Edmonds, Christopher M.

Working Paper
The Role of Infrastructure in Land-use Dynamics and Rice Production in Viet Nam

ERD Working Paper Series, No. 16

Provided in Cooperation with:
Asian Development Bank (ADB), Manila

Suggested Citation: Edmonds, Christopher M. (2002) : The Role of Infrastructure in Land-use Dynamics and Rice Production in Viet Nam, ERD Working Paper Series, No. 16, Asian Development Bank (ADB), Manila, http://hdl.handle.net/11540/1933

This Version is available at:
http://hdl.handle.net/10419/109237

Terms of use:
Documents in EconStor may be saved and copied for your personal and scholarly purposes. You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.
The Role of Infrastructure in Land-use Dynamics and Rice Production in Viet Nam’s Mekong River Delta

Christopher Edmonds

July 2002
Christopher Edmonds is an Economist with the Development Indicators and Policy Research Division of the Economics and Research Department, Asian Development Bank. The author acknowledges the close collaboration of S.P. Kam (GIS Specialist at the International Rice Research Institute) in GIS aspects of the research; H.C. Viet (Institute of Agricultural Sciences, Ho Chi Minh City) in the data collection and interpretation; and L. Villano (IRRI) in programming and research assistance. The support and assistance of several other individuals were important in enabling this research to be carried out, namely, from the Institute of Agricultural Sciences of Vietnam: Professors P.V. Bien, H.T. Quoc, and T.T. Khai; from IRRI: C.T. Hoanh and T.P. Tuong; from Can Tho University: V.Q. Minh; and from the Sub-Institute for Agricultural Planning and Projection: Dr. N.V. Nhan. Any errors are the sole responsibility of the author. The research was funded in part by the Rockefeller Foundation Social Science Research in Agriculture Program.
Asian Development Bank
P.O. Box 789
0980 Manila
Philippines

©2002 by Asian Development Bank
July 2002
ISSN 1655-5252

The views expressed in this paper
are those of the author(s) and do not
necessarily reflect the views or policies
of the Asian Development Bank.
Foreword

The ERD Working Paper Series is a forum for ongoing and recently completed research and policy studies undertaken in the Asian Development Bank or on its behalf. The Series is a quick-disseminating, informal publication meant to stimulate discussion and elicit feedback. Papers published under this Series could subsequently be revised for publication as articles in professional journals or chapters in books.
# Contents

Abstract vii  
I. Introduction 1  
II. Description of the Study Area 2  
III. Land Use Model 7  
IV. Estimation Strategy and Results 8  
V. Simulation Model for Evaluation of Investments 15  
VI. Conclusion 16  
References 17
Abstract

This study examines the role of infrastructure development and technical change in explaining increases in agricultural production and changes in land use in the Mekong Delta Region of Viet Nam during the mid-1990s. The study relies on econometric analysis of household-level longitudinal farm survey data covering about 150 farms from eight villages in the Mekong River Delta from 1994 to 1998. A model is developed that combines spatial factors in a neoclassical production framework to examine changes in land use and agricultural technology. Estimates make use of panel data estimation procedures that control for the effect of unobserved variables. Major findings emerging from the study are that the transportation costs involved in moving agricultural input and output between farms and markets significantly effect farm land use and production decisions. Greater transport costs reduced the likelihood that farms adopt intensive cropping patterns or cultivate nonrice crops. Improvements in roads and waterways both reduce transport costs in the area. Results suggest the quality of local water management infrastructure is much more important than transport costs in explaining the increased intensity of land use and level of production observed in the Mekong Delta during the 1990s. A simulation model is developed to highlight the implications of findings for policy aiming to increase rice production or alter land use in the Mekong Delta in the future. Unfortunately, lack of information on the costs of alternative infrastructure investments limits the policy conclusions that can be drawn from the study.
I. INTRODUCTION

The increase in rice production in Viet Nam during the 1990s represents one of the recent success stories of Asian agricultural development. The increase in national production took the country from having a large deficit between rice demand and supply to becoming the third largest rice exporter worldwide. This expansion contributed to the country’s high rate of GNP growth by providing urban areas with cheap food and generating foreign exchange earnings. Increases in rice production in the Mekong River Delta, which supplies about half of Viet Nam’s total rice production, averaged about 6.3 percent per year during the 1990s according to official statistics. Although the rapid growth in rice production in Viet Nam is widely known, there have been few studies of the changes in market and physical infrastructure that prompted farm-level changes in rice production techniques and land use, and led to the production increases.

Both biophysical and socioeconomic constraints influence land use decisions and limit the production activities of farming families in the Mekong River Delta. Infrastructure development and changes in economic policies modify both types of constraints. This makes understanding these constraints essential to developing technologies and advising on policies to increase agricultural production and spur economic development in the region. Integration of traditional econometric techniques with data organized in a geographic information system (GIS) offers a promising method for modeling constraints. This paper reviews a microeconomic model developed to explore the relationship between biophysical and socioeconomic characteristics and to derive hypotheses concerning the importance of local infrastructure development, market expansion, new technology adoption, and changes in input application in the mid-1990s in explaining production changes observed in the Mekong Delta. Hypotheses are examined using available data. Different areas in the Delta can be understood as being emblematic of different levels of agricultural development in the transition from rainfed to irrigated rice agriculture. This makes it a useful case to study, and findings carry implications for other areas in Asia making the transition between rainfed and irrigated agriculture.

This paper begins by characterizing the changes in the agricultural environment and the household-level responses to these changes as captured in farm survey, GIS, and provincial level statistics. Two important developments in the study area during the 1990s were the “deepening” and geographic extension of market reforms started in 1988, and the installation of new water control and transport infrastructure. This latter development increased both the area protected from saline water intrusion and the reach of irrigation for dry season rice cultivation. The major changes in policies, institutions, and infrastructure relevant to rice agriculture during the 1990s are also briefly considered. Our review of the biophysical characteristics of surveyed villages relied on GIS data compiled by the International Rice Research Institute (IRRI) and collaborating research
institutions in Viet Nam. We capture farm-level changes in rice output and land use from a longitudinal household survey (1994 to 1997). The survey data were collected by the Institute of Agricultural Sciences (IAS) of Viet Nam and Unité d’Economie Générale, Faculté Universitaire des Sciences Agronomiques de Gembloux, Belgique, for a separate study of rice marketing channels in southern Viet Nam. In our estimates, we use data covering 149 farms from eight villages in three Mekong River Delta provinces. Because of nonreporting of some villages and to a lesser extent farm attrition from the survey, the sample size varies over time. Sampled villages represent a range of agroecological and production situations.

The paper presents a model that combines spatial factors in a neoclassical production framework to examine changes in land use and agricultural technology that led to the increased output. Estimable forms of the production, land use, and revenue functions implied by the model are derived. Econometric models make use of panel data estimation procedures that control for the effect of unobserved variables. Estimations on single years of the survey use instrumental variable and system of equation estimators to correct for endogeneity bias in estimates of the effect of variables that are simultaneously determined with the outcomes of interest (e.g., cropping intensity, choice, and production level). The paper concludes by discussing estimation results. A simulation model is developed to highlight policy implications of findings.

II. DESCRIPTION OF THE STUDY AREA

The study area was characterized according to the following biophysical variables: location of rice producers and accessibility of markets, soils, rainfall and temperatures, and seasonal flooding and saltwater intrusion on farmland. Figure 1 in the Appendix superimposes land use as reported by farms in the eight surveyed villages on a land use map for the Mekong Delta (circa 1996). The figure indicates the high correspondence between farm land use captured from remote sensing presented on the map and that reported by farms completing the longitudinal survey. The map also describes how land use in the surveyed villages changed over time.

Beginning in 1988 with the adoption of Resolution 10 by the Politburo, Viet Nam undertook an ambitious program of decollectivizing its agriculture and liberalizing agricultural markets. Resolution 10 established farm households as autonomous economic entities in rural areas, and farms were permitted to own capital and land. Land formerly held in agricultural cooperatives was assigned to individual farms under long-term lease agreements. Because agricultural cooperatives functioned largely as a legal formality in the Mekong River Delta region where household farms were the ex facto productive unit earlier, the effect of Resolution 10 in that region was lesser here than in other regions of Viet Nam.

