The Economics of Agricultural Land Use Dynamics in Coconut Plantations of Sri Lanka

by

T. D. Marawila, T. Ancev and I. Odeh

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Outline

1. Introduction

2. Conceptual framework

3. Data and Methodology

4. Results and Discussion

5. Conclusion

1. Introduction

- Fragmentation and Conversion of agricultural land to other uses has been a primary concern
  - -Inability of markets to account for non-market benefits
  - -negative externalities

- Tax based policies : low property tax, use value programs , tax on fragmentation

- Zoning Restrictions

- Growth Management policy tools

- Economic Incentives/supports –subsidies, research and extension

- Farmland Protection Programs - conservation easements, development right, certification, programs, private rural land

- Land use exaction

Motivation

Fragmentation and conversion of prime coconut lands to other uses in Sri Lanka

-income and employment loss

-negative environmental externalities

Government intervention in coconut sector

- 1958 – Government entered into commercial farming
- 1971 – promoted cooperative farming
- 1972 &1975 - Land Reforms - Private ownership subjected to ceiling
- 1979 - Cess on Coconut exports
- 1992 - Privatization of Coconut plantations
- 2005 - Act of the control of fragmentation of Tea, Coconut, Rubber
- 2007 -Tax on unauthorized fragmentation (conversion)
- Subsidies (from 1973)
- Research and extension services (1928)

Broad Objective

To evaluate the land use change in the coconut triangle in Sri Lanka in a changing regional and policy environment and to determine the spatial and temporal effects of land use change

Specific Objectives

1. Characterize the spatial and temporal nature of land use change in a traditional coconut growing district of Sri Lanka

2. Identify and quantify the proximate economic, bio physical and geographical factors and processes that drive land use change

3. Predict future land use conversion pattern

Analytical framework

Model of land use conversion

following Bockstael (1996) and Carrion-Flores and Irwin (2004)

A profit maximising land owner will convert parcel *j* which is currently in land use *u* to land use *r* in time *t* if,

$$W_{jrt/u} - C_{jrt/u} \geq W_{jmt/u} - C_{jmt/u}$$

For all land uses m=1,……..,a…….,M

$W_{jrt}|u$ – PV of future stream of returns to parcel *j* in use *r* at time *t,* given that the parcel was in use *u* at time *t-1*

$C_{jrt}|u$ is the cost of converting parcel *j* from land use *u* to use *r* in period *t*

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Returns of land use can be treated as stochastic , and land use decision in probabilistic terms can be expressed

$$p \quad Y(it) = V_{ijt} + \varepsilon_{ijt} \geq 0$$

V_{idut} observable attributes

ε_{idut} random component of variables unobservable by the researcher

Spatial data → Spatial dependence

1. Spatial auto correlation –dependency of observations over space due to parcel specific or neighbourhood characteristics

2. Spatial heterogeneity –heteroscedasticity (non constant error variance)

When spatial autocorrelation incorporated into deterministic term (McMillen (1992) (Vichinesan et al. 2005)),

$$p \ \ Y \ \ it \ \ = \beta_{du} X_{idut} + Z_{it} + \varepsilon_{idut} \geq 0$$

X_{idut} vector of observable parcel specific and location specific variables
Z_{it} spatial dependencies across decision makers

To allow for spatial and temporal correlations across observations,

$$p \ \ Y \ \ it \ \ = \beta_{du} X_{idut} + Z_{it} + u_{it} + \varepsilon_{it} \geq 0$$

$u_{i.}$ individual and choice specific effect (random or fixed)/unobservable heterogeneity, observable by land owners

