FOOD SECURITY AND FARMLAND PRESERVATION

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I. INTRODUCTION

The World Food Summit held in Rome in November 1996 reinvigorated interest in food security and, indirectly, farmland preservation due to its contribution to food security. However, food security is only one dimension of farmland protection. Farmland also has scenic, wildlife, recreation, and open space benefits sometimes referred to as rural amenities. Urban sprawl compromises these amenity benefits (rural greenfields) while sometimes leaving behind abandoned buildings and empty lots referred to as urban brownfields. Law and economics professionals are challenged to create public policy options protecting rural areas while diminishing urban brownfields. Key questions regarding farmland preservation include the following: What is the proper role of the market and public policy in allocating land for agricultural versus other uses? What is the magnitude of agricultural land loss to other uses? What are the sources of the loss? Is the loss mainly due to urban encroachment or the lack of demand for land to produce crops and livestock? What

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is likely to be the future demand for farmland based on long-term trends in food demand and supply? How important is maintaining land in agriculture as an option to respond to future world food needs? What are appropriate public policies for long-term preservation of land for agriculture?

II. WHAT IS THE PUBLIC INTEREST IN PRIVATE PROPERTY?

This nation has relied on markets and public policies to allocate land among its many uses. Markets work best to allocate land to its highest and best use when incremental private costs incurred by market participants align with social costs accruing to society. Values of rural landscapes that do not enter the monetary accounting of land buyers and sellers are referred to as externalities. Reliance on private markets alone does not recognize externalities in pricing, and does not properly protect agricultural land from loss to development.

Society has long recognized that agricultural land has value for the following environmental uses in addition to crop and livestock production: ecological services, such as water quality; habitat services, such as wildlife for species preservation, hunting, or bird watching; and amenity services, such as a bucolic scene of grazing livestock, quilted crop rotations, or contoured hills.[1] The value of environmental benefits is illustrated by outlays for restoring strip-mined land where crops had once been. Costs of private back-filling and revegetation mandated by government to restore basic topography and productivity for agriculture in the late 1970s averaged over $18,000 per acre in Appalachia, $16,000 per acre in the Midwest, and $17,000 per acre in the West.[2] These costs, over twenty times the value of land for agricultural production, imply huge environmental benefits from land. Though the magnitude of the ratio of environmental to agricultural value strains credulity and may imply political failure, even allowing for considerable error in public choice the price paid implies a very high environmental value for cropland.

Permanent grazing or forest land would appear to have greater environmental benefits than cropland. Researchers and analysts, Dennis T. Avery and Alex Avery, contend that the optimal strategy for global food security is intensive production of crops and livestock on non-fragile lands, thereby safeguarding fragile lands for wildlife, recreation, and beauty.[3]

More recently, interest has revived in the option value of cropland—avoiding conversion of cropland to low-value irreversible non-crop uses. For example, development sprawl onto rural lots "too big to mow and too small to sow," diminishes land available for future generations. Markets best reflect use value for

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1. *See* Dan Bromley, *Agricultural Land as an Environmental Asset, in* HANDBOOK OF AGRICULTURAL ECONOMICS (Bruce Gardner & Gordon Rausset eds., forthcoming 1998).

2. *See* NATIONAL RESEARCH COUNCIL COMMITTEE ON SOIL AS A RESOURCE, SURFACE MINING: SOIL, COAL, AND SOCIETY 183-200 (1981).

3. *See* DENNIS T. AVERY & ALEX AVERY, FARMING TO SUSTAIN THE ENVIRONMENT 3-5 (Hudson Institute Briefing Paper Herman Kahn Center No. 1, 1996).

market participants. The price system imperfectly accounts for the option value or existence value of rural amenities and farmland preserved production capacity. By preventing irreversible built-up uses, land will be available for future generations when needs for food and open spaces might be greater.

Those landowners who hold cropland for a time when higher food prices will reward them, face much risk. Private firms demand a high return to compensate for that risk. Will the private sector alone adequately insure against the rare multiyear cycle of poor crop conditions especially afflicting poor countries? Because the government is involved in many risky investments, the law of averages reduces risk and, hence, the cost of capital. Low cost of capital raises the chances that higher food prices eventually will compensate for holding cropland. Although willingness to pay may be a good measure of the public or private commitment to preserve cropland, government failure to correctly decide such issues is at least as frequent as private market failure.