In 1993, the Seventh Party Congress adopted Resolution 5 and the Road to Industrialization, which strengthen earlier reforms and adopted measures to promote rural industry and migration of workers out of employment in traditional agriculture. Investments in technology transfer (particularly in dissemination of higher yielding varieties) and water management infrastructure
Figure 1. Land use in the Mekong River Delta

Source: Base land use map from V.G. Minh, Soil Science Department, College of Agriculture, Can Tho University, Vietnam; villages, roads, and village-level land use trends by the author.
spurred continued rice production increases. Terms of land leases were lengthened, and farms were given the right to exchange, transfer, lease, inherit, and mortgage land. Resolution 5 also sought to renovate and modernize remaining agricultural cooperatives and state-owned industries. Accompanying economic reforms lowered trade restrictions (although export quotas on rice remained) and devalued the national currency during this same period. Price controls were gradually relaxed on selected inputs and products over the course of the 1990s, and new agricultural firms entered into input and output markets. Marketing channels expanded to more remote rural areas under more competitive conditions than existed previously. The prices of rice and the major chemical inputs to rice production evolved as a result of these market changes, and changes in world price and local supply and demand. The years covered by the panel survey used in this survey were marked by large increases in rice production and in rice exports. The number of firms permitted to export rice increased and some glutting of the market led to real price declines in rice during 1996 and the first half of 1997, but the government subsequently increased regulation of the operations of rice exporters, leading to increases in prices despite continued growth in production.

Accessibility to markets plays a key role in determining the land use and rice-cropping intensity adopted by farms. Accessibility indicators were calculated for the eight surveyed villages based on travel distances and times between single markets (the nearest local market to the farm and Ho Chi Minh City) and average distances/times for transport between the farm and all surrounding markets. Indicators can be divided into two groups: Those that consider accessibility from the supply perspective, (i.e., service areas from the point of view of a facility, such as the serviceable area of a tube well), and measures of accessibility from the demand perspective. This study focused on accessibility from the demand perspective (i.e., the ease of reaching or accessing services, economic and social opportunities by a user, or how many markets are within a given travel time or travel effort). Particular emphasis was placed on the issue of physical accessibility as a measure of the degree of market integration and its influence on the economics of agricultural production.

Spatial economic models emphasize the importance of the spatial location of economic agents relative to market centers, economic infrastructure, and to one another in determining the economic activities pursued by the agents. They offer a good framework for considering the effects on land use of the biophysical characteristics and changes in such characteristics due to infrastructure development. Accessibility indicators included in the model are used to predict farmers’ land use and production decisions.

Survey and secondary data (official statistical and information generated using GIS) are used to characterize the demographic characteristics and resource endowments of surveyed farms, and to examine changes in agricultural and market development in the Mekong River Delta in the 1990s. Table 1 summarizes selected descriptive statistics from the database used in this study.
### Table 1. Sample Means from Data Set Used in Study

<table>
<thead>
<tr>
<th>Variable</th>
<th>Units</th>
<th>1994 (N=89)</th>
<th>1995 (N=149)</th>
<th>1996 (N=122)</th>
<th>1997 (N=105)</th>
<th>All years</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>S.D.</td>
<td>Mean</td>
<td>S.D.</td>
<td>Mean</td>
<td>S.D.</td>
<td>S.D.</td>
</tr>
<tr>
<td>Number of reporting villages</td>
<td></td>
<td>6 of 10</td>
<td>10 of 10</td>
<td>8 of 10</td>
<td>9 of 10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household demographic characteristics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Years since family settled in area$^1$</td>
<td>years</td>
<td>42.3</td>
<td>19.2</td>
<td>1</td>
<td>85</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age of the head of household$^1$</td>
<td>years</td>
<td>53.0</td>
<td>15.4</td>
<td>21</td>
<td>85</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Most educated HH member (primary)$^1$</td>
<td>0/1 dummy</td>
<td>0.29</td>
<td>—</td>
<td>0</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Most educated member (secondary)$^1$</td>
<td>0/1 dummy</td>
<td>0.57</td>
<td>—</td>
<td>0</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Most educated member (post-secondary)$^1$</td>
<td>0/1 dummy</td>
<td>0.04</td>
<td>—</td>
<td>0</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total persons residing in household</td>
<td></td>
<td>4.7</td>
<td>1.52</td>
<td>5.8</td>
<td>1.79</td>
<td>5.8</td>
<td>1.71</td>
<td>5.6</td>
</tr>
<tr>
<td>Land/Labor ratio in household</td>
<td></td>
<td>0.36</td>
<td>0.31</td>
<td>0.40</td>
<td>0.52</td>
<td>0.34</td>
<td>0.45</td>
<td>0.40</td>
</tr>
<tr>
<td>Landholding and biophysical characteristics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total land owned by farm</td>
<td>hectares</td>
<td>0.91</td>
<td>0.63</td>
<td>1.22</td>
<td>0.79</td>
<td>1.15</td>
<td>0.70</td>
<td>1.07</td>
</tr>
<tr>
<td>Farming plots cultivated by family</td>
<td>number</td>
<td>1.3</td>
<td>0.69</td>
<td>1.5</td>
<td>0.79</td>
<td>1.1</td>
<td>0.45</td>
<td>1.0</td>
</tr>
<tr>
<td>Quality adjusted landholding size</td>
<td>quality adj. has.</td>
<td>1.14</td>
<td>1.11</td>
<td>1.47</td>
<td>1.92</td>
<td>1.30</td>
<td>1.81</td>
<td>1.34</td>
</tr>
<tr>
<td>Alluvial soil$^2$</td>
<td>0/1 dummy</td>
<td>0.51</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium-slightly acid sulfate soil$^2$</td>
<td>0/1 dummy</td>
<td>0.10</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saline soils with dry season saltwater$^2$</td>
<td>0/1 dummy</td>
<td>0.21</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rice production, marketing, and land use</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paddy yield during winter-spring</td>
<td>kilos/hectare</td>
<td>3841</td>
<td>1382</td>
<td>5288</td>
<td>1490</td>
<td>5670</td>
<td>1073</td>
<td>5023</td>
</tr>
<tr>
<td>Area cultivated to rice autumn-winter</td>
<td>hectares</td>
<td>0.88</td>
<td>0.55</td>
<td>1.00</td>
<td>0.61</td>
<td>0.92</td>
<td>0.62</td>
<td>0.79</td>
</tr>
<tr>
<td>Total yearly rice production in province</td>
<td>1000 m. tons</td>
<td>—</td>
<td>—</td>
<td>10529</td>
<td>5430</td>
<td>13792</td>
<td>3615</td>
<td>11539</td>
</tr>
<tr>
<td>Rice cropping intensity</td>
<td>number</td>
<td>1.8</td>
<td>0.79</td>
<td>1.9</td>
<td>0.69</td>
<td>1.9</td>
<td>0.76</td>
<td>2.1</td>
</tr>
<tr>
<td>Cultivated nonrice/nonrow crop</td>
<td>0/1 dummy</td>
<td>0.12</td>
<td>—</td>
<td>0.55</td>
<td>—</td>
<td>0.59</td>
<td>—</td>
<td>0.56</td>
</tr>
<tr>
<td>Paddy sold by farm during year</td>
<td>kilos</td>
<td>—</td>
<td>—</td>
<td>5459</td>
<td>5901</td>
<td>5541</td>
<td>5486</td>
<td>5405</td>
</tr>
<tr>
<td>Average sale price of paddy during year$^3$</td>
<td>$US/kilo</td>
<td>0.13</td>
<td>0.03</td>
<td>0.17</td>
<td>0.04</td>
<td>0.14</td>
<td>0.02</td>
<td>0.15</td>
</tr>
<tr>
<td>Average local market paddy price during year</td>
<td>$US/kilo</td>
<td>0.14</td>
<td>0.01</td>
<td>0.18</td>
<td>0.02</td>
<td>0.15</td>
<td>0.01</td>
<td>0.14</td>
</tr>
</tbody>
</table>

(continued)
Table 1. (cont’d.)