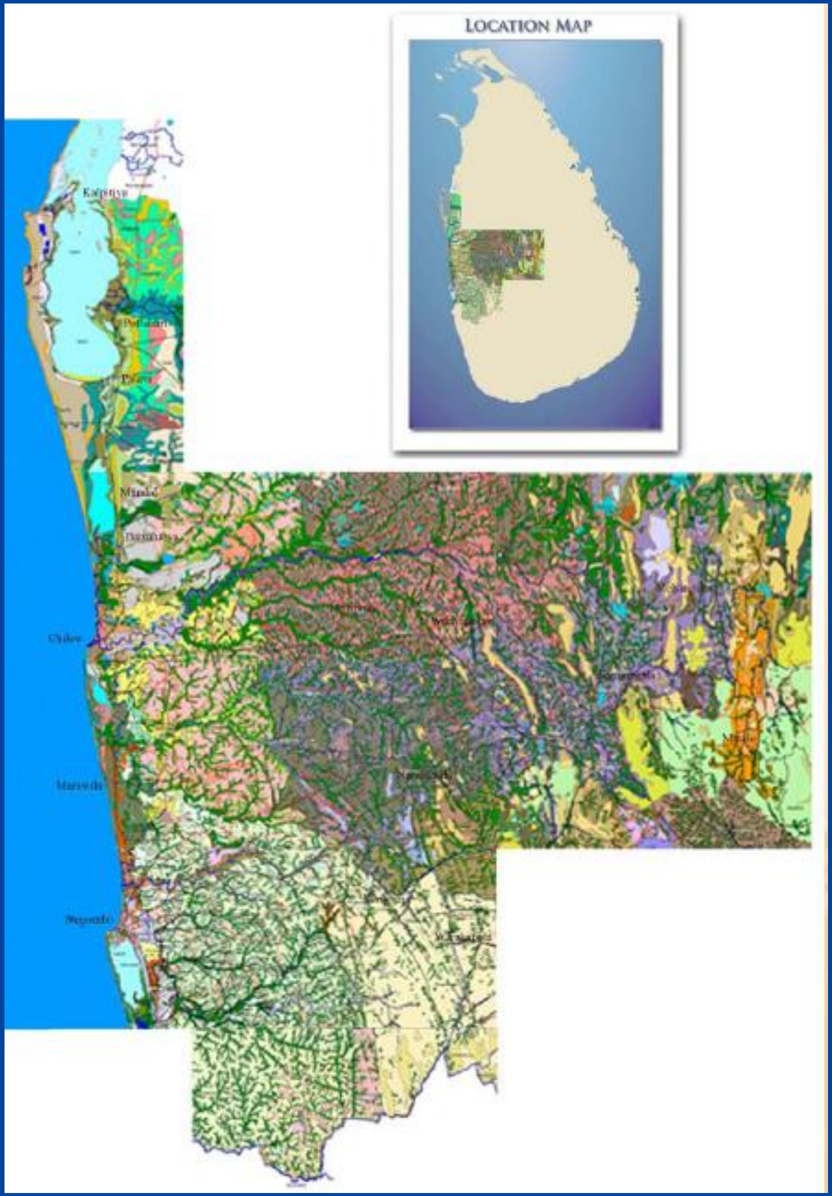
ϵ_{it} idiosyncratic error component which is individual as well as time specific

The econometric model

$$Y_{ijt} = \alpha + \beta_1 LSC_i + \beta_2 disturb_i + \beta_3 popd_{jt} + \beta 4\, forestd_{jt} + \beta 5 Avgyld_t + \beta_6 resext_t + Z_i + u_{ijt} + \varepsilon_{ijt}$$

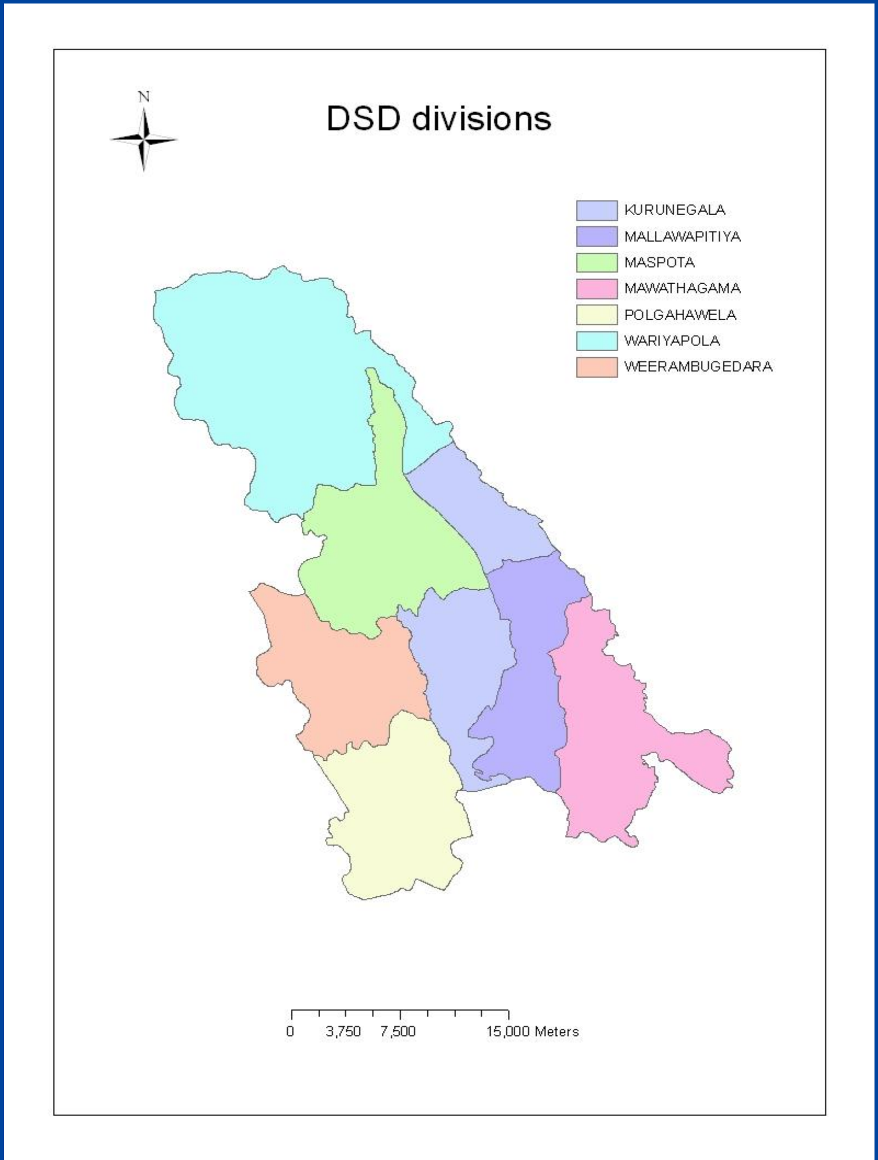
Y_{ijt}	land use observed in grid *i* in time *t*, in DSD *j* *cat 1= coconut <50%, cat2 =coconut 50-75% cat 3=coconut>75%* *cat4 = urban >50%, cat5 = other agriculture> 50%*
α	preference of an individual *i* to choose the *j* alternative (captures individual heterogeneity)
LSC_i	Land suitability class of individual *i*
$disturb_i$	distance to nearest urban centre
$popd_{jt}$	population density
$forestd_{it}$	Forest density
$avgyld_t$	10 yearly average yield
$resext_t$	10 yearly average subsidy and research extension cost
Z_i	spatial dependence across decision makers
$u_{i.}$	Individual specific effect
ϵ_{it}	idiosyncratic error component

