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ABSTRACT

While the adoption of new mechanical and biological-chemical technology has brought revolutionary changes in agricultural production, these changes have also contributed to a decline in employment in many rural industries. There are, however, a number of new technologies, likely to impact on rural areas in the 1980s and beyond, that should level off the trend toward substitution of technology for labor in rural areas. These technologies include closed-environment production, energy self-sufficiency, municipal waste utilization, renewable fuels, telecommunications, alternative farming systems, and genetic improvements. Some of these technologies are related to energy constraints, including rising prices and the possibility of shortages and interruptions. Others respond to local control concerns that have been developing in recent years. The possibilities for wide adoption, the likely impact on the number and kinds of jobs in existence, and new employment opportunities likely to result from each of these new technologies must be examined separately. (Related reports on rural development in America are available separately through ERIC--see note.) (MN)

"Balancing Technological and Human Resources Development: A New Priority for Rural America"

By Roger Blobaum

Rural America has had a long love affair with the wonders and marvels of scientific discoveries and technologies. Advances ranging from farm mechanization and hybrid seeds to computers and pesticides have had an enormous economic and social impact on rural and metropolitan areas alike.

The adoption of new mechanical and biological-chemical technology brought revolutionary change to agriculture, where capital and energy-intensive inputs and scientific knowledge were substituted for physical labor and land. Agricultural output per hour of labor has increased nearly 6 percent a year since 1950, more than double the rate for all new industries. 1/ New technologies have brought similar, though less dramatic, gains to lumber, pulpwood, coal, and other resource-based rural industries.

Those changes also contributed to the long decline in employment in farming, mining, forestry, and other rural industries. Farm numbers declined from 5.6 million in 1950 to 2.6 million in 1979, for example, and total agricultural employment dropped during that period from 7.2 million to 3.3 million. The

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1/ Rasmussen, Wayne. "The Past 200 Years of American Farming." Agricultural Outlook. Economic Research Service. U.S. Department of Agriculture. July, 1976.

number of coal miners employed in 1975, despite rapid expansion of mining following the oil embargo, was still only about half the number employed 25 years earlier.

The main response to these reduced employment opportunities, particularly by young and minority workers, was mass migration to large industrial centers. More than 30 million people migrated from rural to metropolitan areas beginning in the 1940s, sapping the economic vitality of rural communities and contributing to congestion, pollution, unemployment, and other social problems in urban areas.

Growing concern over the impact of this movement to the cities eventually brought a political response, including rural development studies by two Presidential task forces and enactment in 1972 of the Rural Development Act. The limitations of federal rural development efforts were described by Lynn Daft, who noted that rural development emphasized programs rather than policies. 2/ "Despite a multitude of programs, each with its own administrative machinery and clientele, there is no overall agreement on end objectives," he wrote. "Each program goes its separate way, sometimes complementing the activities of other programs, sometimes working at cross purposes."

Fortunately the rate of population growth of nonmetropolitan counties had exceeded the growth rate of metropolitan areas by 1970, making the new federal effort less critical. The change

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Daft, Lynn. "Toward a Possibly Practical Framework for Rural Development Policies and Programs." Southern Journal of Agricultural Economics. July, 1972.

in the profile of the rural workforce was described later in the Rural Policy Statement issued by the Carter Administration:

> Rural employment, previously declining and historically tied to the land, is now growing and diversifying. Not only are new jobs being created at a faster rate in rural than in urban areas but the composition of rural work itself is changing. Although agriculture is still the dominant influence in many rural economies, overall, employment in manufacturing, trade, and professional services now exceeds direct agricultural employment. 3/

Although net outmigration was reversed early in the 1970s, the search for better ways to balance technological and human resources development in rural areas continues. This paper will identify new technologies likely to be adopted in rural America in the 1980s, discuss some issues relating to their impact on human resources, and suggest some ways that education can help achieve a better balance in the future between the adoption of technology and human resources development.

Technology, which is often defined in terms of hardware, is used here to mean the application of both mechanical and scientific knowledge. Human resources development is an effort to use educational and other assistance in developing a trained and productive workforce, including professionals and operators of individual enterprises.

A number of mechanical and scientific technologies are likely to impact rural America in the 1980s and beyond. Several are described as "appropriate technology," a relatively new term

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3/ The Carter Administration, Small Community and Rural Development Policy. December, 1979.

that usually involves labor-intensive alternatives. Some in the biological-chemical category, which became important earlier, are still producing new techniques and products that will have an impact in the 1980s and beyond. These include growth inhibitors, defoliants, and delayed-release fertilizers.