<table>
<thead>
<tr>
<th></th>
<th>Units</th>
<th>1994 (N=89)</th>
<th>1995 (N=149)</th>
<th>1996 (N=122)</th>
<th>1997 (N=105)</th>
<th>All years</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Agricultural technology, practices, and inputs</strong></td>
<td></td>
<td>Mean</td>
<td>S.D.</td>
<td>Mean</td>
<td>S.D.</td>
<td>Mean</td>
</tr>
<tr>
<td>Traditional nongluttinous rice</td>
<td>0/1 dummy</td>
<td>0.18</td>
<td>—</td>
<td>0.11</td>
<td>—</td>
<td>0.11</td>
</tr>
<tr>
<td>Modern short-duration nonglutinous</td>
<td>0/1 dummy</td>
<td>0.20</td>
<td>—</td>
<td>0.35</td>
<td>—</td>
<td>0.37</td>
</tr>
<tr>
<td>Modern medium/long-duration nonglutinous</td>
<td>0/1 dummy</td>
<td>0.52</td>
<td>—</td>
<td>0.40</td>
<td>—</td>
<td>0.34</td>
</tr>
<tr>
<td>Urea per hectare year average</td>
<td>kilos/hectare</td>
<td>160</td>
<td>87</td>
<td>160</td>
<td>74</td>
<td>169</td>
</tr>
<tr>
<td>Price of urea—(weighted yearly average) '97 $US/kilo</td>
<td>0.244</td>
<td>0.028</td>
<td>0.236</td>
<td>0.022</td>
<td>0.248</td>
<td>0.016</td>
</tr>
<tr>
<td>Local market price urea (yearly average) '97 $US/kilo</td>
<td>0.35</td>
<td>0.009</td>
<td>0.302</td>
<td>0.005</td>
<td>0.232</td>
<td>0.014</td>
</tr>
<tr>
<td>No mechanized tractor used</td>
<td>0/1 dummy</td>
<td>0.3</td>
<td>—</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Whether homestead with dry. court</td>
<td>0/1 dummy</td>
<td>0.3</td>
<td>—</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>Water management infrastructure (water)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land leveling carried out on farm</td>
<td>0/1 dummy</td>
<td>0.38</td>
<td>—</td>
<td>0.28</td>
<td>—</td>
<td>0.29</td>
</tr>
<tr>
<td>Dike constructed by farm</td>
<td>0/1 dummy</td>
<td>0.48</td>
<td>—</td>
<td>0.36</td>
<td>—</td>
<td>0.34</td>
</tr>
<tr>
<td>Interpolated annual rainfall at village</td>
<td>millimeters</td>
<td>1251</td>
<td>66</td>
<td>1616</td>
<td>216</td>
<td>1863</td>
</tr>
<tr>
<td>Flooding .5-1 m. lasting 3 months</td>
<td>0/1 dummy</td>
<td>0.1</td>
<td>—</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Brackish (&gt;4g/l) water &gt; 6 months</td>
<td>0/1 dummy</td>
<td>0.1</td>
<td>—</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Rainfed farm (no irrigation)</td>
<td>0/1 dummy</td>
<td>0.1</td>
<td>—</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Limited irrigation available</td>
<td>0/1 dummy</td>
<td>0.1</td>
<td>—</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Reliable irrigation on farm</td>
<td>0/1 dummy</td>
<td>0.6</td>
<td>—</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>Market accessibility and travel distances</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance to nearest local market</td>
<td>kilometers</td>
<td>19.8</td>
<td>4.6</td>
<td>12</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>Accessibility index distance nearest market</td>
<td>kilometers</td>
<td>19.5</td>
<td>4.7</td>
<td>11</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>Accessibility index time all local markets</td>
<td>minutes</td>
<td>130.2</td>
<td>70.2</td>
<td>51</td>
<td>255</td>
<td></td>
</tr>
</tbody>
</table>

Notes:
1 Figures reported come from: (i) a baseline survey that did not include all households later interviewed for the longitudinal survey, and (ii) from interpolation or overlay of values generated from GIS coverages. Number of observations for particular variables can vary from general sample sizes reported.
2 Soil, water availability, and accessibility measures where derived from GIS coverages available in Mekong Delta Provinces only.
3 Calculated as the weighted average (by quantity of rice sold) sale price of rice reported by surveyed farms.
III. LAND USE MODEL

Building upon a von Thünen type framework and the work of Chomitz and Gray (1995), the effect of travel distances between farms and markets on cropping patterns and land use intensity of farms are modeled. Model formulation begins with the assumption that farmers will use land for the activity that generates the highest rent given the physical characteristics of the plot (local climate, basis of land tenure, labor available for farming), and farm-gate input and output prices that depend upon the cost of transport. A revenue function for each alternative use of the plot can then be defined.

\[ R_{ik} = P_{ik} Q_{ik} (P_{ik}, C_{ik}, Z_i) - C_{ik} X_{ik} (P_{ik}, C_{ik}) + u_{ik} \]  

(1)

where \( R_{ik} \) gives the rent on plot/point \( i \) in use \( k \)

\( P_{ik} \) is the price of output/crop \( k \) at plot/point \( i \) (farm gate price of \( k \))

\( C_{ik} \) is a vector of prices of inputs needed for production of crop \( k \) at plot/point \( i \)

\( Z_i \) is a vector of fixed characteristics of the plot that influence the land’s production efficiency in use \( k \)

\( X_{ik} \) is the optimal input level for production of crop \( k \) per unit at land at point \( i \)

\( Q_{ik} \) is the potential output of crop \( k \) at plot/point \( i \) (potential production)

\( u_{ik} \) is a random disturbance term.

The prices of inputs and outputs in the revenue equation depend upon the distance of the farm from the market. It is assumed that the prices of inputs increase, and the prices farms can obtain for output decrease, as farms move further away from markets.

A functional relationship between the level of input applied to farming and the amount of output produced by the farm is specified. The level of output produced depends upon input levels, agroclimatic conditions, and other fixed land characteristics. Using the production function and the expressions for net revenue associated with cultivation of each crop, the relationships between the factors determining net revenue and production and the demand for inputs by the farm can be derived. The demand for inputs for crop \( k \) cultivated at location \( i \) is a function of the cost of the inputs, the farm gate price of the output, the characteristics of the plot, and the efficiency of production of crop \( k \) on the plot.

Using the expressions for input demand, production, and the effect of travel distances on revenues, an expression for the net returns associated with cultivation of crop \( k \) on parcel \( i \) that incorporates the effects of travel cost and the production technology of the farm is defined. Two travel distances are considered in the model. \( D_i \) is the distance between the homestead and the farming plot or plots operated by the family, while \( T_i \) is the average distance between the homestead and the input/output market(s) accessible to the farm. Both distances are relevant in the model since various inputs used in farming (e.g., labor, fertilizer, seed, etc.) and the outputs produced are transported between homesteads, farm plots, and markets over the course of a production period.
season. The expression generates the hypothesis that the likelihood a plot will be applied to cultivation of a particular crop, and its intensity of use, will fall as the distance between the plot and the output/input market increases. At the extreme, very distant plots will not be cultivated, while plots located closest to markets are expected to be used for intensive commercial farming.

An expression for net revenue from cultivation of crop $k$ on plot $i$, which is amenable to estimation from earlier equations can then be formed:

$$\ln(R_{ik}) = a_{0k} + a_{1k}\ln(D_i) + a_{2k}\ln(T_i) + a_{3k}\ln(z_{1i}) + a_{4k}\ln(z_{2i}) + \ldots + a_{Nk}\ln(z_{Li}) + u_{ik}$$

Adding technical assumptions concerning the distribution of error terms ($u_{ik}$) and the correlation of errors, the probability of any crop $k$ being cultivated on plot $i$ can be assumed to be distributed according to the multinomial logit distribution. This provides the basis for using the multinomial logit model in empirical tests of the model. If one is able to rank the alternative land uses—as is possible when the sample is limited to farms cultivating rice and the model is applied to explain rice cropping intensity—the model can be modified to take the form of an ordered logit model.

Under the model, the coefficients on distances ($D_i$ and $T_i$) are expected to be negative, while those on productivity-enhancing land characteristics ($s_{ik}$) are expected to have a positive sign. The magnitude of the estimation coefficients will depend upon per unit costs of transportation of different crops and the relevance of a particular land characteristic to the production of a particular crop. Whether the crop being cultivated on the plot is destined for commercial or subsistence use will also affect the influence of distance on the likelihood that a particular crop is produced and its cropping intensity—subsistence crop production being less influenced by distance.

**IV. ESTIMATION STRATEGY AND RESULTS**

The model provides the basic framework applied in analyzing farm survey data, and establishes the multinomial logit and ordered probit estimators as appropriate for estimating land use and cropping intensity. The form of the estimation equation is given by equation (2) above. The key variables of interest in estimates are the distances between the homestead and the farming plots, and the distances between the homestead and markets accessible to the farm. The effect of farm accessibility to markets would be expected to have its greatest effect on farm commercial cultivation of perishable crops such as fruits or vegetables and the cropping intensity and inputs applied.

The exogenous or predetermined $z$ variables in equation (2) are other household or farm characteristics expected to influence household land use decisions, and include characteristics of the biophysical environment where farms are located, family characteristics, and variables capturing market conditions in surveyed villages. Standard microeconomic production and supply
analysis also guides the selection of variables and our expectations regarding their signs, but these are not reviewed in the interest of brevity. Different sets of right hand side variables are employed in estimates, depending upon the relevance of variables to the left hand side variable. In some estimates, the number of right hand side variables had to be reduced in order for the estimator to solve. These difficulties resulted from missing data and the relatively small sample size of the panel survey.

Estimates use both cross-section- and panel data-based estimation procedures. Panel data estimation procedures provide more robust estimates because they can account for the effect of unobserved variables and have the potential to measure more precisely the effect of changes in explanatory variables. The empirical analysis also uses cross-sectional data-based estimators for two reasons. Panel data estimators cannot accommodate the use of time invariant right hand side variables in estimation equations, and many of the right hand side variables of interest were invariant or observed only a single time during the years of the survey.