Methods and Data



Source: Coconut Research Institute of Sri Lanka

Kurunegala district – 7 DSDs



area: 809.28 sqkm

- ***Data sources***

  1981 land use map-European digital archive of soil maps (EuDASM)
  1990 land use layers –Survey Department of Sri Lanka
  1990, 2001 and 2009 satellite images - (USGS) LANDSAT Thematic Mapper
  Land suitability maps: Coconut Research Institute, Sri Lanka

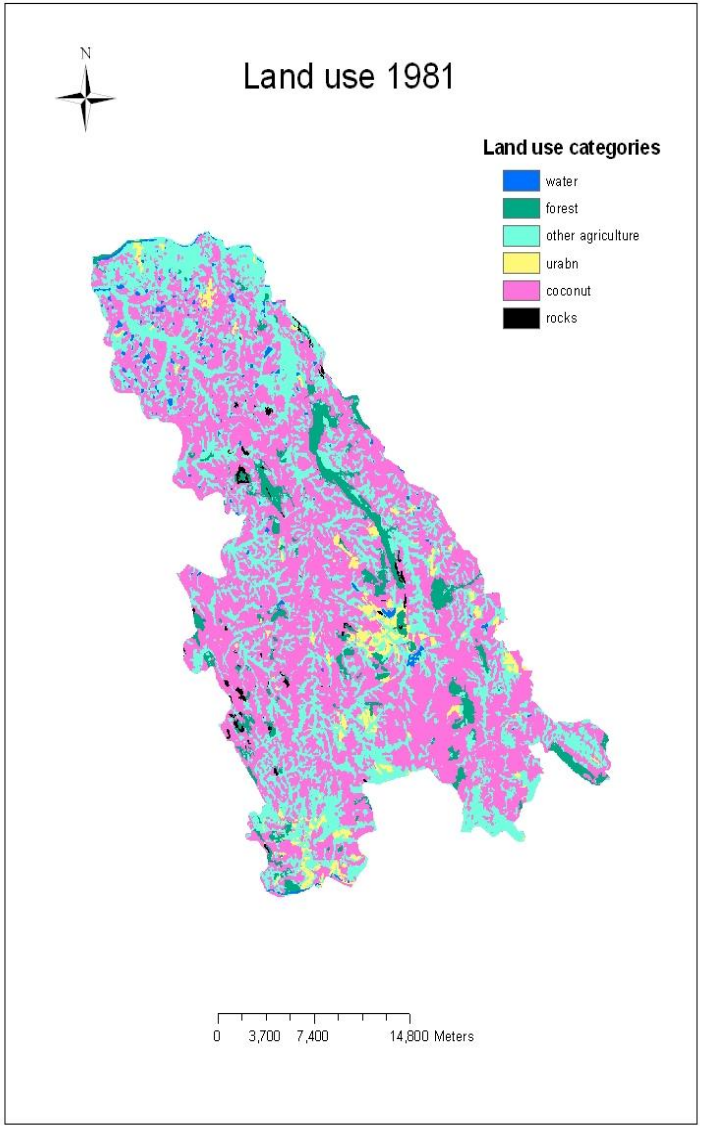
  geographic coordinate system : GCS_WGS_1984