The list of newly-emerging technologies expected to impact rural America in the 1980s includes closed-environment production, energy self-sufficiency, municipal waste utilization, renewable fuels, telecommunications, alternative farming systems, and genetic improvements. Some of these technologies are related to energy constraints, including rising prices and the possibility of shortages and interruptions. Others respond to environmental, resource, and local control concerns that have been developing in recent years.

Although the impact of this list of technologies on human resource development would be mixed, the net effect would be a leveling off of the trend toward substitution of technology for labor in rural areas. Some like energy self-sufficiency and production of biomass fuels would create new employment opportunities in rural areas. Others like closed-environment production systems, while requiring new types of skills, would have a net effect in most cases of reducing labor requirements.

Future Rural Technologies

This section will describe new technologies likely to be important in rural areas in the 1980s. It will briefly discuss the possibilities for wide adoption, the likely impact on the

number and kinds of jobs in existence, and new employment opportunities likely to result.

Controlled-Environment Production. This technology provides production under the highly-controlled conditions created by greenhouses, livestock or poultry confinement units, and similar operations. These capital-intensive units produce most of the nation's poultry and eggs, for example, and about one-fourth of the nation's hogs.

A simple extrapolation of trends indicates that nearly all of the nation's hogs will eventually be produced in large and very large factory units. 4/ These hog factories utilize antibiotics for disease control, have special buildings and equipment, tend to sell directly to packers rather than through public markets, and can produce 5,000 hogs a year and up with only two or three workers. This production replaces hogs formerly produced on smaller diversified farms that were unable to survive periods of low prices. The main employment impact is making it more difficult for small operators to resume hog production at a later time.

Some controlled-environment technologies, like large-scale greenhouse production, can create a large number of new jobs in rural areas where vegetables, flowers, and other high-value crops have not been grown commercially. It is particularly adaptable to rural areas close to urban centers. Its main purpose is

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4/ Grimes, Glenn, and James Rhodes. "The Changing Structure of the Hog Industry." In "Farm Structure: A Historical Perspective on Changes in the Number and Size of Farms." Committee on Agriculture, Nutrition, and Forestry, U.S. Senate. April, 1980.

off-season production rather than industrialization of an agricultural production sector for labor-saving or related purposes.

Researchers also are learning to grow shellfish and other seafood economically and reliably in controlled-environment aquaculture. 5/ This technology may develop fairly rapidly in response to nutritional needs, water shortages, fear of toxic substances, and related research on things that have not been cultivated previously in water.

The technology of transportation, including refrigerated trucks using interstate highways, has been the most significant factor in removing the need for farmer proximity to consumers. It has made it possible for a highly-mechanized, year-around, fresh produce industry to flourish in states like Florida, Texas, and California. The time is rapidly approaching when off-season greenhouse production in cold climates will be profitable for these crops.

The commercial greenhouse industry has made considerable progress in fuel conservation and controlled-environment production is becoming competitive with shipped-in produce. Developing greenhouse complexes adjacent to industries that produce waste heat can help them become more competitive. A 5,000-square-foot solar greenhouse in Cheyenne, which has not required any supplemental heat through three winters, is demonstrating possible commercial

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5/ Coates, Joseph F. "Science, Technology, and Rural America. A paper presented at the "Five-Year Plan Symposium sponsored by the National Educational Institute for Economic Development at Annapolis, Maryland. March 3, 1980.

application of this energy-saving approach. 6/

Energy Self-Sufficiency. The Department of Agriculture has proposed a goal of net energy self-sufficiency for production agriculture by 1990 under conditions that sustain productivity. 7/ This would be done by making production more energy efficient and by developing and applying alternative sources of energy. A long-range USDA research plan has identified 27 use categories where energy reduction is possible. 8/ The categories with greatest potential are identified as irrigation, tillage, crop drying, greenhouse heating, space heating of livestock and poultry buildings, and water heating for dairies.

Most of the commercial energy systems being developed have not been widely demonstrated on working farms. The main government-initiated demonstration is a program that began in 1978 and now involves model projects on about 90 farms. 9/ This on-going USDA effort is testing systems designed to reduce fossil fuel consumed in drying grain and other crops, heating livestock

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6/ Office of Technology Assessment. An Assessment of Technology for Local Development. U.S. Congress, January, 1981.

7/ Statement of Jim Williams, Deputy Secretary of Agriculture, before the Subcommittee on Agricultural Research and General Legislation, Senate Committee on Agriculture, July 23, 1979.

8/ "Energy Alternatives and Actions for U.S. Agriculture," a report prepared for the Sept. 27, 1979, meeting of the National Research and Extension Users Advisory Board. U.S. Department of Agriculture.