In the estimates, cropping patterns and land uses are defined by cardinal rankings (e.g., monocropping, double cropping) and according to the type of crop cultivated. Crops are divided into broad categories: (i) rice; (ii) upland row crops (e.g., sugarcane, potato, vegetables); and (iii) fruit trees or perennial fruit crops (e.g., dragon fruit) or trees maintained by farms for wood (e.g., eucalyptus). In order to apply panel data estimators, it is necessary to define cropping patterns and land use intensity as binary outcomes.

Table 2 reports the results of three estimations that used a random effects probit estimation procedure: (i), farm cultivation of nonrice crops, (ii) farm cultivation of fruit trees or other perennial crops on its land, and (iii) cultivation of two or three rice crops per year. Because household-specific error terms are included in the models, the number of right hand side variables that could be considered in panel estimates was limited. The variables considered are: the on-farm land-labor ratio (acres per full-time equivalent family worker), age of the head of household, rice variety cultivated, and farm investment in dikes or land leveling. It is expected that households with lower land-labor ratios are more likely to farm land more intensively. Older farm operators and farmers with lower levels of educational attainment are expected to be more traditional and hesitant to adopt new technologies. The rice variety planted by farms clearly influences the feasible cropping intensity. Dummy variables are used to define farms growing short-duration, modern varieties and medium- or long-duration varieties. Because rice variety choice is endogenous with the choice of cropping pattern, estimates are open to endogeneity bias under the present specification. Unfortunately, data needed for suitable estimation procedures to control for endogeneity could not be identified. The parameter $\rho$ indicates the significance of farm specific error estimates.

The three models were each highly statistically significant. Several measures of the overall performance of the models in explaining land use are shown at the bottom of Table 2. Psuedo-$R^2$ measures vary between 44.7 and 6.4 percent across measures and models. Lastly, the table reports the share of land use categories correctly predicted by each model, and the distribution of actual versus predicted land use. This shows all three models performed well, predicting farm’s land use decisions correctly.
The estimates of whether the farm cultivated a nonrice crop show that the land-labor ratio and the head of household’s age both had statistically significant negative affects on the probability that the farm cultivated a crop besides rice. Use of medium- or long-duration rice varieties and farm investments in water management infrastructure were found to increase significantly the likelihood of farm cultivation of a nonrice crop.¹ The estimated marginal effect of a one percent

¹ The random effects probit estimator is nonlinear, so estimation coefficients cannot be interpreted directly. The marginal effect of a change in a right hand side variable on the probability that a farm chose a particular land use at the mean values of the right hand side variables must be estimated using an approximation algorithm (see Greene 2000).
increase in the land-labor ratio of farms is a reduction of 4.0 percent in the likelihood that the farm cultivated more than a single crop per year. An increase of ten years in the age of the household head was associated with only a 0.2 percent decrease in the likelihood the farm cultivated a non-rice crop. Farm use of medium- or long-duration modern rice was associated with an 8.4 percent increase in the likelihood the farm grew a crop besides rice. The signs of the estimation coefficients are consistent with the expected signs outline in the previous section of the report.

Farm-level investments in land leveling and water management were estimated to have a statistically significant effect on the likelihood that the farm cultivated tree crops, while older farm operators where significantly more likely to cultivate tree crops. Farms that invested in land leveling or other soil improvement or in water management infrastructure were, respectively, 35.9 and 30.6 percent less likely to cultivate a tree crop. The negative effect of the investments to improve the farm on tree crop cultivation is consistent with the understanding that such investments act as substitute responses to tree crop cultivation in addressing water scarcity and poor soil quality.

Farms with a large amount of land per family worker were significantly less likely to cultivate three rice crops. A one percent increase in the land-to-labor ratio was associated with a 14.6 percent decrease in the likelihood of triple cropping. Farm use of medium- or long-duration varieties of rice was also found to have a positive statistically significant effect on the likelihood of triple cropping, although—surprisingly—use of short-duration varieties did not. Farms planting medium- or long-duration varieties were 33.7 percent more likely to grow three crops of rice a year.

To summarize the discussion of Table 2, across these estimates it was found that farm size, particularly the relative abundance or scarcity of family agricultural labor in relation to the land operated by the farm, plays an important role in driving farm land use as expected. Farms with scarce labor relative to their farm size are less likely to cultivate land intensively. The choice of rice variety and corresponding crop maturation period of chosen varieties is closely related to broader land use choices of farms. Finally, investments in farm- or plot-level improvements in water management were also clearly linked to land use choices. One of the benefits of dike construction appears to be the opportunities it creates for farms to cultivate non-rice crops. In the absence of such investments, farms appeared to adopt land use options (i.e., fruit trees and other perennial crops) with greater immunity to the effects of poor water management. Lastly, the statistical significance of the estimation parameter $\rho$ suggests that unobserved farm characteristics significantly influence land use choices, which underscores the complexity and idiosyncrasy of the land use choices of farms.

Measures of market accessibility and variables characterizing biophysical conditions in the surveyed villages used in estimates were fixed over time or observed at only a single point in time. This makes it impossible to examine the principal hypotheses of the model related to these variables using the panel estimators. Instead, cross-sectional estimates of cropping patterns and rice cropping intensity are used to estimate the effect of time invariant regressors. Rice cropping intensity is a categorical variable where the categories have a natural ordering, so an ordered probit estimator is used.
Rice cropping intensity estimates are significant overall in each of the four years, according to the goodness of fit measures reported on Table 3. Variables of particular interest in estimates are the measures of the distance between farming villages and the average travel time to all local markets, and the distance between homesteads and the plot or plots cultivated. The greater these distances, the lower the likely rice cropping intensity to be adopted by the farm. Estimation results

Table 3. Summary of Estimates of Rice-cropping Intensity

<table>
<thead>
<tr>
<th>Left-hand side/dependent variable estimation coefficient</th>
<th>Rice-cropping intensity in 1994a (N = 60)</th>
<th>Rice-cropping intensity in 1995a (N = 114)</th>
<th>Rice-cropping intensity in 1996a (N = 114)</th>
<th>Rice-cropping intensity in 1997a (N = 77)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>7.2873 (5.5589)</td>
<td>−17.884 *** (4.217)</td>
<td>16.599 *** (4.678)</td>
<td>−34.870 *** (11.088)</td>
</tr>
<tr>
<td>Average distance between homestead and plot or plots</td>
<td>0.0011 (0.1183)</td>
<td>−0.131 (0.138)</td>
<td>−0.062 (0.139)</td>
<td>−0.025 (0.185)</td>
</tr>
<tr>
<td>Average travel time to all accessible local markets</td>
<td>0.0323 (0.0333)</td>
<td>−0.041 (0.011)</td>
<td>0.020 *** (0.007)</td>
<td>−0.060 *** (0.027)</td>
</tr>
<tr>
<td>Land-labor ratio on farm (hectares/household laborer)</td>
<td>0.0308 (0.9918)</td>
<td>0.689 (0.521)</td>
<td>0.356 (0.464)</td>
<td>−0.100 (0.834)</td>
</tr>
<tr>
<td>Years since family settled in current place of residence</td>
<td>0.0064 (0.0110)</td>
<td>−0.007 (0.007)</td>
<td>−0.003 (0.007)</td>
<td>−0.012 (0.014)</td>
</tr>
<tr>
<td>Maximum educational attainment of any family member</td>
<td>0.0020 (0.5324)</td>
<td>0.311 (0.296)</td>
<td>0.071 (0.294)</td>
<td>0.526 (0.461)</td>
</tr>
<tr>
<td>Whether farm served by good-quality water control system</td>
<td>2.2076 (1.5133)</td>
<td>2.053 *** (0.466)</td>
<td>4.266 *** (0.843)</td>
<td>4.704 *** (1.668)</td>
</tr>
<tr>
<td>Annual precipitation at locality where farm is located</td>
<td>−0.0091 (0.0056)</td>
<td>0.013 *** (0.003)</td>
<td>−0.011 *** (0.003)</td>
<td>0.025 *** (0.008)</td>
</tr>
<tr>
<td>Mu (1)</td>
<td>0.3267 ** (0.1487)</td>
<td>2.208 *** (0.330)</td>
<td>1.801 *** (0.309)</td>
<td>4.765 ** (2.182)</td>
</tr>
</tbody>
</table>

Goodness of fit diagnostics:
- Pseudo R²: Cragg-Uhler = 0.432, Maddela = 0.361, McFadden = 0.248
- Likelihood ratio (χ²) test (degrees of freedom): 26.862 *** (7), 92.256 *** (7), 70.189 *** (7), 81.707 *** (7)

% correctly predicted: 0.890, 0.719, 0.632, 0.805

Actual/predicted: 0 1 2 Tot. 0 1 2 Tot. 0 1 2 Tot. 0 1 2 Tot.

Model estimated using the ordered probit estimator.