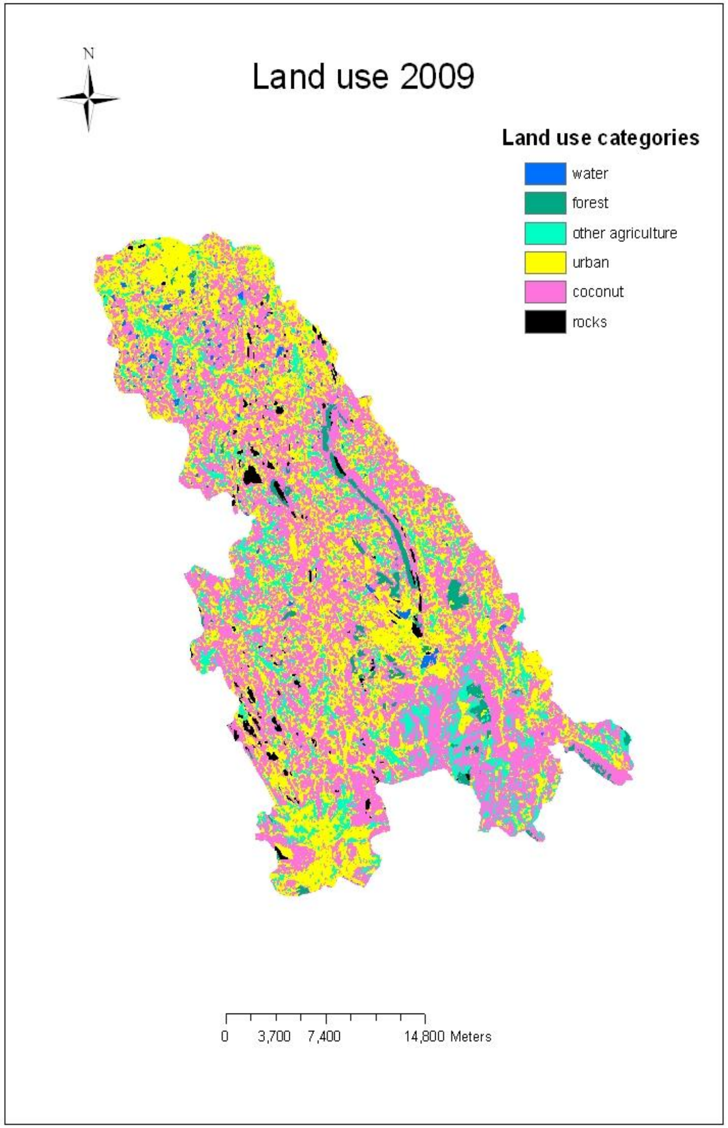
  Land use classification: ERDAS Imagine software,
  GIS analysis : ArcGis
  Markov chain/ CA_Markov analysis – IDRISI software

- ***Unit of analysis***: 500*500m grids, 13.692 grids

- ***Data***

Land use %, forest density, land suitability class, distance to urban centre - GIS
Data on average yield, research and extension cost, subsidies – CRI
Data on population- Department of Census and statistics


N
Land use 1981
Land use categories
water
forest
other agriculture
urabn
coconut
rocks
0 3,700 7,400 14,800 Meters


N
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water
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Methodology

Multinomial response panel model -unobserved effects correlated over time and space

→ spatial multinomial probit model with random effects

non linear model with single common random effect (Greene 2001)

$$Y_{it} \left| x_{it} \alpha_i \right. = g \quad y_{it}, \beta' x_{it}, \alpha_i, \theta$$

individual specific effect α_i has the specified distribution $h(\alpha_i \setminus \vartheta)$,

α_i need to be integrated, to obtain the likelihood function

$$\log L = \sum_{i=1}^{N} \log \left[\alpha_i \prod_{i=1}^{\tau(i)} g \quad y_{it} \left| x_{it}, \alpha_i, \beta, \theta \right. \right] h \quad \alpha_i \setminus \theta \quad d\alpha_i$$

-no analytical solution available (Cameron and Trivedi 2009) ,numerical integration used

Existing approaches

- ➢ Poisson/ negative binomial models with Gamma distributed RE (Chen and Kuo, 2001)
- ➢ Quadrature solution - Gaussian hermite (Hedeker (2003), Hartzel et al. (2001))
- ➢Simulated maximum likelihood (Hole (2007), Hanna and Uhlendorff (2006))

Method

multinomial data transformed into binary data by expanding observations to allow pair wise comparison of alternatives –(as in the mixed logit models)

- New binary choice variable generated for each record
- spatial dependence: negative exp function of the distance between two adjoining grids, included in deterministic component (Vichiensan et al. 2005)
- random effects: to capture unobserved characteristics that vary across individuals
- with random effects (Madala 1987) and spatial data probit model appropriate

