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SOIL-AMENDING TECHNOLOGY, GRASSLAND FARMING, AND
NEW ZEALAND ECONOMIC DEVELOPMENT:
A STUDY OF THE ORIGINS, APPLICATION, AND IMPLICATIONS
OF AN INNOVATION STREAM IN NEW ZEALAND AGRICULTURE

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ABSTRACT

This dissertation explores the role of soil-amending technology in the development of New Zealand's agricultural sector. In a survey of the evolution New Zealand's farming systems it is shown that the use of soil amending emerged from a set of circumstances whereby the utilization of grassland farming methods was favoured by the development of refrigerated marine transport and governmental policy which fostered the formation of small, family farms adapted to more intensive livestock production whose produce refrigerated ships could deliver to the British market.

The relative shortages of capital and labour in this institutional structure led to the introduction of labour-saving technology which promoted grassland-based farming systems. The need to develop and maintain consistently high levels of quality produce, particularly in dairying, entailed the investigation of British agriculture's soil-amending technology. Its successful adaptation and adoption, favoured by its highly divisible labour and capital demands, was a key element in stabilizing the 'small farm structure as it successfully boosted agricultural productivity and enabled other innovations based on highly productive plants and animals to enter the farming systems. The perfection of mechanical distribution methods from tractors to ground-spreading vehicles and aircraft allowed this technology to be extended from the lowland plain dairy and fat-lamb farms into more rugged terrain areas producing wool and store stock.

An agricultural focus to scientific research was a feature supported by government in the establishment and funding of organizations investigating ways to increase and improve agricultural output. Successful research and development brought improved plants and stock which benefited from soil amending through the addition of soil nutrients and trace elements and the control of soil acidity. Concern with the study of pasture as an ecosystem was a basic factor in the advances made. Pedological investigation and the adaptation of foreign research findings especially after 1945 induced rapid increases in livestock output as better distribution methods facilitated the use of the technology devised. Continued economic growth was the outcome of this expansion of output.

The comparative stability of the British market was a central element in the production environment in which such technological

development occurred. The ability to focus attention on a small range of produce for which demand continued to increase through much of the 1890-1960 period meant that New Zealand producers could benefit substantially from improvements of those innovations adopted. Research activity too could be concentrated, so maximizing relatively limited capital and personnel resources. Later deterioration of that market's stability has led to increasing uncertainty and a search for new strategies in production, marketing, and economic planning.

Government has been a central factor in agriculture's development through policy decisions and supporting research, and has become increasingly involved as its role in regulating the economy has grown. Its part in the production environment within which soil-amending technology developed has strongly influenced the pattern of that development.

Noting the relevance of this combination of factors is essential to the geographic study of New Zealand agriculture as a concluding review of a selection of such studies reveals.

PREFACE

This dissertation grew initially from an interest in the utilization of aircraft in New Zealand agriculture for fertilizer distribution. Investigation into the creation and evolution of this technology began to point to a continuity in the use of fertilizer rather than a marked change occasioned by the application of aircraft. The attempt to understand the progression in the use of fertilizer in New Zealand farming systems prompted a review of its evolution. Such an historical approach was productive in that it began to furnish a number of insights into the interaction between the farming systems created and the technology employed therein. Soil amending, the use of substances to alter and improve the productive properties of soils, appeared as a technology basic to the development of productive grassland. The grassland basis of production was a prime characteristic of the farming systems present.

The utilization of grassland developed in the particular capital and labour supply situation found in a small country specializing in animal product output for a market half a world away. The concern with soil amending emerged in the evolution of New Zealand farming systems from extensive to more intensive forms subsequent to transport technology innovation and a program of legislation which stimulated change in the institutional structure of farming. The production environment was apparently a factor in the development of soil-amending technology. The latter's association with dairying in particular appeared to demonstrate how technology could both enable a farm enterprise to exist and induce change within it. The extension of this soil-amending technology to the other livestock enterprises during the present century was a major source of the high productivity of New Zealand's agriculture. The use of aircraft could then be seen as but a later phase in the evolution of soil amending--a means of overcoming the slope constraint imposed on earlier fertilizer distribution techniques.

The above consideration highlighted the related role of resource appraisal and cultural values implicit in the decision to employ a certain technology, particularly where it was new. Continued contact with the source areas of the New Zealand farming systems and the emergence of the scientific study of agriculture in one of them,

the United Kingdom, evidently facilitated the transfer of information while, concurrently, the local pioneering environment encouraged the testing of the techniques proposed. Adapting foreign research to develop technology of use locally was a pattern which persisted.

Successful innovation resulted in the reappraisal of existing production resources in New Zealand and prompted the extension of new farming enterprises. Such a situation is dynamic as the technology introduced creates a disequilibrium. The attempt to rectify the initial disequilibrium can contribute to disequilibria elsewhere in the system. Innovation is stimulated to offset the production difficulties encountered and take advantage of opportunities presented. As productivity improvement is a possible consequence of such moves to more efficiently employ resources, and economic growth is an outcome of improved productivity, following the Schumpeterian view (Schumpeter, 1928, 377-378), change in technology can be the basis for growth in the economy. From such growth, economic development, a change in the relative importance of the sectors of the economy and in the society in which they operate, is thought to follow. This profound change then influences the resource utilization patterns within the economy. This resource-appraisal consideration is not the central concern of this dissertation, however, and its elaboration is not pursued further.

