" economic values required in small area studies.

At the present time, the projections employed in water and related land resource planning are the OBERS series (jointly developed by the Economic Research Service (ERS) and the former Office of Business Economics). Projections of regional economic activity by Water Resource Subareas (WRSA) have been made throughout the United States (e.g., California was subdivided into 10 WRSA). One purpose of these projections is the creation of a nationally consistent data base which can be used in river basin or regional studies as a baseline to determine National Economic

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[1] See the work of the Water Resources Council [1970a, 1970b, 1970c, 1972a, 1972b, 1973, 1974].

[2] This paper builds upon and suggests extensions of agricultural projections research conducted under Professor Harold O. Carter and the river basin planning research conducted by the California-USDA-ERS River Basin Planning Staff.

[3] The Public Law 566 limitation of 250,000 acres or less is used as a reference point for the small area.

Development (NED) and Regional Development (RD) values of goods and services in the context of "with" and "without" program or project analyses. While the definitions of the WRSA are not necessarily mutually consistent with the delineation of political and planning authority, integrated resource planning requires a common regional specification. In particular, the small area may be considered to be a subarea of the WRSA.

The projections are primarily need oriented. They are developed as national requirements to meet specific per capita consumption, population, and import-export assumptions. Since these are not national demand estimates, little consideration has been given to price and income elasticities. The region's baseline is determined by the historical trend in market share which is a function of past economic variables, including resource development. The influence of past resource development on the baseline has been recognized by ERS [U.S. Department of Agriculture, 1974] but it is virtually impossible to separate project or program effects over time.

The OBERS projections, however, are not unique in the lack of economic content, the absence of linkages between national, regional, and small areas, and the failure to develop specific price, cost, and income data for benefit–cost studies. A review of the projections literature does not reveal any direct relationship or interaction between national level projections and small area benefit-cost and analyses.[4] Consequently, a sounder theoretical economic basis must be introduced into projections models in order to generate economic criteria for agricultural land use planning. Projection model parameters must be linked to economic variables. Projections of per capita consumption should be based on the underlying demand structure reflecting price and income elasticities. Projected regional shares of national production should reflect anticipated production cost, projected yield, and return differentials between regions. The relationship between yield and production uncertainties needs to be established by crop and region. State and subbasin acreage projections need to be related to the specific resource endowment. National, regional and small area goals and objectives should be reflected in the projected land use patterns in order to make the opportunity costs of alternative actions affecting land and water use explicit.

A conceptual flow chart of the proposed vertically integrated projections system is formulated in Figure 1. The system is hierarchically divided into three levels of aggregation. The national level is that part of the system associated with the projection of national demand requirements and national–level parameters. Existing agricultural projections research has generally been foucused at the national level. The basic procedure to project national demand requirements utilizes the methodology employed by Culver and Chai [1970] with modifications.[5]

The regional level of the projections system includes the disaggregation of the national projections to the regional level, the derivation of implied resource requirements and a regional crop price forecasting model. The basic analytical framework for the disaggregation of national demand requirements to the regional level is taken from Dean, et al, [1970]. Their disaggregation procedure centers about the projection of the regional share of national production, based on trend analysis and expert opinion.[6] The projected regional share is then applied to the projected national demand requirements to generate a projection of regional demand requirements. The next step is to project regional yields which can be used to determine the projected regional acreage requirements implied by those demand requirements. The procedures applied in the projection of yields are entirely analogous to those described for share projection. Bullock and Carlson [1973] applied the Delphi procedure in the case of projecting yeilds in North Carolina. Quance, et al, [1971] have developed a yield simulator. Trend analysis could be used to project the percentage of regional acreage that is irrigated and, subsequently, regional irrigated acreage. This procedure follows that of Dean, et al, [1970]. The last major element of the regional component of the model is the regional crop price forecasting model. A simple price forecasting model as employed by McKusick [1973] or detailed econometric studies such as McKusick [1973], Kip and King [1970], or Lyons [1968] could be used to determine prices based on predetermined quantities.