*** = estimated coefficient statistically significant at 99% confidence level,

** = estimated coefficient statistically significant at 95% confidence level,

* = estimated coefficient statistically significant at 90% confidence level.
generally support the model's hypotheses. Greater distances between farms and markets were associated with a reduced probability of intensive rice cultivation by the farm in 1995 and 1997, and estimated parameters were highly statistically significant. According to 1995 estimation results, a ten minute increase in the average travel time between the farm and available local markets was associated with 14 and 21 percent decreases in the probability of cultivating two and three crops during the year, respectively. The distance between farms and local markets in 1996 had a positive and statistically significant effect on rice cropping intensity. This result appears to be related to the heavy rains and the sample of villages surveyed that year. The distance between plots and homesteads had a negative, but not statistically significant effect on rice cropping intensity in 1995 through 1997.

The availability of low-saline irrigation water to farms had a positive and statistically significant effect on the intensity of land use in all estimates. The magnitude of the effect of high-quality irrigation on cropping intensity was much greater than the effects of other explanatory variables included in the model. Rainfall levels had mixed effects on the cropping intensity of surveyed farms. In years with normal to high rainfall, increased rain was associated with increased cropping intensity. Rains in 1996 were particularly heavy and higher rainfall in that year was associated with significantly reduced levels of cropping intensity among surveyed farms likely due to flooding problems associated with the heavy rains. Results show rice variety selection was clearly linked to cropping intensity, with the adoption of modern, short-duration rice varieties enabling more intensive rice cultivation by farm. Farm-level investments in land leveling or dike construction increased the likelihood that farms adopted intensive rice agriculture. Other variables such as the level of education in the household, the age of the household head, or the farming experience of the family did not have consistent statistically significant effects.

Rice production estimates explained most of the observed variation in the levels of rice output across surveyed farms. Results of production function estimates, which are used in the simulation model discussed next, are summarized on Table 4. Adjusted R\(^2\) coefficient estimates across the production models ranged between 0.76 and 0.89. All four models were highly statistically significant overall. The cropping intensity had consistent and statistically significant effect on annual production levels in all estimates. Monocropping was associated with significantly lower levels of output and triple-cropping was associated with significantly higher output levels compared to double-cropping. The land area cultivated and the amount of rice seed used were also associated with significantly higher levels of output in all estimates. The amount of hired labor applied on the farm had a positive and statistically significant effect on output in all the estimates except the 1994 cross-sectional estimate. The level of fertilizer applied on the farm had a positive and statistically significant effect on rice output in 1996 and 1997. The amount of family labor applied on farm was difficult to measure accurately from available data, but had a negative and significant effect on rice output in 1994 and a positive and significant effect in 1995. Pesticide application had a positive and statistically significant effect on output only in 1994. The signs of these estimated coefficients all conform to expectations. The one exception involved the use of modern varieties, which had inconsistent effects on rice production across estimates. It had statistically significant
negative effects in estimates carried out using data from 1995 and 1997 and a positive effect in 1996. One explanation for this is that the variable was imprecisely defined due to aggregation across many distinct varieties. A second reason is that due to collinearity with rice cropping intensities, the principal effect of modern variety use seems to have been to enable farms to pursue more intensive rice production. Considered together, the various estimates provide a clear indication of the factors driving farm land use, production, and marketing decisions.

Table 4. Rice Production Estimates (cross sectional estimators)

<table>
<thead>
<tr>
<th>Left-hand side/dependent variable estimation coefficient (estimated standard error)</th>
<th>Rice production in 1995(^a) (N = 117)</th>
<th>Rice production in 1996(^a) (N = 134)</th>
<th>Rice production in 1997(^a) (N = 121)</th>
<th>Rice production in 1995-97(^b) (N = 372)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant(s)</td>
<td>7.493 *** 0.322</td>
<td>4.642 *** 0.765</td>
<td>6.295 *** 0.350</td>
<td>N.R. ***</td>
</tr>
<tr>
<td>Single-cropped rice</td>
<td>-1.281 *** 0.253</td>
<td>-3.479 *** 0.469</td>
<td>-1.947 *** 0.271</td>
<td>-0.416 0.453</td>
</tr>
<tr>
<td>Triple-cropped rice</td>
<td>0.608 *** 0.132</td>
<td>1.570 *** 0.257</td>
<td>0.972 *** 0.130</td>
<td>-0.015 0.226</td>
</tr>
<tr>
<td>Largest area planted to rice in any season</td>
<td>0.789 *** 0.075</td>
<td>0.469 *** 0.070</td>
<td>0.558 *** 0.070</td>
<td>1.090 *** 0.254</td>
</tr>
<tr>
<td>Total household expenditure on hired labor</td>
<td>0.067 0.081</td>
<td>0.483 *** 0.077</td>
<td>0.098 *** 0.029</td>
<td>0.210 *** 0.052</td>
</tr>
<tr>
<td>Imputed value of family labor applied on farm</td>
<td>-0.194 ** 0.097</td>
<td>0.428 *** 0.165</td>
<td>0.102 0.098</td>
<td>0.176 0.127</td>
</tr>
<tr>
<td>Expenditure on fertilizer</td>
<td>0.029 0.060</td>
<td>0.205 0.108</td>
<td>0.151 ** 0.068</td>
<td>0.033 0.072</td>
</tr>
<tr>
<td>Expenditure on pesticides or herbicides</td>
<td>0.096 *** 0.038</td>
<td>0.010 0.075</td>
<td>0.016 0.034</td>
<td>-0.320 0.048</td>
</tr>
<tr>
<td>Average quantity of rice seed used per season cultivated</td>
<td>0.622 *** 0.125</td>
<td>0.735 *** 0.236</td>
<td>0.747 *** 0.101</td>
<td>-0.419 ** 0.192</td>
</tr>
<tr>
<td>Use of any modern variety of rice seed</td>
<td>-0.123 * 0.067</td>
<td>0.226 * 0.134</td>
<td>-0.119 ** 0.058</td>
<td>0.295 0.092</td>
</tr>
<tr>
<td>Year 1995</td>
<td>– – – 0.010</td>
<td>– – – 0.058</td>
<td>– -0.010</td>
<td>– 0.069</td>
</tr>
<tr>
<td>Year 1996</td>
<td>– – – 0.113</td>
<td>– – – 0.058</td>
<td>– -0.103 ***</td>
<td>– 0.063</td>
</tr>
</tbody>
</table>

Goodness of fit diagnostics:

<table>
<thead>
<tr>
<th>Adjusted R(^2)</th>
<th>0.892</th>
<th>0.868</th>
<th>0.888</th>
<th>0.835</th>
</tr>
</thead>
</table>

Notes:

*** estimated coefficient statistically significant at a 99% confidence level
** estimated coefficient statistically significant at a 95% confidence level
* estimated coefficient statistically significant at a 90% confidence level
\(^a\)Estimated in logarithms using the ordinary least squares estimator.
\(^b\)Estimated in logarithms using the fixed effects estimator for panel data. The results of the Hausman test (46.950 *** with 11 d.f.) supported use of the fixed effects specificat.
N.R. means household-specific intercepts are not reported.
V. SIMULATION MODEL FOR EVALUATION OF INVESTMENTS

The implications of model estimates for evaluating the effect of development of different types of infrastructure can be better understood by generating a simulation model using estimation parameters. The results of a simulation model derived from empirical estimates are summarized in Tables 5 and 6. Table 5 shows the distribution of rice cropping intensities among surveyed farms. The actual distribution of farms in each of the four years of the survey is shown, along with the projected distribution under alternative scenarios. One scenario involves improvements in travel networks between surveyed villages and local markets. The second considers the effect of land transport improvements or land consolidation that brings homesteads and farm plots closer. The third contemplates extension of water control infrastructure to an additional 10 percent of the

Table 5. Simulation of Effects of Investments on Distribution of Farm Rice-cropping Intensity

<table>
<thead>
<tr>
<th>Rice Cropping intensity</th>
<th>Actual distribution of farms</th>
<th>Transportation system:</th>
<th>Land consolidation:</th>
<th>Water control infrastructure:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monocropping</td>
<td>37</td>
<td>33</td>
<td>31</td>
<td>12</td>
</tr>
<tr>
<td>Double cropping</td>
<td>7</td>
<td>55</td>
<td>51</td>
<td>45</td>
</tr>
<tr>
<td>Triple cropping</td>
<td>16</td>
<td>26</td>
<td>32</td>
<td>20</td>
</tr>
</tbody>
</table>

Table 6. Simulation of Effects of Investments on Rice Production among Surveyed Farms (tons)

<table>
<thead>
<tr>
<th>Actual production</th>
<th>Predicted production for travel to market (−10 min)</th>
<th>Predicted production for distance from home to plot reduced by 1 km</th>
<th>Predicted production for better water management extension +10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 × rice farm production</td>
<td>5</td>
<td>41</td>
<td>24</td>
</tr>
<tr>
<td>3 × rice farm production</td>
<td>13</td>
<td>22</td>
<td>26</td>
</tr>
<tr>
<td>Total rice production % change in total production</td>
<td>44</td>
<td>85</td>
<td>61</td>
</tr>
<tr>
<td>0.4</td>
<td>3.0</td>
<td>5.2</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Columns may not sum to total rice production due to rounding error.
surveyed farms. Using results of production function estimates, the implied changes in the share of farms that double- or triple-crop rice can be applied to calculate an implied increase in aggregate rice output across farms. The production estimates provide a measure of the average change in annual rice yield associated with mono, double, or triple cropping of rice. Table 6 details the changes in total rice production from the scenarios.