Although people will pay for option value because they might use amenities later or will pay for existence value even if they never plan to directly use the amenities, in many instances no market or public program exists at acceptable transaction cost where they can vote with dollars for preservation. "Free rider" problems add to the market failure. Any individual desiring to preserve farmland and rural landscapes will have an imperceptible impact. That individual, however, will benefit if someone else preserves landscape and farmland. Thus, no individual will act alone but will wait for others to act. Whether the desire to preserve rural amenities, option value for food security, and the high private discount rate justify public intervention in markets to preserve farmland is ultimately a political decision. Some might contend that the only necessary public policy is to stop subsidies to infrastructure and services currently encouraging urban sprawl into the countryside. At any rate, the purpose of this Article is to provide information that will help the public make more informed choices regarding the public interest in private property, and the legal profession translate those public choices into instruments meeting needs for crop land preservation.

III. What is the Magnitude and Sources of Agricultural Land Loss to Other Uses?

For the nation, farmland fell from 1,141.6 million acres in 1945[4] to 945.5 million acres in 1992.[5] This loss averaged 4.2 million acres or 0.4% per year. If losses continued at this rate, the loss would exhaust all farmland in 227 years.

Cropland, which excludes farmland in forest and permanent pasture, displays a very different trend than farmland. The United States had more cropland in 1992 than in 1945.[6] Additional irrigation, drainage, and clearing offset cropland losses to urban development and other uses.

The relatively stable national cropland statistics belie uneven rates of cropland change among states. From 1949 to 1992, cropland loss rates were highest in the eastern states, especially in the extreme northeast where there are large urban populations and much marginal farmland and the extreme southeast which has a rapidly growing urban population and marginal farmland that is better suited for alternative uses such as forest land.[7]

Cropland converted to urban use is of special concern because it is mostly an irreversible shift from agriculture. Of the developed land category in the forty-eight contiguous states, urban areas—(towns and cities with more than 2500 people) residential, business, commercial, and street areas—accounted for only 0.8% of all U.S. land area in 1945, 2.6% in 1982, and 3.1% in 1992.[8]

In the forty-eight contiguous states, developed land (urban areas, recreation, transportation, wildlife, and military use) increased from 168.9 million acres in 1982 to 188.3 million acres in 1992, an average of 1.94 million acres or 1.1% per year.[9] Urban land increased from 49.6 million acres in 1982 to 58.0 million acres in 1992, an average of 0.84 million acres per year or 1.6% per year.[10]

Cropland fell by 920,000 acres per year or 0.20% per year between 1982 and 1992.[11] Thus, only approximately 377,400 acres per year, or 41% of this loss, was to

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4. *See* Economics and Statistics Admin., U.S. Dep't of Commerce, 1945 Census of Agriculture 5 (1947).

5. *See* Economics and Statistics Admin., U.S. Dep't of Commerce, 1992 Census of Agriculture 8 (1994).

6. *See* U.S. Dep't of Agric., Agricultural Handbook No. 712, Agricultural Resources and Environmental Indicators, 1996-97 3 (1997).

7. *See* Luther Tweeten, Ohio State University, Competing for Scarce Land: Food Security and Farmland Preservation 25 (Dep't. of Agric., Envtl., & Dev. Econ. Occasional Paper ESO 2385, 1998).

8. *See* U.S. Dep't of Agric., Agricultural Handbook, No. 712, Agricultural Resources and Environmental Indicators, 1996-97 3 (1997).

9. *See id.*

10. *See id.*

11. *See* U.S. Dep't of Agric., Agric. Handbook No. 712, Agric. Resources and Envtl. Indicators 3 (1997).

urban development in the decade in the forty-eight contiguous states.[12] If urban use were the only claimant on the 460 million acres of cropland in 1992 such land would last 1200 years.

Highways, parks, wetlands, recreation, wildlife, rangeland, pastureland, forest land, water reservoirs, and military land use account for the bulk of cropland loss. Many of these uses are more reversible than the conversion of cropland to urban use.