The last level is that focusing on the subbasin and small area. Regional information is related to the small area to generate projections of production and resource requirements and economic land use information. Subbasin crop yields could be projected by the same techniques employed at the regional level. The land resource endowment of the subbasin could be inventoried and coded according to

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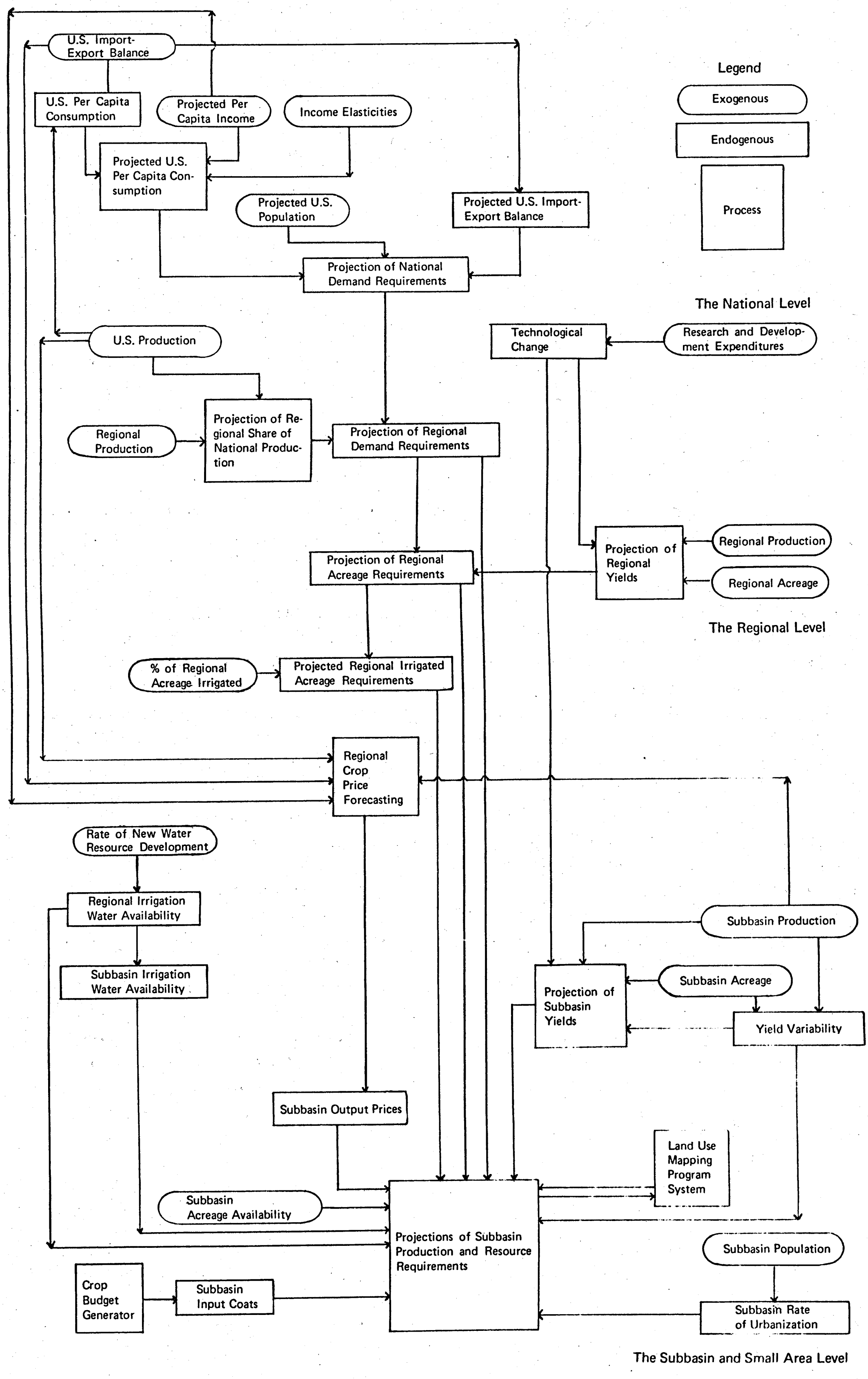
[4]Projections research at the national level has been conducted by Barton and Rogers [1956], Daly [1956], Daly and Egbert [1966], Mayer and Heady [1969], Culver and Chai [1970], McFarquhar [1971], and the Water Resources Council [1972, 1974]. At the regional or state level Dean and McCorkle [1961]; Schaller and Dean [1965]; Lee [1967]; Casler [1970]; Dean, et al [1970]; Shumway, et al [1970]; Bullock and Carlson [1963]; and the State of California [1974] have produced projections studies. Any linkage to small areas beyond hydrologic subregion has generally been avoided. The Soil Conservation Service has stated that "OBERS projections will not be used as a constraint on NED (National Economic Development) in developing Level C (implementation) plans until such time as OBERS user guidelines are developed by the WRC which allow for reliable disaggregation of projected data and have been used for the current Level B study (river basin or regional) which covers the Level C area" [USDA, SCS, 1975, p. 14].

