Model Classification

		Model name	*Model name*	*Model name*	*Model name*
		Clue-s	**ICLUS**	**I-Places3s**	**IPM**
Background information	**Technical Platform/software**	Own developed DMS software of ObjectVision	ArcGIS-based	Web-based system, i.e. no specialized hardware/software is required. (based on ESRI's ArcIMS software, which is an outdated platform) Model home-Page is down (http://places.energy.ca.gov/places/)	ArcGIS-based
	Data types	Raster, grid	Raster grid	Raster grid (vector)	Raster grid (vector)
	Dependency of other software (if any).	ArcGIS Spatial analyst extension is necessary to graphically display results. SPSS/SAS statistical software needed for allocation regression analysisi and to evaluate results.	-	Dependent on access to a third-party GIS program (e.g. ESRI's ArcGIS) for data preparation, and any transport model for transport data input.	Extension Spatial analyst required
	OP system	Windows 32 bit only	Windows 32/64	n.a.	Windows 32/64
	Ownership, diffusion and any legal issues	Free download Wageningen University, NL. Demo-version of model is also distributed as freeware.	Free download (ArcGIS toolbox)	Unclear (Probably free, but Model home-page is down) Managed by SACOG and a private company provides programming, maintenance and web hosting. SAOG is currently migrating to other model (UrbanFootprint)	Free (with permission of Stockholm County Council)
	Modular or monolithic software	Modular (2) (Non-spatial demand module and Spatial allocation module, based on regression analysis)	Modular (ICLUS consists of a demographic and a spatial allocation model.)	Monolithic (But dependent on transport model for input transportation data)	Modular (part of an integrated model system with regional economic model rAps, and transport model LuTRANS)
	Age, year of dev.	1996-	2009-	1996-	2006-
	Number of implementations (if any)	More than 30. Latest implementation 2010. Among the most frequently used land use models globally.	One found, in 2013	2 found (SACOG and King County, WA)	Around 5 Latest implementation in 2011. Further development of model is currently ongoing.
	User Manual/Support?	User manual is available, but no support.	User manual is available, but no support	User manual is available, unclear about support	Basic user manual is available User support on agrement with WSP Sweden
Classification Variables	**Main field of application, markets covered**	Mainly agricultural/natural environmental applications (land use change), but the model can probably also be used to outline future urban areas. Scenario based, driven by demand in submodel 1.	Integrated Climate and Land Use Planning. Allows users to create and compare scenarios reflecting policy choices	Regional and comprehensive urban planning Allows users to create and compare scenarios reflecting policy choices	Regional Planning. Future land use, policy driven Allows users to create and compare scenarios reflecting policy choices
	Input data: Spatial, thematic	Restrictions, current and historical land use (via satellite images, mandatory), allocation characteristics etc. -> consolidated suitability	Housing units, undevelopable land, percent impervious surfaces	"Places" are the spatial building blocks, and are user defined. E.g. Housing, Employment, Transport, Infrastructure, Energy, Constraints etc.	Building density, transport accessibility, statistics, green areas, elevation data, planning restrictions -> Suitability based on multi criteria analysis
	Input data: Non-Spatial	Land Use-demand in several categories (from submodel1) Spatial policies, translated into weighting of physical factors	County Population Projections, Housing Density Projections Assumptions on demographic factors needed for demographic model (e.g. fertility, mortality, migration etc.)	Assumptions on avg. future household size, floorspace size etc.	Forecasts of housing, population and employment (from regional economic and population model)
	Output data: Spatial representation	Maps of future land use in different categories, main focus on agricultural land	Maps of future built up areas (urban land use), future land demand for different activities	Maps of the geographical distribution of the total demand for housing and employment. Avg. density for different land use categories, etc.	Maps of future built up areas, change in densities, Spatial representation of future land demand and urban growth, total and for different activities (housing and employment) according to scenario.
	Output data: Non-spatial	Unclear	Metric data: Mainly changes in demographic structure	Metric data: Energy, Emissions and other mainly environmental indicators for comparision of scenario results.	Metric evaluation data E.g. Land demand, average built up densities per optional area, loss of valuable land.