The topography of prime farmland lowers infrastructure costs for development and makes such land a tempting target for development. Fortunately, much of the nation's urban expansion is not in agricultural regions. Sources of acres converted to urban use from 1982-1992 were as follows:[13]

	(Percent)
Forest land	37
Range and pasture land	29
Cropland	28
Other	6
	100

The 28% of urban land from cropland exceeded the 24% of all the nation's land in cropland.[14] However, Economist Ralph E. Heimlich, and Professor Nelson L. Bills noted that only 48% of the converted cropland was classified as prime cropland.[15] The proportion of prime cropland for urban use was lower than the proportion of prime cropland in the nation, hence urban areas made relatively more use of nonprime than of prime cropland.[16] Five additional studies reviewed by Heimlich and Bills showed no consistent relationship between land quality and urbanization.[17]

12. *See* NATURAL RESOURCES AND ENV'T DIV., U.S. DEP'T OF AGRIC., MAJOR LAND USE CHANGES IN THE CONTIGUOUS 48 STATES (Updates on Agricultural Resources and Environmental Indicators No. 3, 1997).

13. *See* Ralph E. Heimlich & Nelson L. Bills, Soils in Urbanizing Areas: Changes in Productive Capacity and Limitations for Development, Presentation at the Meeting of the American Agricultural Economics Association 14 (July 27-30, 1997) (transcript on file with the *Drake Journal of Agricultural Law*).

14. *See* U.S. DEP'T OF AGRIC., AGRIC. HANDBOOK NO. 712, AGRIC. RESOURCES AND ENVL. INDICATORS 3 (1997).

15. *See* Ralph E. Heimlich & Nelson L. Bills, Soils in Urbanizing Areas: Changes in Productive Capacity and Limitations for Development, Presentation at the Meeting of the American Agricultural Economics Association 8 (July 27-30, 1997) (transcript on file with the *Drake Journal Agricultural Law*).

16. *See id.*

17. *See id.* at 5.

> Urban development hinges on location relative to existing population and employment centers and institutional factors and is not significantly affected by soil quality for agricultural production. . . . Thus, developers will not incur significantly higher costs if zoning and other institutional tools are used to direct them toward less productive ag land, as long as it is located in close proximity to the same population and employment centers as more productive land.[18]

Two broad "generic" forces work to influence this loss of cropland. First, greater profitability of farming and numbers of people on farms create demand for cropland, raise land prices, and retain or expand land in agriculture. The second force is nonfarm development in broad terms, creating demands for cropland to convert to urban and other build-up uses. Thus, the area in cropland is the result of the interaction between farm and nonfarm forces. At issue is whether lack of demand for land for farm use caused by low farm profitability, and falling farm population, as opposed to high demand for development use, caused by high development profitability and rising nonfarm population, is the major cause of farmland loss.

The contribution of farm and urban influences to cropland conversion was estimated from cross sectional data by state for agricultural census years from 1949 to 1992.[19] Changes in cropland acres by state were estimated by multivariate statistical analysis as a function of changes in farm population per square mile, urban population per square mile, and the ratio of gross farm income per person on farms to per capita income in the state.[20] The theory is that a rising ratio of farm income per capita to income of all state residents per capita, or a rising farm population would tend to keep more cropland in farming.[21] Alternatively, a rising ratio of income of all state residents per capita relative to farm income per capita and a rising urban population would convert cropland to other uses.[22]

The proportion of cropland loss due to farm causes, such as a lack of ability of farmers to compete for more land, was calculated by multiplying the change in independent variables between 1949 and 1992 times their respective statistical coefficients.[23] This predicted change in cropland acres due to farm variables (farm population and per capita farm income relative to per capita state income) was then expressed as a percent of the predicted change in total cropland from 1949 to 1992 from the statistical equation.[24] "The farm share for the United States, that is the

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18. *Id.* at 13.

19. *See* LUTHER TWEETEN, OHIO STATE UNIVERSITY, COMPETING FOR SCARCE LAND: FOOD SECURITY AND FARMLAND PRESERVATION 25 (Dep't of Agric., Envtl., & Dev. Econ. Occasional Paper ESO 2385, 1998).

20. *See id.*

21. *See id.*

22. *See id.*

23. *See id.*

24. *See id.*

proportion of the cropland change predicted from the change in farm income and population, was 74%."[25] The urban share, that is the proportion of the cropland change predicted from the change in overall state income per capita and urban population, was 26% for the United States.[26]

The implication of this modest statistical analysis is that lack of farm economic viability rather than urban encroachment was the principal reason for cropland loss. This result is consistent with the earlier finding that principal cropland losses have been to forest, grazing, recreation, wildlife, and other uses rather than to urban development.