[5]Dean and King [1970] have projected per capita consumption using the projected change in per capita income and the individual commodity income elasticities. George and King [1971] have developed a methodology for the estimation of demand parameters. Techniques for the projection of import-export balances have been discussed by Rojko [1973] and Abel [1974].

[6]Alternative procedures include the Delphi technique pioneered by Helmer [1966], the use of Bayesian analysis in which expert option formulated on a probabilistic basis could be used as a subjective prior to modify the information contained in the trend analysis, and the internally consistent share model developed by Burnham [1972].

Fig. 1. A vertically integrated projections system for agricultural land use planning



Soil Conservation Service land use capability classifications or by the Soil Resource Groups currently being used in river basin studies. A system of land use mapping programs developed by Johnston and Thorpe [1974] could be employed to digitize this information. Subbasin population projections could be employed to project the rate of subbasin urbanization according to the methodology outlined by Shumway, et al. [1970]. A crop budget simulator based on the work of Walker and Kletke [1972] has been developed by the California - USDA - ERS River Basin Planning Staff. The simulator could be used to relate soil, water, fertilizer, and energy inputs to subbasin production costs.

The linkage between the projections system and the land use information system may be accomplished through a recursive programming model as developed by Henderson [1959] and applied by Day [1963] and Schaller and Dean [1965]. The projections system and the land use mapping system generate constraints and coefficients for use in the recursive programming (RP) model. Figure 1 details the flow of information to the RP model (described as projections of sub - basin production and resource requirements) from the rest of the system. The most critical element of the RP model is the estimation of flexibility coefficients. Miller [1972] and Sahi and Craddock [1974] have suggested a number of alternative estimation procedures which would have to be assessed. Once the constraints and initial conditions are supplied to the RP model, it could be run over a variable time horizon. Outputs from the model would be: (1) sub - basin supply response; (2) prices of projected output; (3) levels of resource utilization; (4) resource shadow prices; (5) an analysis of crop profitability; (6) the spatial pattern of production and resource utilization within the sub - basin; (7) identification of binding system constraints; and (8) sensitivity and parametric analyses. These outputs may be employed in the development and evaluation of land use plans and/or benefit-cost analyses.

The resource inventory developed by the USDA-ERS California River Basin Planning Staff has organized the land resources of the study area into Soil Resource Groups which are further subdivided into qualitative categories (e.g., poorly, partially, and adequately drained). From the optimization model, shadow prices for each of these categories corresponding to alternative national and regional projections (OBERS and California Department of Water Resources) and regional price forecasts are generated. These shadow prices could be used in small area studies, e.g., Watershed Investigation Reports (PS-566) to estimate benefits and costs which reflect some measure of interregional competition. Although these shadow prices would not fully account for the user cost associated with intertemporal dependencies in resource allocation decisions, one advantage of their use is that market shares do not have to be employed to disaggregate the requirements projections beyond the regional level. It is our feeling that small area studies should not use a market share approach to derive the economic values necessary for project, program, or planning analysis but rather should rely on river basin or regional models for such values. Small area shares may be so small that rounding error would be a significant problem. There is also a greater range of spatial production substitution possibilities between small areas than between regions. Small area supply response is particularly difficult to estimate due to unique resource problems and unique microclimatic conditions.

We have attempted to demonstrate how existing and anticipated projections research may be synthesized to provide a linkage between projections and land use information systems. Such a linkage, we feel, shows a need for regional crop forecasting and programming models which can generate economic values of resources and commodities for use in small area land use planning and benefit - cost analyses. Through the use of simulation, planners' subjective attitudes as to alternative futures, goals, restraints, and plans could be combined with economic and physical variables and analyses to enhance the total planning process.

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