↓

Binary probit panel model with random effects

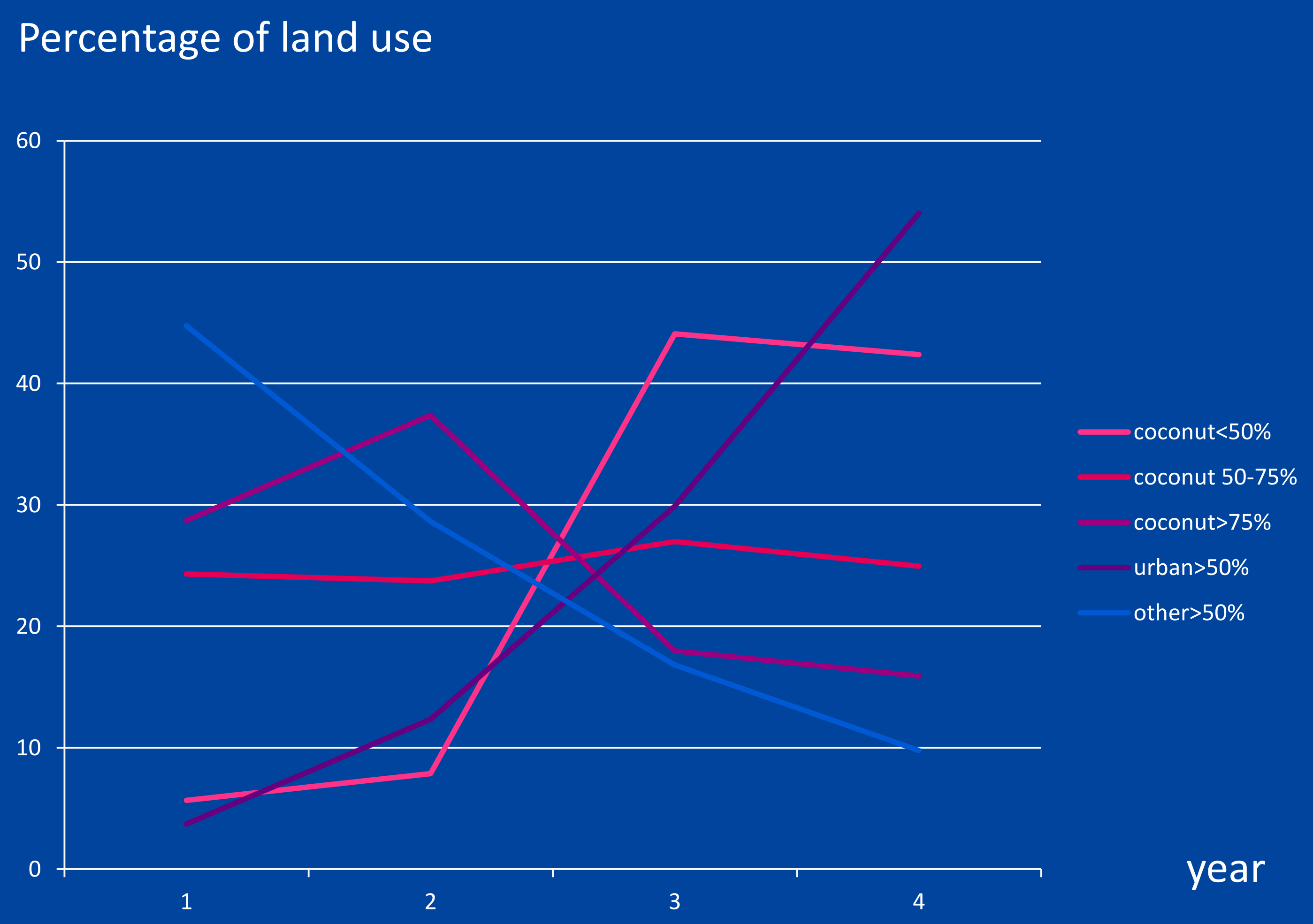
base =category 3

Results and Discussion

Transition between land use categories

	Coconut <50%	Coconut 50-75%	Coconut 75%	Urban > 50%	Other > 50 %
Year 1981-2001					
Coconut 50%	.432	.372	.112	.034	.049
Coconut 50-75%	.125	.456	.381	0.01	.027
Coconut >75%	.049	.137	.785	.017	.012
Urban % > 50%	.214	.071	.071	.643	0.00
Other% > 50%	.364	.119	.082	.034	.404
Year 1990-2001					
Coconut < 50%	.774	.106	.013	.092	.016
Coconut 50- 75%	.465	.456	.060	.012	.061
Coconut 75%	.146	.418	.427	. 076	.045
Urban > 50%	.146	.019	.023	. 760	.045
Other > 50%	.403	.110	.050	.036	.400
Year 2001-2009					
Coconut < 50%	.793	.091	.027	.081	.007
Coconut 50- 75%	.262	.623	.105	.017	.009
Coconut >75	.053	.405	.533	.062	.003
Urban > 50%	.203	0.00	.012	.783	.029
Other > 50%	.395	.240	.043	.017	.300