It would be tempting to conclude that the best way to hold cropland in farming is to raise farm commodity prices. The following analysis suggests that favorable economic conditions may hold cropland in current use in the next few decades better than did the less favorable economic conditions of recent decades. But government interventions to improve the farm economy's attractiveness through price supports or transfer payments would be a prohibitively costly policy to preserve farmland.

IV. Will Cropland Have High Value in the Future?

The future is inscrutable, but we can gain perspective by examining pressures on the land resource from trends in global food supply and demand. Historic global yield and area trends for five major crops provide the foundation for projections of the future food supply.[27] Grains are of special concern because, through livestock, they directly or indirectly provide over half of all food supplies, because data are more reliable for grains than for other foods, and because grains are pivotal for buffer stocks and for trade. Livestock and livestock products receive less attention in this section because livestock output depends heavily on crop output and because data on livestock productivity trends are meager.

This Article first examines historic and prospective trends in population and income as components of food demand. Then these trends are compared with supply projections to judge the future demand for cropland.

A. *Demand Trends*

Demand for food is driven by two major components—population and income. Population growth is the more important of these two drivers.

Demographers are projecting a dramatic population trend turnaround: The world seems headed for zero population growth (ZPG) in the future after growing

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25. *Id.* at 15.
26. *See id.*
27. *See infra* Table 1.

exponentially for at least two centuries. Progress towards ZPG is apparent in all world regions except Africa.

Overall food demand depends on income as well as population. The most likely scenario is for global aggregate food demand to increase by 0.3% per capita annually on average due to rising incomes. Adding the impact of population growth to income, total demand for food is projected to increase from 144%[28] to 201%[29] from the 1995 level before ZPG is reached. The latter estimate implies that food production will have to triple from 1995 levels before reaching global ZPG. The United Nations medium population projection used in Table 1[30] to project food demand implies a need to increase global food output 2.5 times the 1995 level before achieving ZPG.[31]

B. *Supply of Food*

Global oilseed crop area has expanded, but *net* global area in all crops has remained quite stable since 1960 and is not very sensitive to price. The stable net area hides considerable expansion of cropland by drainage, deforestation, and irrigation offset by losses of cropland to desertification, development, and other uses. Although future demand for land is not explicitly measured in subsequent analysis, readers can infer possible needs for additional cropland based on the imbalance between trends in expected demand for food and expected supply of food from yield gains alone.

Only yield data are shown in Table 1 because global harvested area in each of the five major crop categories, except oilseeds, was almost the same in 1996 as in 1961 and is not expected to change markedly in the future without considerably higher food prices.[32]

1. *Cereals*

Past cereal supply trends display notable characteristics. From 1961 to 1996, global cereal yields expanded around the straight line predicted by Thomas Malthus.[33] The rate of gain averaged 44 kilograms per hectare per year. The linear

28. *See infra* Table 1.

29. *See* EDUARD BOS ET AL., WORLD POPULATION PROJECTIONS 5 (1994-95).

30. *See infra* Table 1.

31. *See* POPULATION DIV., U.N. DEP'T OF ECON. & SOCIAL INFO. & POLICY ANALYSIS, WORLD POPULATION PROSPECTS: THE 1996 REVISION, ANNEX I: DEMOGRAPHIC INDICATORS 11 (1996).

32. *See* Luther Tweeten, *Dodging a Malthusian Bullet in the 21st Century,* 14 AGRIBUSINESS: AN INTERNATIONAL JOURNAL (forthcoming 1998) (manuscript at 10-13, on file with the *Drake Journal of Agricultural Law*).

33. Thomas Malthus, author of *Essay on the Principle of Population*, examined the theory that although food supply could exceed food needs at particular points in history, inevitably population outgrows food supply. *See id.* at 2.

yield line implies declining percentage rates of yield growth. For example, the 3.2% trend growth rate for cereal yield in 1961 fell by half to 1.6% in 1991.[34] If global population continued to grow at the 1.7% annual trend rate of 1990, the portents for world food security would be onerous indeed.[35]

2. *Other Crops*

Yield graphs for other crops also show the linear trends apparent for cereals.[36] In Table 1, projected yields merely are extensions of historic linear yield trends.[37] Yield percentage gains for other crops are lower than for cereals. Like cereals, percentage rates of yield increase were slowing. However, unlike cereals, the rates of gain were not halved between 1961 and 1990.