The simulation model shows a large effect of investments in irrigation extension on rice production, and more moderate effects obtained from improvements in the transportation system or land consolidation. Incorporating the estimates obtained in this research with other linear programming or general simulation models would be an important extension of this research.

VI. CONCLUSION

These results generally support the hypothesis that the time and direct cost of transporting inputs and outputs between rural homesteads, farm plots, and markets influence the land use and production decisions of farming households. Estimation results confirm our expectation that greater transport distances reduce the cropping intensity and make the cultivation of nonrice crops less likely. However, results suggest the quality of the water management infrastructure is far more important in determining land use than transport infrastructure. The magnitude of the effect of having high quality water management infrastructure dwarfed the effect of other variables. Other variables including the use of modern seed varieties, the age of the farm operator, the land-to-labor ratio of the farm, and rainfall influenced farm land use as predicted. Results suggest that investments in water management offer more promise in improving farm land use options and increasing rice production than transport infrastructure investments in the Delta. However, information on the relative costs of extending road and water management infrastructure is necessary before it would be appropriate to offer policy conclusions in this regard. This study relied on existing sources of data originally collected for a cost-price accounting study, and as a result encountered data constraints in analyses.


PUBLICATIONS FROM THE ECONOMICS AND RESEARCH DEPARTMENT

ERD WORKING PAPER SERIES (WPS)  
(Published in-house; Available through ADB Office of External Relations; Free of Charge)

No. 1 Capitalizing on Globalization  
—Barry Eichengreen, January 2002

No. 2 Policy-based Lending and Poverty Reduction: An Overview of Processes, Assessment and Options  
—Richard Bolt and Manabu Fujimura, January 2002

No. 3 The Automotive Supply Chain: Global Trends and Asian Perspectives  
—Francisco Veloso and Rajiv Kumar, January 2002

No. 4 International Competitiveness of Asian Firms: An Analytical Framework  
—Rajiv Kumar and Doren Chadee, February 2002

No. 5 The International Competitiveness of Asian Economies in the Apparel Commodity Chain  
—Gary Gereffi, February 2002

No. 6 Monetary and Financial Cooperation in East Asia—The Chiang Mai Initiative and Beyond  
—Pradumna B. Rana, February 2002

No. 7 Probing Beneath Cross-national Averages: Poverty, Inequality, and Growth in the Philippines  
—Arsenio M. Balisacan and Ernesto M. Pernia, March 2002

No. 8 Poverty, Growth, and Inequality in Thailand  
—Anil B. Deolalikar, April 2002

No. 9 Microfinance in Northeast Thailand: Who Benefits and How Much?  
—Brett E. Coleman, April 2002

No. 10 Poverty Reduction and the Role of Institutions in Developing Asia  
—Anil B. Deolalikar, Alex B. Brilliante, Jr., Raghu Gaiha, Ernesto M. Pernia, Mary Racelis with the assistance of Marita Concepcion Castro-Guevarra, Lisa L. Lim, Filipinas F. Quising, May 2002

No. 11 The European Social Model: Lessons for Developing Countries  
—Assar Lindbeck, May 2002

No. 12 Costs and Benefits of a Common Currency for ASEAN  
—Srinivasa Madhur, May 2002

No. 13 Monetary Cooperation in East Asia: A Survey  
—Raul Fabella, May 2002

No. 14 Toward A Political Economy Approach to Policy-based Lending  
—George Abonyi, May 2002

No. 15 A Framework for Establishing Priorities in a Country Poverty Reduction Strategy  
—Ron Duncan and Steve Pollard, June 2002

No. 16 The Role of Infrastructure in Land-use Dynamics and Rice Production in Viet Nam’s Mekong River Delta  
—Christopher Edmonds, July 2002

No. 17 Measuring Willingness to Pay for Electricity  
—Peter Chojnowski, July 2002

No. 18 Economic Issues in the Design and Analysis of a Wastewater Treatment Project  
—David Dole, July 2002

ERD TECHNICAL NOTE SERIES (TNS)  
(Published in-house; Available through ADB Office of External Relations; Free of Charge)

No. 1 Contingency Calculations for Environmental Impacts with Unknown Monetary Values  
—David Dole, February 2002

No. 2 Integrating Risk into ADB’s Economic Analysis of Projects  
—Nigel Rayner, Anneli Lagman-Martin, and Keith Ward, June 2002

No. 3 Measuring Willingness to Pay for Electricity  
—Peter Chojnowski, July 2002

No. 4 Economic Issues in the Design and Analysis of a Wastewater Treatment Project  
—David Dole, July 2002

ERD POLICY BRIEF SERIES (PBS)  
(Published in-house; Available through ADB Office of External Relations; Free of Charge)

No. 1 Is Growth Good Enough for the Poor?  
—Ernesto M. Pernia, October 2001

No. 2 India’s Economic Reforms: What Has Been Accomplished? What Remains to Be Done?  
—Arvind Panagariya, November 2001

No. 3 Unequal Benefits of Growth in Viet Nam  
—Indu Bhushan, Erik Bloom, and Nguyen Minh Thang, January 2002

No. 4 Is Volatility Built into Today’s World Economy?  
—J. Malcolm Dowling and J.P. Verbiest, February 2002

No. 5 What Else Besides Growth Matters to Poverty Reduction? Philippines  
—Arsenio M. Balisacan and Ernesto M. Pernia, February 2002

No. 6 Achieving the Twin Objectives of Efficiency and Equity: Contracting Health Services in Cambodia  
—Indu Bhushan, Sheryl Keller, and Brad Schwartz, March 2002

No. 7 Causes of the 1997 Asian Financial Crisis: What Can an Early Warning System Model Tell Us?  
—Juzhong Zhuang and Malcolm Dowling, June 2002

No. 8 The Role of Preferential Trading Arrangements in Asia  
—Christopher Edmonds and Jean-Pierre Verbiest, July 2002

No. 9 The Doha Round: A Development Perspective  
—Jean-Pierre Verbiest, Jeffrey Liang, and Lea Sumulong, July 2002
**EDRC REPORT SERIES (ER)**