9/ U.S. Department of Energy. Solar Energy for Agricultural and Industrial Process Heat. Report No. CS-0053. September, 1978.

and poultry buildings, and heating and cooling greenhouses.

Several low-cost systems have been demonstrated by the Small Farm Energy Project, a national research and demonstration project carried out over a three-year period in northeast Nebraska. It provided technical and other assistance to 24 farm families to help them adopt a wide range of energy-producing and energy-saving technologies. It is unique because the farmers themselves were involved in selecting and designing energy systems, purchasing construction materials, and building and maintaining them.

Experience with the project suggests that farmers with no previous experience with energy alternatives can utilize their skills and ingenuity in designing and constructing a wide variety of projects. 10/ Owner-built projects constructed included three types of solar water heaters for dairy barns, an attached solar greenhouse, three types of solar grain dryers, several types of solar vertical wall collectors, a portable solar collector used for home heating and grain drying, two types of compost turners, solar food dryers, and a roof-mounted collector with storage on a farrowing barn.

The results suggest that large numbers of farmers could construct low-cost systems that are reasonably reliable, are not too complicated, have relatively short payback periods, can be retrofitted to existing buildings, are made from materials

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10/ Blobaum, Roger. "Toward Energy Self-Sufficiency: The Small Farm Energy Project Experience." A paper prepared for the annual meeting of the American Association for the Advancement of Science. Toronto. January, 1981.

obtained from local businesses, and that require a minimum of maintenance. There also is evidence that many other farmers would have systems of this type constructed on their farms if local energy contractors were available.

This approach also is being demonstrated successfully in the San Luis Valley in south central Colorado, where more than 600 low-cost solar systems have been retrofitted on homes, schools, and businesses. 11/ Solar enthusiasts estimate this six-county area, the nation's most solarized rural area, will be obtaining 20 percent of its energy from solar sources by 1985. This solar activity supports about 20 permanent, mostly skilled, jobs that range from architects and designers to contractors and dealers.

Constructing systems of this kind will create jobs and more business for local hardware stores and lumberyards that stock glazing materials, thermostats, fans, heat resistant paints, and other materials. It also would provide an opportunity for energy specialists who would be in business, as television and CB radio repair persons are now, to service these energy systems.

More complicated factory-built systems also are becoming available in rural areas. Local dealerships also will be needed to sell and service these solar, wind, methane, alcohol, and mini-hydro systems. In addition, a large share of the 21 million

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11/ "San Luis: Most Solarized Community in the Nation." A.T. Times. National Center for Appropriate Technology. Jan.-Feb., 1980.

homes in rural areas will need wood-burning stoves or furnaces, solar retrofits for space and water heating, or other energy producing systems.

No estimates are available on the number and kinds of jobs that a move toward energy self-sufficiency in rural America could support. A study of 10 model community-based energy projects, including five in rural areas, suggests that it would generate thousands of new jobs and provide a financial base for hundreds of new small businesses. 12/

Several government-funded studies, however, have examined employment opportunities likely to be generated in making a national transition to solar in the 1980s. A MITRE Corporation report concluded, for example that meeting the federal government's goal of 2.5 million solar heating, cooling, and hot water systems by the mid-1980s would increase the number of direct solar jobs to 66,300 by 1985. 13/ A 1979 study prepared for a Congressional committee estimated 3 million jobs could result if the nation made a massive shift to solar in the 1980s. 14/

Municipal Waste Utilization. Applying sewage sludge, paunch manure, and other organic wastes to agricultural land at agronomic

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12/ Blobaum, Roger. "The Job Creation Potential of Alternative Energy Systems." A report prepared for the Midland Energy Institute. Kansas City. December, 1980.

13/ Spewak, Peter C. "Labor Requirements for Solar Heating, Cooling, and Hot Water." MITRE Corporation Working Paper No. 12569. McLean, Virginia. September, 1977.

14/ Rodberg, Leonard. "Employment Impact of the Solar Transition." A report of the Subcommittee on Energy, Joint Economic Committee, U.S. Congress. April, 1979.

rates is an emerging technology that is economically feasible when close-in farmland is available and the content of heavy metals and toxic organic compounds does not exceed acceptable levels. The value of these wastes as a fertilizer supplement -- and soil amendment has been demonstrated in hundreds of rural communities.

Most of these wastes in urban areas are still being burned in incinerators, landfilled, or dumped in the ocean. Land utilization can be accomplished without increasing costs, in most instances, and the economic feasibility is expected to improve as energy prices continue to go up.