3. *Livestock*

Data comparable to those for crops in Table 1 are not available for livestock and livestock products. However, livestock only offer limited opportunities to expand productivity of agriculture. They require more resources per calorie of food than do crops. Also, they may offer fewer opportunities for productivity advances than crops. The Office of Technology Assessment projected the following growth rates in American animal production technology from 1982 to year 2000: [38]

	Annual growth (%)		Annual growth (%)
Pounds beef per pound feed	0.2	Pounds pigmeat per pound feed	0.6
Pounds milk per pound feed	0.2	Pounds poultry meat per pound feed	2.0

These yield gains fall short of weighted average crop yield gains shown in Table 1.[39] If these rates are representative of world conditions, they provide little optimism that livestock productivity gains will improve food security. Nonetheless,

34. *See infra* Table 1.
35. *See infra* Table 1.
36. *See* Luther Tweeten, *Dodging a Malthusian Bullet in the 21st Century*, 14 AGRIBUSINESS: AN INTERNATIONAL JOURNAL (forthcoming 1998) (manuscript at 28-36, on file with the *Drake Journal of Agricultural Law*).
37. *See infra* Table 1.
38. *See* OFFICE OF TECHNOLOGY ASSESSMENT, U.S. CONGRESS, OTA-F-285, TECHNOLOGY, PUBLIC POLICY, AND THE CHANGING STRUCTURE OF AMERICAN AGRICULTURE 10 (1986).
39. *See infra* Table 1.

livestock remains an excellent means to utilize land unsuited for crops, provide a buffer for consumption when crops fail, supply high quality protein and other nutrients, and are a favored food as income rises.

C. *Supply-Demand Balance*

To address whether expected demand increases will cause real food prices to rise, Table 1 summarizes demand and supply balances by decade to the year 2050, in which projected rates of supply (yield) gain are merely extensions of the distinct linear yield trends that dominate from 1961 to 1996.[40] Demand projections are medium United Nations population projections plus income gains that are assumed to decline systematically from 0.3% per capita in 1996 to 0.2% per capita in year 2050.[41]

Three supply and demand balance periods characterize data in Table 1.[42] The first period is prior to 1980, when weighted average yield gains on average exceeded demand gains. Real food prices fell sharply and reserve capacity accumulated as diverted acres, storage stocks, and subsidized exports. The trend reversed in the 1980s, but the United States had enough reserve capacity in commodity stocks and diverted acres to avoid rising real food prices. However, real commodity prices at the farm level were not much different in 1996 than a decade earlier.

Now that the United States's reserve capacity of diverted cropland, accumulated stocks, and subsidized exports is spent, a second era of potential food insecurity is apparent to 2040. On average, demand could increase faster than yields. Without yield and area advances in excess of those anticipated or slower population growth, real prices for farm food ingredients may need to rise to draw more land and other resources into food production.

A third period emerges after 2040. World demand is expected to increase 0.68% per year (medium U.N. population, 0.20% per capita demand growth) in 2050, somewhat less than projected annual crop yield growth of 0.77% in 2050.[43] However, distant projections become quite unreliable.

By year 2000, demand growth could exceed all crop and livestock yield growth by 0.5% per year.[44] A 0.5% global excess food demand growth would raise the price of farm food ingredients 1.4% annually.[45] The shortfall of yield growth below demand growth is less and, thus, price increments are less after year 2000.[46]

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40. *See infra* Table 1.

41. *See* POPULATION DIV., U.N. DEP'T OF ECON. & SOCIAL INFO. & POLICY ANALYSIS, WORLD POPULATION PROSPECTS: THE 1996 REVISION, ANNEX I: DEMOGRAPHIC INDICATORS 11 (1996).

42. *See infra* Table 1.

43. *See infra* Table 1.

44. *See infra* Table 1.

45. *See infra* Table 1.

46. *See infra* Table 1.