<table>
<thead>
<tr>
<th>No.</th>
<th>Title</th>
<th>Authors</th>
<th>Publication Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ASEAN and the Asian Development Bank</td>
<td>Seiji Naya</td>
<td>April 1982</td>
</tr>
<tr>
<td>2</td>
<td>Development Issues for the Developing East and Southeast Asian Countries and International Cooperation</td>
<td>Seiji Naya and Graham Abbott</td>
<td>April 1982</td>
</tr>
<tr>
<td>3</td>
<td>Aid, Savings, and Growth in the Asian Region</td>
<td>J. Malcolm Dowling and Ulrich Hiemenz</td>
<td>April 1982</td>
</tr>
<tr>
<td>4</td>
<td>Development-oriented Foreign Investment and the Role of ADB</td>
<td>John Lewis</td>
<td>June 1982</td>
</tr>
<tr>
<td>5</td>
<td>Notes on External Debt of DMCs</td>
<td>Evelyn Go</td>
<td>July 1982</td>
</tr>
<tr>
<td>6</td>
<td>Small and Medium-Scale Manufacturing Establishments in ASEAN Countries: Perspectives and Policy Issues</td>
<td>Mathias Bruch and Ulrich Hiemenz</td>
<td>January 1983</td>
</tr>
<tr>
<td>7</td>
<td>A Note on the Third Ministerial Meeting of GATT</td>
<td>Jungsoo Lee</td>
<td>January 1983</td>
</tr>
<tr>
<td>8</td>
<td>Macroeconomic Forecasts for the Republic of China, Hong Kong, and Republic of Korea</td>
<td>J.M. Dowling</td>
<td>January 1983</td>
</tr>
<tr>
<td>9</td>
<td>ASEAN: Economic Situation and Prospects</td>
<td>Seiji Naya</td>
<td>March 1983</td>
</tr>
<tr>
<td>10</td>
<td>The Future Prospects for the Developing Countries of Asia</td>
<td>Seiji Naya</td>
<td>March 1983</td>
</tr>
<tr>
<td>11</td>
<td>Energy and Structural Change in the Asia-Pacific Region, Summary of the Thirteenth Pacific Trade and Development Conference</td>
<td>Seiji Naya</td>
<td>March 1983</td>
</tr>
<tr>
<td>12</td>
<td>A Survey of Empirical Studies on Demand for Electricity with Special Emphasis on Price Elasticity of Demand</td>
<td>Wisarn Pupphavesa</td>
<td>June 1983</td>
</tr>
<tr>
<td>16</td>
<td>Relative External Debt Situation of Asian Developing Countries: An Application of Ranking Method</td>
<td>Jungsoo Lee</td>
<td>June 1983</td>
</tr>
<tr>
<td>17</td>
<td>New Evidence on Yields, Fertilizer Application, and Prices in Asian Rice Production</td>
<td>William James and Teresita Ramirez</td>
<td>July 1983</td>
</tr>
<tr>
<td>18</td>
<td>Inflationary Effects of Exchange Rate Changes in Nine Asian LDCs</td>
<td>Pradumna B. Rana and J. Malcolm Dowling</td>
<td>July 1983</td>
</tr>
<tr>
<td>19</td>
<td>Public Investment Criteria: Economic Internal Rate of Return and Equalizing Discount Rate</td>
<td>Pradumna Rana, Jungsoo Lee, and Emma Banaria</td>
<td>March 1985</td>
</tr>
<tr>
<td>20</td>
<td>The Climate for Energy Development in the Pacific and Asian Region: Priorities and Perspectives</td>
<td>V.V. Desai</td>
<td>April 1986</td>
</tr>
<tr>
<td>21</td>
<td>The Impact of Foreign Capital Inflow on Investment and Economic Growth in Developing Asia</td>
<td>Evelyn Go</td>
<td>May 1985</td>
</tr>
<tr>
<td>22</td>
<td>Sources of Balance of Payments Problem in the 1970s: The Asian Experience</td>
<td>Kedar N. Kohli</td>
<td>November 1984</td>
</tr>
<tr>
<td>23</td>
<td>The Effect of Terms of Trade Changes on the Balance of Payments and Real National Income of Asian Developing Countries</td>
<td>Jungsoo Lee and Emma Banaria</td>
<td>March 1985</td>
</tr>
<tr>
<td>25</td>
<td>Alternatives to Institutional Credit Programs in the Agricultural Sector of Low-Income Countries</td>
<td>Jennifer Sour</td>
<td>March 1984</td>
</tr>
<tr>
<td>26</td>
<td>Meeting Basic Human Needs in Asian Developing Countries</td>
<td>Seiji Naya and Ulrich Hiemenz</td>
<td>February 1984</td>
</tr>
<tr>
<td>27</td>
<td>The Prospects for East and Southeast Asian Developing Countries</td>
<td>Seiji Naya and Ulrich Hiemenz</td>
<td>February 1984</td>
</tr>
<tr>
<td>28</td>
<td>A Study on the External Debt Indicators Applying Logit Analysis</td>
<td>Seiji Naya and Clarita Barreto</td>
<td>February 1984</td>
</tr>
<tr>
<td>29</td>
<td>Economic Scenic in Asia and Its Special Features</td>
<td>Kedar N. Kohli</td>
<td>November 1984</td>
</tr>
<tr>
<td>30</td>
<td>Smuggling and Domestic Economic Policies in Developing Countries</td>
<td>Seiji Naya and Ulrich Hiemenz</td>
<td>February 1984</td>
</tr>
<tr>
<td>31</td>
<td>The Prospects for East and Southeast Asian Developing Countries</td>
<td>Seiji Naya and Ulrich Hiemenz</td>
<td>February 1984</td>
</tr>
<tr>
<td>32</td>
<td>Developing Member Countries of the Bank</td>
<td>Seiji Naya and Ulrich Hiemenz</td>
<td>February 1984</td>
</tr>
<tr>
<td>33</td>
<td>Impact of Appreciation of the Yen on Developing Member Countries of the Bank</td>
<td>Seiji Naya and Ulrich Hiemenz</td>
<td>February 1984</td>
</tr>
<tr>
<td>34</td>
<td>Emerging Issues in Asia and SocialCost Benefit Analysis</td>
<td>E.M. Pernia</td>
<td>May 1987</td>
</tr>
</tbody>
</table>
—I. Ali, September 1988

No. 42 Shifting Revealed Comparative Advantage: Experiences of Asian and Pacific Developing Countries —P.B. Rana, November 1988

No. 43 Agricultural Price Policy in Asia: Issues and Areas of Reforms —I. Ali, November 1988

No. 44 Service Trade and Asian Developing Economies —M.G. Quibria, October 1989

No. 45 A Review of the Economic Analysis of Power Projects in Asia and Identification of Areas of Improvement —I. Ali, November 1989


No. 48 Economic Growth Performance of Indonesia, the Philippines, and Thailand: The Human Resource Dimension —E.M. Pernia, January 1990


No. 50 Public Investment Criteria: Financial and Economic Internal Rates of Return —I. Ali, April 1990


No. 53 Issues in Assessing the Impact of Project and Sector Adjustment Lending —I. Ali, December 1990

No. 54 Some Aspects of Urbanization and the Environment in Southeast Asia —Ernesto M. Pernia, January 1991


No. 56 A Framework for Justifying Bank-Assisted Education Projects in Asia: A Review of the Socioeconomic Analysis and Identification of Areas of Improvement —Etienne Van De Walle, February 1992

No. 57 Medium-term Growth-Stabilization Relationship in Asian Developing Countries and Some Policy Considerations —Yun-Hwan Kim, February 1993


No. 59 The Need for Fiscal Consolidation in Nepal: The Results of a Simulation —Filippo di Mauro and Ronald Antonio Bationg, July 1993

No. 60 A Computable General Equilibrium Model of Nepal —Timothy Buehler and Filippo di Mauro, October 1993


No. 62 Rural Reforms, Structural Change, and Agricultural Growth in the People's Republic of China —Bo Lin, August 1994

No. 63 Incentives and Regulation for Pollution Abatement with an Application to Waste Water Treatment —Sudipto Mundle, U. Shankar, and Shekhar Mehta, October 1995

No. 64 Saving Transitions in Southeast Asia —Frank Harrigan, February 1996

No. 65 Total Factor Productivity Growth in East Asia: A Critical Survey —Jesus Felipe, September 1997

No. 66 Foreign Direct Investment in Pakistan: Policy Issues and Operational Implications —Ashfaque H. Khan and Yun-Hwan Kim, July 1999

No. 67 Fiscal Policy, Income Distribution and Growth —Sailesh K. Jha, November 1999

ECONOMIC STAFF PAPERS (ES)

No. 1 International Reserves: Factors Determining Needs and Adequacy —Evelyn Go, May 1981

No. 2 Domestic Savings in Selected Developing Asian Countries —Basil Moore, assisted by A.H.M. Nuruddin Choudhury, September 1981


No. 4 By-Passed Areas, Regional Inequalities, and Development Policies in Selected Southeast Asian Countries —William James, October 1981

No. 5 Asian Agriculture and Economic Development —William James, March 1982

No. 6 Inflation in Developing Member Countries: An Analysis of Recent Trends —A.H.M. Nuruddin Choudhury and J. Malcolm Dowling, March 1982

No. 7 Industrial Growth and Employment in Developing Asian Countries: Issues and Perspectives for the Coming Decade —Ulrich Hiemens, March 1982


No. 9 Developing Asia: The Importance of Domestic Policies —Economics Office Staff under the direction of Seiji Naya, May 1982


No. 11 Industrial Development: Role of Specialized Financial Institutions —Kedar N. Kohli, August 1982


No. 13 Credit Rationing, Rural Savings, and Financial Policy in Developing Countries —William James, September 1982

No. 14 Small and Medium-Scale Manufacturing —William James, September 1982
OCCASIONAL PAPERS (OP)