An assessment of the feasibility of applying these wastes to agricultural land in a 3-County Midwest region showed that nearly all the fertilizer required annually on more than 70,000 acres of cropland could be met by the year 2000 by applying compost made from all the sludge, paunch manure, and stockyards manure available from that region's urban sources. 15/ The soil conditioning benefits included increasing the water-holding capacity of light soils to make them more drought resistant, increasing the organic matter in heavy soils to increase air and water permeability, and a reduction in soil compaction and erosionn.

All of these wastes can be composted in rural areas near

15/ Blobaum, Roger, and S. Fast, L. Holcomb, and L. Swanson. "An Assessment of the Potential for Applying Urban Wastes to Agricultural Land." A report prepared for the National Science Foundation. Roger Blobaum & Associates. Washington. 1979.

where they are generated. Sludge also can be injected into the soil with special equipment or applied on the surface and worked in.

This technology would create new employment on a year-around basis for workers needed to assemble and/or compost wastes, truck them to farms, and apply they to the land. They also can be composted to make them storable, easier to handle, and more more marketable. These operations could be operated by municipalities or by private firms that had contracts with the government entity responsible for waste management.

Renewable Fuels. The production of energy from biomass is emerging as an important new technology with high potential for creation of new jobs in rural America. This stored energy is available from wood, grasses, agricultural crops and their residues, animal wastes, and municipal solid waste. It is estimated that up to one-fourth of the nation's energy could be produced from biomass conversion by the year 2000. 16/

This stored energy can be converted at rural sites, including farms, into liquid and gaseous fuels, thermal energy, and electricity. The biomass forms considered most promising for supplying energy in the near future are wood for gasification, alcohol fuels production, and direct combustion; grain and sugar crops for alcohol fuels production; animal manure for anaerobic

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16/ Office of Technology Assessment. Energy From Biological Processes. U.S. Congress. October, 1979.

digestion, and municipal solid waste for direct combustion. Energy also can be obtained from unconventional types of biomass like oil-bearing crops, arid land and native rangeland plants, and acquatic weeds.

Wood burning is the largest current use of biomass for fuel and firewood production provides a growing number of rural jobs. But an estimated 900 million gallons of gasohol, a blend of 10 percent alcohol and 90 percent gasoline, was sold in service stations in 1980. A recent analysis by the Congressional Office of Technology Assessment indicates up to 18 billion gallons of gasohol could be produced without creating serious environmental problems or running up food prices. Production of methane in anaerobic digesters is being demonstrated on a growing number of livestock and poultry operations and municipal solid waste is being used for fuel in several city-owned power plants.

Gasifying cobs and using the low BTU fuel produced to generate electricity at community-level power plants is another alternative being considered. An estimated 36 million tons of cobs are produced in a good year in the Corn Belt. If long-term contracts at $15 to $25 per ton for cobs delivered to local power plants were provided, the annual value of corn produced in the 10-state region would be enhanced by $540 to $900 million. This would create new jobs in small communities and increase the value of corn by 11 to 17 cents a bushel. 17/

17/ O'Toole, James J., and T. E. Wessels, B. C. English, and R. J. Blobaum, "Corn Cob Gasification and Diesel Electric Generation." A paper presented at the 8th Annual Energy Technology Conference. Washington, March 11, 1981.

The OTA report concludes that biomass energy development in most cases will be more labor-intensive than the increased use of oil, coal, or other conventional fuels and will result in more jobs per Quad of energy produced. These jobs, it notes, are likely to occur in agriculture and forestry, in small and medium-size businesses manufacturing conversion equipment (stills, digesters, wood stoves, etc.), and in the construction and operation of large-scale conversion facilities such as alcohol fuel plants.

Employment in harvesting, conversion, and related sectors also is likely to be highly dispersed, avoiding the public service impacts and problems of secondary development that can be associated with centralized development of fossil fuels in rural areas. "Rather, in rural areas currently experiencing unemployment and underemployment, the increased resource management and capital investment associated with biomass energy are likely to be welcomed," the OTA report stated. "These factors should make it easier for rural areas to plan for and achieve long-term economic growth."

Telecommunications. This complex package of technology includes a growing list of information systems that ranges from computers and cable television to hand calculators and space satellites. 18/ These systems have the potential to bring a flow

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18/ Coates, Joseph F. "Aspects of Innovation: Public Policy Issues in Telecommunications Development." Telecommunications Policy, Vol. 1, No. 3, June, 1977.

of new information, increased information-processing capability, and automation to even the most remote farms and businesses in rural America. They may approach rural free delivery and radio in terms of their importance in the delivery of information to rural people.