The real price of farm food ingredients fell 50% from 1910–14 to 1986, hence the tighter future global food supply-demand balance is a sharp departure from the past.[47] However, any price increase is likely to be readily absorbed and hardly noticed by consumers in developed countries. Americans, for example, on average spend only 2% of their income on farm food ingredients. Even a doubling of farm food ingredient prices would reduce consumers' real income only 2%. Nonetheless, rising real food prices are a hardship for low income families at home and abroad because they spend a much higher proportion of their income on food than does the average American family. Farmers benefit from price increases, but should be cautious about excessive bidding for land. Instability will continue to be the major economic problem for commercial farmers, and cyclical downturns in economic conditions could punish land market plungers.

V. INDIVIDUAL STATES' INTEREST IN GLOBAL FOOD SECURITY

Even though the foregoing analysis highlights that the future global food supply and demand balance is likely to be tighter on average than experienced since World War II, food shortages in the United States are in no way implied. The prospectively tighter global food demand and supply situation primarily threatens poor nations, especially African nations where food production has fallen per capita and where dependence on food aid imports is substantial.

How much are American's willing to sacrifice to conserve agricultural land and devote financial resources mostly to help third-world countries? An average state accounts for 2.0% of the nation's farm production and the nation accounts for 10% of world food production.[48] Hence, an average state accounts for only 0.2% of global production.[49] The land resource accounts for no more than 14% of farm output; other resources, such as capital, account for the rest.[50] Thus, an average state's farmland accounts for no more than 0.04% of world food output.[51] Even doubling an average state's food output would have little impact on global food security. Such a small impact is unlikely to motivate the state's citizens to pay the high cost of preserving farmland from development to promote third-world food security. They probably prefer to be "free riders," waiting for other states and nations to make sacrifices to preserve resources for food security. Every state and nation

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47. *See* NATIONAL AGRIC. STATISTICS SERV., U.S. DEP'T OF AGRIC., AGRICULTURAL STATISTICS 1997 IX-27 (1997).

48. *See* AGRICULTURE AND TRADE ANALYSIS DIV., U.S. DEP'T OF AGRIC., STATISTICAL BULLETIN NO. 861, WORLD AGRICULTURE: TRENDS AND INDICATORS 1970-91, at 17 & 550 (1993).

49. *See id*.

50. *See* MARY AHEARN ET AL., AGRICULTURAL PRODUCTIVITY IN THE UNITED STATES 5 (U.S. Dep't of Agric., Agriculture Information Bulletin No. 740, 1998).

51. *See* AGRICULTURE AND TRADE ANALYSIS DIV., U.S. DEP'T OF AGRIC., STATISTICAL BULLETIN NO. 861, WORLD AGRICULTURE: TRENDS AND INDICATORS 1970-91, at 17 & 550 (1993).

will want to be a free rider and, thus, no one will take action. Hence, preserving farmland to promote world food security requires a national or, better yet, international effort.

Much food processing would remain and food wholesaling and retailing might expand if productive nonfarm development and population expanded to occupy more agricultural land in a state. Value added in a state might be enhanced if more land-intensive economic activity, such as manufacturing plants or national service firm office buildings, absorbed some additional farmland—especially if availability of such land was decisive in promoting job development.

Policies to preserve farmland ideally recognize the diverse interests in farmland as follows: local populations wish to preserve amenity value of open space, states wish to preserve an economic base, and the national government in cooperation with other countries seeks food security. Often, these interests overlap. A legal framework for public policy that coordinates these interests while allowing markets to work where possible will best serve the public.

VI. Conclusions and Policy Recommendations

The world appears to be entering a new era of tighter food supply and demand balance and possibly rising real food prices and land values at the farm level. Nonetheless, the land market alone is unlikely to register the public interest in the option value of land preserved for farming in future years when food supplies may be tighter than now anticipated. Creating the legal initiatives for policy makers to address national and international food security concerns while serving other public interests in private property is a major challenge.

Farmland preservation by any one state has no perceptible impact on international food supplies. Hence, the food security dimension of farmland preservation will only be served by combining that dimension with other objectives of farmland preservation.