Land use change over last 30 years



Econometric results

	Coefficient	*Std Err*	*z*
Constant	-.6523624	.011669	-55.91
cata1	-10.03899	1.061998	-9.45
cata2	3.955422	1.058596	3.74
cata4	-11.77347	1.979737	-5.95
cata5	-4.491795	1.561683	-2.88
disuc1	-1.39e-06	1.95e-06	-0.71
disuc2	-.0000151	2.00e-06	-7.55
disuc4	.0000294	3.50e-06	8.41
disuc5|	.0000461	2.90e-06	15.91
popd1	1.99e-06	6.00e-07	3.33
popd2	-2.99e-06	6.03e-07	-4.96
popd4	.0000118	1.24e-06	9.57
popd5	3.82e-06	1.08e-06	3.53
resex1	.0054853	.000326	16.83
resex2	.0011896	.0003181	3.74
resex4	.001906	.0006312	3.02
resex5	-.0046884	.0005089	-9.21
for1	.0110554	.0006702	16.49
for2	.0017358	.0006499	2.67
for4	.0021815	.0013938	1.57
for5	-.0091719	.00104	-8.82

	Coefficient	*Std Err*	*z*
soil1c1	-.0304375	.040278	-0.76
soil1c2	-.0510338	.0416376	-1.23
soil1c4	.1443753	.0711951	2.03
soil1c5	-.2714253	.0552438	-4.91
soil2c1	-.0941196	.0307526	-3.06
soil2c2	.1378713	.0313844	4.39
soil2c4	-.1027928	.0564449	-1.82
soil2c5	-.607333	.043543	-13.95
ayld1	.001570	.0000885	17.75
ayld2	.0002015	.000087	2.31
ayld4	.000709	.0001685	4.21
ayld5	-.001673	.000156	-10.72
spd1	-.0543147	.0181981	-2.98
spd2	-.1258454	.0185247	-6.79
spd4	.1041271	.032429	3.21
spd5	.3689424	.0247765	14.89
lnsig2u	-3.76183	.023046	
sigma_u	.1524506	.0017567	
rho	.0227133	.0005116	

Discussion on econometric results

- As the distance to market centre increases more intensive coconut farming is practiced - Von Thunen's theory holds

- In highly suitable lands for coconut, intensive coconut farming is practised or converted to urban lands – Richardian theory holds

- In highly populated DSDs, conversion of large coconut farms has increased

- In DSDs with high forest density, conversion of large coconut farms has increased except for other agricultural lands

- Subsidies, research and extension do not prevent conversion of large coconut lands

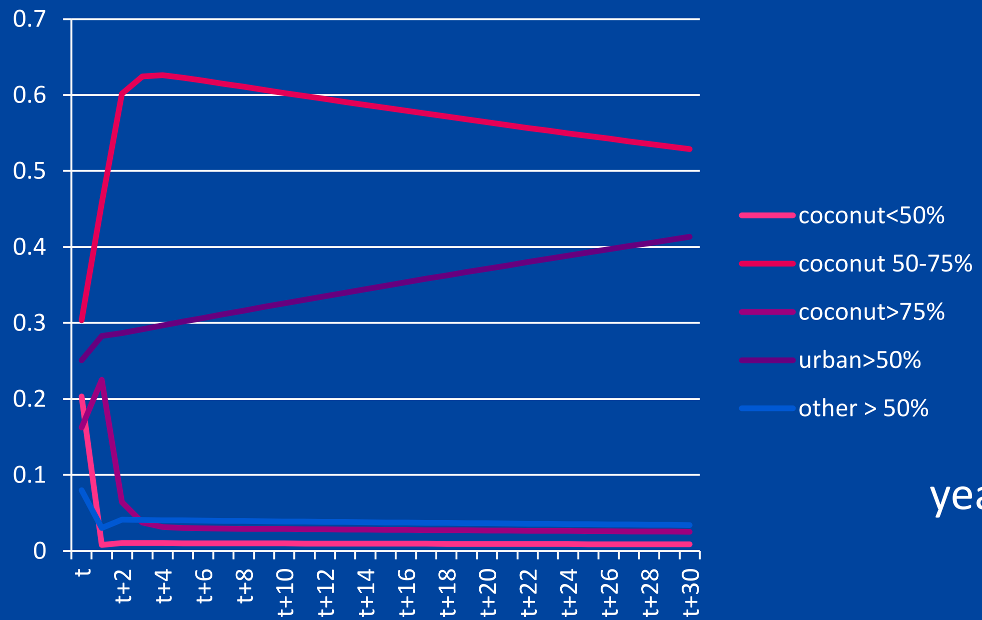
- Increase in average yield over the years has not been sufficient to prevent conversion of coconut.