No. 1 Poverty in the People's Republic of China: Recent Developments and Scope for Bank Assistance —K.H. Moinuddin, November 1992
No. 2 The Eastern Islands of Indonesia: An Overview of Development Needs and Potential —Brien K. Parkinson, January 1993
No. 4 Fiscal Deficits and Current Account Imbalances of the South Pacific Countries: A Case Study of Vanuatu —T.K. Jayaraman, December 1993
No. 5 Reforms in the Transitional Economies of Asia —Pradumna B. Rana, December 1993
No. 6 Environmental Challenges in the People's Republic of China and Scope for Bank Assistance —Elisabetta Capannelli and Omkar L. Shrestha, December 1993
No. 7 Sustainable Development Environment and Poverty Nexus —K.F. Jalal, December 1993
No. 9 Interest Rate Deregulation: A Brief Survey of the Policy Issues and the Asian Experience —Carlos J. Glover, July 1994
No. 10 Some Aspects of Land Administration in Indonesia: Implications for Bank Operations —Sutanu Behuria, July 1994
No. 12 Managing Development through Institution Building —Hilton L. Root, October 1995
No. 13 Growth, Structural Change, and Optimal Poverty Interventions —Shiladitya Chatterjee, November 1995
No. 15 The Rural-Urban Transition in Viet Nam: Some Selected Issues —Sudipto Mundle and Brian Van Arkadie, October 1997
No. 16 A New Approach to Setting the Future Transport Agenda —Roger Alipport, Geoff Key, and Charles Melhuish, June 1998
No. 17 Adjustment and Distribution: The Indian Experience —Sudipto Mundle and V.B. Tulasidhar, June 1998
No. 18 Tax Reforms in Viet Nam: A Selective Analysis —Sudipto Mundle, December 1998
No. 19 Surges and Volatility of Private Capital Flows to Asian Developing Countries: Implications for Multilateral Development Banks —Pradumna B. Rana, December 1998
No. 21 Occupational Segregation and the Gender Earnings Gap —Joseph E. Zweglich, Jr. and Yana van der Meulen Rodgers, December 1999

STATISTICAL REPORT SERIES (SR)

No. 2 Multivariate Statistical and Graphical Classification Techniques Applied to the Problem of Grouping Countries —I.P. David and D.S. Maligalig, March 1985
No. 3 Gross National Product (GNP) Measurement Issues in South Pacific Developing Member Countries of ADB —S.G. Tiwari, September 1985
No. 4 Estimates of Comparable Savings in Selected DMCs —Hananto Sigit, December 1985
No. 5 Keeping Sample Survey Design and Analysis Simple —I.P. David, December 1985
No. 6 External Debt Situation in Asian Developing Countries —I.P. David and Jungsoo Lee, March 1986
No. 7 Study of GNP Measurement Issues in the South Pacific Developing Member Countries. Part I: Existing National Accounts of SPDMCs—Analysis of Methodology and Application of SNA Concepts —P. Hodgkinson, October 1986
No. 8 Study of GNP Measurement Issues in the South Pacific Developing Member Countries. Part II: Factors Affecting Intercountry Comparability of Per Capita GNP —P. Hodgkinson, October 1986
No. 9 Survey of the External Debt Situation in Asian Developing Countries, 1985 —Jungsoo Lee and I.P. David, April 1987
No. 17 Purchasing Power Parity in Asian Developing Countries: A Co-Integration Test —Min Tang and Ronald Q. Butling, April 1994
No. 18 Capital Flows to Asian and Pacific Developing Countries: Recent Trends and Future Prospects —Min Tang and James Villafuerte, October 1995
SPECIAL STUDIES, COMPLIMENTARY (SSC)  
(Published in-house; Available through ADB Office of External Relations; Free of Charge)

1. Improving Domestic Resource Mobilization Through Financial Development: Overview September 1985
5. Financing Public Sector Development Expenditure in Selected Countries: Overview January 1988
7. Financing Public Sector Development Expenditure in Selected Countries: Bangladesh June 1988
8. Financing Public Sector Development Expenditure in Selected Countries: Indonesia June 1988
10. Financing Public Sector Development Expenditure in Selected Countries: Pakistan June 1988
11. Financing Public Sector Development Expenditure in Selected Countries: Philippines June 1988
12. Financing Public Sector Development Expenditure in Selected Countries: Thailand June 1988
16. Foreign Trade Barriers and Export Growth

SPECIAL STUDIES, ADB (SS, ADB)  
(Published in-house; Available commercially through ADB Office of External Relations)

1. Rural Poverty in Developing Asia  
   Edited by M.G. Quibria  
   Vol. 1: Bangladesh, India, and Sri Lanka, 1994  
   $35.00 (paperback)  
   Vol. 2: Indonesia, Republic of Korea, Philippines, and Thailand, 1996  
   $35.00 (paperback)
2. External Shocks and Policy Adjustments: Lessons from the Gulf Crisis  
   Edited by Naved Hamid and Shahid N. Zahid, 1995  
   $15.00 (paperback)
3. Gender Indicators of Developing Asian and Pacific Countries  
   Asian Development Bank, 1993  
   $25.00 (paperback)
   Edited by Ernesto Pernia, 1994  
   $20.00 (paperback)
5. Indonesia-Malaysia-Thailand Growth Triangle: Theory to Practice  
   Edited by Myo Thant and Min Tang, 1996  
   $15.00 (paperback)
6. Emerging Asia: Changes and Challenges  
   Asian Development Bank, 1997  
   $30.00 (paperback)
7. Asian Exports  
   Edited by Dilip Das, 1999  
   $35.00 (paperback)  
   $55.00 (hardbound)
8. Mortgage-Backed Securities Markets in Asia

Edited by S.Ghon Rhee & Yutaka Shimomoto, 1999  
$35.00 (paperback)
9. Corporate Governance and Finance in East Asia: A Study of Indonesia, Republic of Korea, Malaysia, Philippines and Thailand  
   Vol. 1, 2000 $10.00 (paperback)  
   Vol. 2, 2001 $15.00 (paperback)
10. Financial Management and Governance Issues  
    Asian Development Bank, 2000  
    Cambodia $10.00 (paperback)  
    People's Republic of China $10.00 (paperback)  
    Mongolia $10.00 (paperback)  
    Pakistan $10.00 (paperback)  
    Papua New Guinea $10.00 (paperback)  
    Uzbekistan $10.00 (paperback)  
    Viet Nam $10.00 (paperback)  
    Selected Developing Member Countries $10.00 (paperback)
11. Guidelines for the Economic Analysis of Projects  
    Asian Development Bank, 1997  
    $10.00 (paperback)
    Asian Development Bank, 1999  
    $15.00 (hardbound)
    Asian Development Bank, 2000  
    $10.00 (paperback)

24
1. Informal Finance: Some Findings from Asia  
   Prabhu Ghate et. al., 1992  
   $15.00 (paperback)

2. Mongolia: A Centrally Planned Economy in Transition  
   Asian Development Bank, 1992  
   $15.00 (paperback)

3. Rural Poverty in Asia, Priority Issues and Policy Options  
   Edited by M.G. Quibria, 1994  
   $25.00 (paperback)

4. Growth Triangles in Asia: A New Approach to Regional Economic Cooperation  
   Edited by Myo Thant, Min Tung, and Hiroshi Kakazu  
   1st ed., 1994 $36.00 (hardbound)  
   Revised ed., 1998 $55.00 (hardbound)

5. Urban Poverty in Asia: A Survey of Critical Issues  
   Edited by Ernesto Pernia, 1994  
   $18.00 (paperback)

   Edited by M.G. Quibria, 1993  
   $15.00 (paperback)  
   $36.00 (hardbound)

7. From Centrally Planned to Market Economies: The Asian Approach  
   Edited by Pradumna B. Rana and Naved Hamid, 1995  
   Vol. 1: Overview $36.00 (hardbound)  
   Vol. 2: People's Republic of China and Mongolia $50.00 (hardbound)

Vol. 3: Lao PDR, Myanmar, and Viet Nam  
   $50.00 (hardbound)

8. Financial Sector Development in Asia  
   Edited by Shahid N. Zahid, 1995  
   $50.00 (hardbound)

9. Financial Sector Development in Asia: Country Studies  
   Edited by Shahid N. Zahid, 1995  
   $55.00 (hardbound)

    Christine P.W. Wong, Christopher Heady, and Wing T. Woo, 1995  
    $15.00 (paperback)

    Edited by M.G. Quibria and J. Malcolm Dowling, 1996  
    $20.00 (hardbound)

12. The Bangladesh Economy in Transition  
    Edited by M.G. Quibria, 1997  
    $55.00 (hardbound)

13. The Global Trading System and Developing Asia  
    Edited by Arvind Panagariya, M.G. Quibria, and Narhari Rao, 1997  
    $55.00 (hardbound)

14. Rising to the Challenge in Asia: A Study of Financial Markets  
    Asian Development Bank, 1999  
    Vol. 1 $20.00 (paperback)  
    Vol. 2 $15.00 (paperback)  
    Vol. 3 $25.00 (paperback)  
    Vols. 4-12 $20.00 (paperback)

SERIALS  
( Co-published with Oxford University Press; Available commercially through Oxford University Press Offices, Associated Companies, and Agents)

1. Asian Development Outlook (ADO; annual)  
   $36.00 (paperback)

2. Key Indicators of Developing Asian and Pacific Countries (KI; annual)  
   $35.00 (paperback)

JOURNAL  
(Published in-house; Available commercially through ADB Office of External Relations)

1. Asian Development Review (ADR; semiannual)  
   $5.00 per issue; $8.00 per year (2 issues)