The list includes moisture sensor systems that can be used to regulate the flow of irrigation water, for example, or more complicated devices that monitor and control the systems involved in controlled-environment production. A computerized agricultural control system has been patented by a University of Pennsylvania electric engineer who stated that it would increase production, conserve energy, reduce pollution, and increase safety. 19/

Although communications technology is likely to displace few jobs in rural areas, it will give urban-based industries a choice of relocating or establishing branch plants in a rural setting. It also widens the opportunity for training and education, including access to data banks and to Plato and other educational packages that can be utilized through home computers. It will stimulate economic growth because it can, in effect, give rural America access to all the information systems now available to metropolitan areas.

The positive response of people in rural areas to CB radio suggests other new telecommunications systems will be well

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19/ Jones, Stacy V. "Computerized Agricultural System." New York Times. April 11, 1977.

received. CB has added a positive dimension to social life and augmented safety and security in rural areas.

Alternative Farming Systems. There is much more interest in alternative farming systems now than at the beginning of the 1970s, when a model farm of the future was featured in a national magazine. This highly-specialized superfarm had livestock and poultry production underway in high-rise buildings and radio-controlled and totally-automated machines that worked fields several miles long without a wheel touching the ground. This vision of agriculture's future assumed an unlimited amount of low-cost capital, unlimited amounts of cheap energy, and unlimited adoption of labor-saving technology. It is generally agreed that something more labor-intensive is appropriate for the 1980s and beyond.

One alternative technology being demonstrated in rural areas is organic farming, an approach that was endorsed as a feasible alternative in a special report prepared under the direction of the Science and Education Administration, an agency of the U.S. Department of Agriculture. 20/ Organic farmers use crop rotations and other practices to control weeds, insects, and other pests and avoid the use of nitrogen fertilizer and other agricultural chemicals. The fertilizer requirements on organic farms usually are met with livestock manure, nitrogen-fixing legumes in crop

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20/ U.S. Department of Agriculture. Report and Recommendations on Organic Farming. A report prepared by the USDA Study Team on Organic Farming. Washington. 1980.

rotations, and purchased organic fertilizers.

Another alternative technology being adopted by an increasing number of farmers is minimum tillage, a method in which unnecessary field operations in crop production are eliminated, crop residues are left on the surface, and chemicals are used to help control weeds. 21/ It may involve little more than substituting chisel plowing for moldboard plowing, leaving crop residues on the surface, and using herbicides to control weeds. Or it may involve a complete changeover to no-till, where the land is not plowed at all and only a small strip of soil where the seeds are planted is disturbed.

The main advantages are fuel savings that can run as high as five gallons per acre with a no-till system, reduced wind and water erosion, increased soil moisture, less soil compaction, and time and labor savings. The disadvantages include a possible increase in weed and insect problems and some need for different tillage and planting equipment. Minimum tillage also is not appropriate for some soil types, may delay soil warmup at planting time, and may result in yield reduction.

The first major study of organic farming, which compared economic returns and energy intensiveness of a group of organic and conventional farms in the Cornbelt, showed that crop yields were roughly comparable, that the value of all crops produced was

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21/ Gavett, Earle. "Agriculture: Energy Use and Conservation." A speech presented at Texas A&M University, College Station, Tex., 1973.

about 11 percent more on the conventional farms, that operating expenses were considerably lower and labor requirements about 10 percent higher on organic farms, and that net returns from both were about the same. 22/ This three-year study also concluded that the organic farmers used about 40 percent less energy than the conventional farmers, mainly because they did not use commercial fertilizer and other farm chemicals.

Organic farmers usually receive price premiums on production marketed through an alternative system that includes health food stores and food cooperatives in urban areas. This requires extra work, like cleaning and bagging grains, and some farmers also add value by grinding flour or rolling oats. The net effect is an increase in farm-based employment and retention on the farm of some of the marketing and processing income that normally goes to middlemen.

Organic farmers tend to have somewhat smaller and more diversified operations than conventional farmers. There also is evidence that commercial-size organic farmers are more likely to be fulltime operators and to work fewer days off the farm. This suggests that organic farmers would be less likely to compete for new jobs in rural areas. 23/

22/ Klepper, R., W. Lockeretz, B. Commoner, M. Gertler, S. Fast, and R. Blobaum. "Economic Performance and Energy Intensiveness on Organic and Conventional Farms in the Corn Belt: A Preliminary Comparison." American Journal of Agricultural Economics. January, 1977.

23/ Blobaum, Roger, and Larry Swanson. "Barriers to Conversion of Small Farms to Ecological Methods: A Survey of Organic Farmers in Five Cornbelt States." A report prepared for the National Center for Appropriate Technology. Butte, Montana. 1980.