- Conversion to urban takes place close to urban areas

Predicted land use change

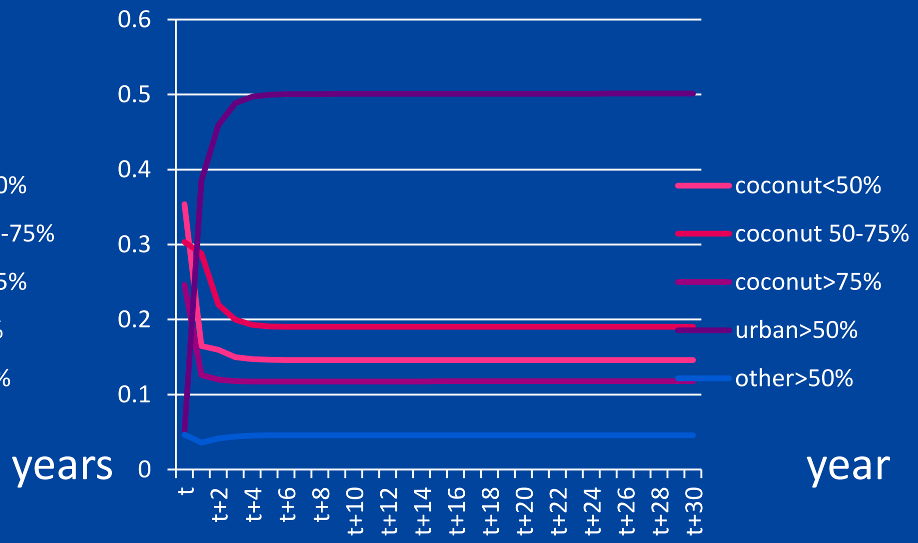
based on econometric analysis

probability



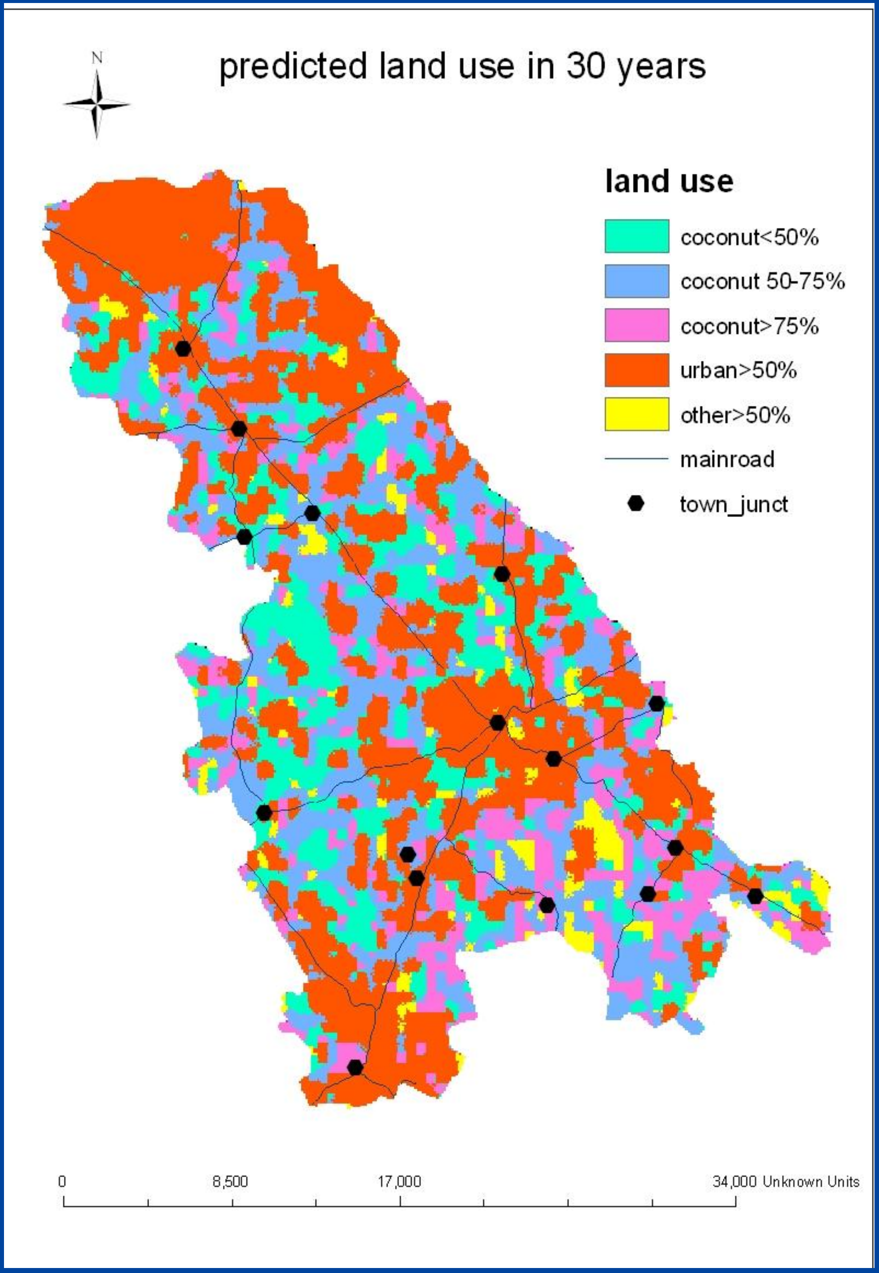
based on Markov Chain analysis

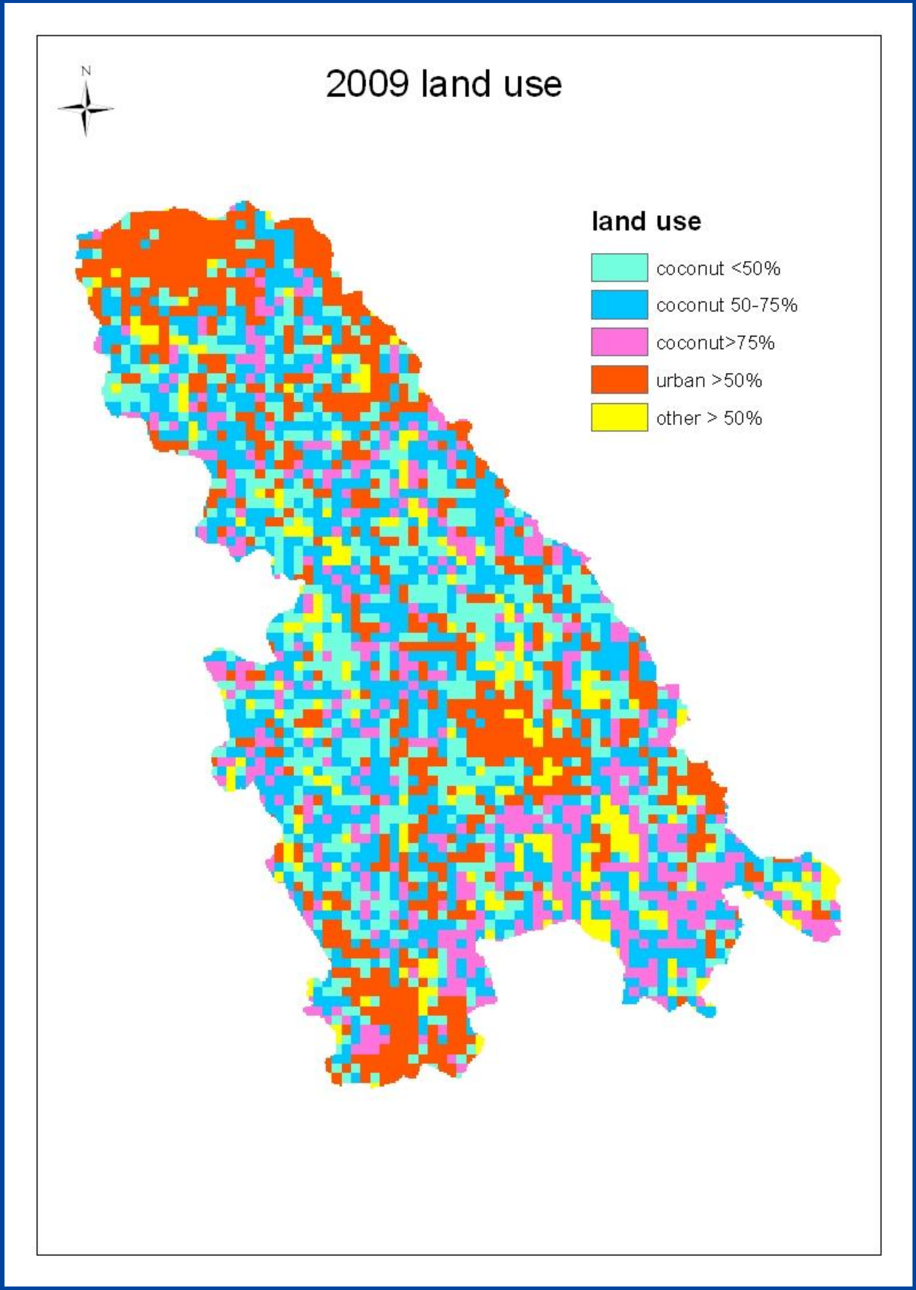
probability



(accuracy level 85%)

Spatial simulation





Conclusion

- The econometric results are according to the expectations and explains rational behaviour of land owners

- Conversion/fragmentation of large coconut plantations has increased
  - close to urban centres/less productive lands/highly populated DSDs

- Conversion to urban uses has taken places close to urban areas, main roads

- Other land uses (forest/other agriculture) has converted to coconut
  - compensated the loss to greater extent

- Next step
  - polygon based analysis –corresponds to individual decision making
  - evaluate impact of land use policy tools
  - environmental impacts

Thank You