Although private markets alone will not protect farmland, past public policies often have failed, encouraging urban sprawl into the countryside while creating urban brownfields. The latter are sometimes the unintended consequences of rent controls; the former, the product of underpriced or subsidized rural services and infrastructure, motor fuel, and mortgage interest. A useful step to better allocation of land—full marginal cost pricing of services—would slow urban sprawl into rural areas.

Another policy instrument is purchase of development rights (PDRs). A public or private entity pays farm landowners the difference between the value of land for development and for farming in return for an easement precluding sale of land for development. Thus, PDRs augment the market by compensating farmland owners for holding land in agriculture. The cost is borne rightly by the public that benefits from food security and preservation of rural landscapes and not by farmland owners who prefer to sell to the highest bidder. PDRs allow public and private groups to correct market failure. If not used properly, PDRs by themselves may be counter-productive, contributing to urban sprawl by being fragmented. The challenge is to combine PDRs with other instruments such as land use planning and zoning, infrastructure development, and community service provision to improve development patterns.

Collaborative federal, state, and local efforts at effective land use can preserve cropland for global food security. Recognizing that no one policy alone is likely to be adequate for wise land use, many counties and municipal communities have formulated comprehensive indicative land use plans. One option is to use PDRs near urban growth boundaries to avoid "taking" from farmland owners whose land is inflated most by development potential. Counties and townships can exercise zoning and public infrastructure investment authority over utility hookups to complement PDRs and full cost pricing in a comprehensive package for guiding development. Ordinarily, the purpose is to channel growth away from prime farmland and reduce sprawl rather than to halt development. Severe restraints on development could sharply raise costs of housing for nonfarm people, causing hardships especially for low income people.

Table 1. World crop yield and demand (population and income per capita) trend growth rates by selected years.[52]

	Historic				Projected					
Yield or demand	1961	1970	1980	1990	2000	2010	2020	2030	2040	2050
	(Percent per year)									
Supply (yield gain)										
Crops[53]										
Cereals	3.20	2.48	1.99	1.66	1.42	1.25	1.11	1.00	0.91	0.83
Vegetables and melons	1.79	1.54	1.34	1.18	1.06	0.95	0.87	0.80	0.74	0.69
Pulses	1.01	0.93	0.85	0.78	0.72	0.68	0.63	0.60	0.56	0.53
Roots and tubers	0.82	0.77	0.71	0.66	0.62	0.59	0.55	0.52	0.50	0.47
Oilseeds	0.49	0.47	0.45	0.43	0.41	0.40	0.38	0.37	0.35	0.34
Total (weighted average)[53]	2.78	2.18	1.77	1.49	1.28	1.14	1.01	0.92	0.84	0.77
Demand										
Population gain										
IIASA[54]	1.83	2.03	1.85	1.74	—[55]	1.47	1.13	0.87	0.67	0.51

52. *See* LUTHER TWEETEN, OHIO STATE UNIVERSITY, COMPETING FOR SCARCE LAND: FOOD SECURITY AND FARMLAND PRESERVATION 11 (Dep't of Agric., & Dev. Econ. Occasional Paper ESO 2385, 1998).

53. Extension of linear trend. Yields of livestock and other crops are assumed to increase at the weighted (by calories) average for the five crops shown to form the total weighted average yield.

54. THE FUTURE POPULATION OF THE WORLD 375-96 (Wolfgang Lutz ed., rev ed. 1996).

55. Not predicted for year 2000.

UN (medium, Table A.2)	1.83	2.03	1.85	1.74	1.44	1.24	1.08	0.88	0.65	0.48
World Bank [56]	1.83	2.03	1.85	1.74	1.47	1.28	1.09	0.91	0.68	0.57
Income effect gain [52]	0.40	0.38	0.36	0.33	0.31	0.29	0.27	0.24	0.22	0.20
Total demand gain										
UN pop. plus income	2.23	2.41	2.21	2.07	1.75	1.53	1.35	1.12	0.87	0.68
Excess demand										
Demand less yield gain	[57]	[57]	[57]	[57]	0.47	0.39	0.34	0.20	0.03	-.09
Price impact										
Price flexibility (3.0) times excess demand	[57]	[57]	[57]	[57]	1.41	1.17	1.02	0.60	0.09	-0.27

56. Eduard Bos et al., World Population Projections 5-13 (1994-95).

57. Not included because depended on stocks, government diverted area, and other considerations not considered in this study.