What is of concern is the effect of technological change. The interaction of technology, resource appraisal, institutional structure and economic change is manifest in both the spatial organization and the distributional patterns of farming systems. Patterns resulting from a particular combination of the above-mentioned elements should be subject to adjustment once change is introduced to any one element in the system and disequilibrium is created. An understanding of any such interaction is basic to explaining existing spatial patterns and assessing the spatial outcome of ongoing change. Identifying changing patterns can indicate some alteration in the relationship of the interacting elements as they influence man's use of land. The analysis by geographers can thus be predictive and diagnostic and so contribute to policy-making.

This dissertation is an overview of the operation of this interacting system of technology, resource appraisal, institutional structure and economic change in New Zealand agriculture with parti-

cular reference to the part played by soil amending. The latter technology was identified as one which proved basic to later development by creating a succession of powerful disequilibrium situations. This survey of the ensuing changes provides a framework within which subsequent, more exhaustive studies of New Zealand agriculture can provide a greater understanding of development processes and their spatial manifestation.

The questions addressed in the dissertation are related to the central problems of the soil amending's place in agricultural development in New Zealand and its role in economic change. Why has soil amending been an important technology in the overall development of New Zealand agriculture and how has it played a role in change in the country's economy? It is seen that innovation in transport technology stimulated the evolution of more intensive farming systems and thereby fostered the need for creating highly productive grasslands. Employing soil amending to increase soil-nutrient levels to create and maintain such grasslands was a means to achieve the development desired. The technological response to altered circumstances in the production environment supported the intensification undertaken. In this way emerged a widespread institutional structure in the agricultural sector--the comparatively small, family farm. The labour- and capital-supply characteristics of this structure strongly influenced the production technology utilized and, it is argued, prompted the adoption of grassland technology.

What were the distinctive features of the labour and capital supply of that structure that influenced the nature of the production technology utilized and fostered the use of grassland technology in particular? Both capital and labour were in short supply, so technology not requiring much of either was favoured. The relatively greater shortage of labour meant that labour-saving technology was more favoured even if it proved more expensive to acquire. Accordingly, a direct relationship developed between the demand for labour within a particular farm enterprise and its use of labour-saving technology. Insofar as grassland technology met this demand, it was employed, particularly when both the use of soil-amending technology and the establishment of farm enterprises able to use it were favoured by the physical environment.

What was the consequence in such farm enterprises of focusing attention on the technology utilized? Would they serve as a source of technological information to other enterprises? If so, grassland technology could be improved and disseminated in relation to the importance of the farm enterprise most dependent upon it. This would be one possible answer to the questions of how the agricultural focus of inventive activity has been maintained and how the results have been spread throughout the farming community.

What is the relationship between technology and the institutional structure of an economic sector? While technology, on the one hand, may play a part in the emergence of an institutional structure, on the other, its development can also be abetted and directed by the same structure, so constraining the pattern followed. What were the consequences of the relationship in New Zealand? Inventive activity was centred on biological concerns related to agriculture. The resultant innovations furnished a basis for increased productivity in that sector as well as for growth in the economy as a whole. Creating institutions active in research as well as in the dissemination of the findings of that research stimulated innovation on the farm and, consequently, these institutions may be viewed as having served a growth-promoting function.

What has been the role of government in the development of agriculture? Creating and supporting the research institutions noted above is but one instance of government's involvement. With greater reliance upon governmental intervention to counter the effects of economic crises, the government's participation in decision-making, especially in the allocation of resources within the economy, has become more important to the development of the various economic sectors. Thus the role and significance of agriculture in the national economy was dependent on government policy. This is evident in the recourse to legislation before the turn of the century to promote the small farm as one of the basic elements of New Zealand agriculture. Furthermore, linkage with other economies through international trade and dependence on foreign markets has become increasingly related to governmental decisions. A weakening of the demand-induced growth effect of the British agricultural produce market, for instance, spawned a re-examination of the trading links. To what extent is the relationship between national economies influential in the economic

development process and can it be an explanatory factor in the nature and extent of such development?

Has dependence upon the British market proved significant in agriculture's development? Where once the nature of that market featured in New Zealand agriculture's continued productivity improvement through providing a measure of stability in the production environment, the market's capacity to absorb the increasing output generated by the effective use of technology diminished. This change created a situation where the basis of New Zealand's economy came under continuing review. Has the change led to an adjustment of the economy to new circumstances? The response of the New Zealand economy is of concern here as the productivity improvement in agriculture has occasioned economic growth; yet the attainment of economic development as suggested in economic theory remains in doubt. An appreciation of the technological and institutional factors important to growth and development can provide insight of value in anticipating, and so planning, the course of further economic restructuring.

In light of these considerations the following assertions are examined:

1) Soil-amending technology has been the key element in boosting agricultural productivity because of its importance to grassland farming, and so this technology has played a significant role in agricultural development and in national economic growth.

2) Farming systems based on grassland have developed and focused inventive activity on those key technologies such as soil amending which support them.

3) The introduction and adoption of grassland technology reflected the capital- and labour-supply situations in the altered institutional structure of agriculture after innovation in transport technology occurred.

4) The characteristics of soil-amending technology strongly influenced its adoption and widespread use.

5) In the course of its diffusion from its point of origin an innovation may be modified through its adaptation to a new environmental setting.

6) The adoption of inventions created modifications in production techniques but the institutional structure and the farming

systems in New Zealand agriculture were able to achieve a high degree of stability.

7) Government has played an important part in the diffusion of agricultural technology through its role in sponsoring research and information dissemination and through the strong effect on resource allocation decisions occasioned by its greater involvement in the economy.

8) Change in the stability of the trade pattern has had a direct effect on the promotion of productivity improvement in agriculture, on the stability of the institutional structure of the agricultural sector, and on the relative importance of the various sectors of the national economy.

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