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	Clue-s	**ICLUS**	**I-Places3s**	**IPM**
Evaluation possibilities	Quantification of (environmental) impacts is possible	Climate/environmental impact (mainly water quality and air quality). Rates of growth in different scenarios, Housing density trends, land demand. Impervious surfaces	Comparison of output parameters (spatial and non-spatial) between different scenarios.	Spatial impact according to policy, allocation efficiency, claims for land for different activities, indicators of nature issues etc.
How are planning goals and policies treated?	Poorly handled. Given input to sub-model 1,(demand module), but the allocation module is based on historical patterns (statistical regression analysis).	By projections of future urban densities	Given input, adjustments of input parameters according to policy scenarios.	Given input (model driven by planning policies)
Time scale	Year by year	Incremental (time-step)	Unknown	Time-step
Spatial scale, resolution and scalability of model	Country, Large regions. Semi-Scalable Standard is 1 km square	Country, Region Scalable? 100x100 m – 1000x1000 m (Transferability? (Customized to the USA)	Regional to local level Scalable 100x100 m raster grid	Country, Region, Municipality Scalable 100x100 m grid
Model engine and behavioural assumptions	Hybrid (CA, Statistical Analysis, decision rules)	Equilibrium (demographic model), Unclassifiable (allocation model)	Rule-based simulation. Regression analysis of observed patterns.	Rule based simulation. Multi-criteria analysis

Model Classification

		Model name	*Model name*	*Model name*	*Model name*
		Land Change Modeler	**Land-Use Scanner**	**LEAM**	**LUSIS**
Background information	**Technical Platform/software**	ArcGIS or IDRISI	Own developed software Special GeoDMS software (free) needed.	Web-based LEAM Desktop which is embedded in a web-based collaborative environment, called the LEAM Planning Portal. Based on open source PLONE.	ArcGIS-based
	Data types	Raster grid (vector)	Raster grid	Raster, grid but also accepts vector data	Raster grid
	Dependency of other software (if any).	-	GeoDMS software (free)	Requires some sort of GIS-system for preparing spatial input data.	ESRI ArcGIS extension spatial analyst needed
	OP system	Windows 32/64	Windows 32/64	n.a.	Windows
	Ownership, diffusion and any legal issues	Commercial software Clark labs (Clark University, MA, USA)	Unclear (For information on setting up a land use model for a different study area, contact developer Object Vision.) VU University Amsterdam and Netherlands Environmental Assessment Agency (PBL) Free demo-version available: http://www.objectvision.nl/demos/download-page	Commercial software Licenced from LEAM Group Inc.	Free (Available as digital copy (CD) in printed edition of "Smart Land-Use Analysis The LUCIS Model" ESRI Press)
	Modular or monolithic software	Monolithic	Monolithic	Monolithic	Monolithic
	Age, year of dev.	Around 2005 (unclear)	1997-	2005	App. 1995-2005
	Number of implementations (if any)	Unknown	More than 10. Latest implementation 2009. Unclear if transferable outside NL.	More than 10. Latest implementation 2012. [Is currently being tested in the Stockholm Region by KTH]	Less than 10 Latest implementation 2009
	User Manual/Support?	No user manual, but technical support available	User manual is available, unclear about support	User manual is available + support	User manual not found Unclear about support
Classification Variables	**Main field of application, markets covered**	Land planning and decision support planning. Main focus on natural environment and climate change. Urban land use is regarded as an integrated part of total land use. Ecological sustainability.	Regional planning. Policy oriented. Allows users to create and compare scenarios reflecting policy choices	Regional and Urban planning, Policy oriented Allows users to create and compare scenarios reflecting policy choices	Land use conflict detection. Scenario/policy driven tool.
	Input data: Spatial, thematic	Historical land use (satellite images) required. Test of "drivers" that explains current land use from historical data (e.g.accessibility).	Suitability drivers (dependent on policy), e.g current land use, built-up density, biophysical conditions etc.	"Driver sets", consisting of population and employment centres, transportation network, land use data and elevation data (all required). Additional data can be restrictions and other drivers.	Different kinds of spatial thematic land-use data, corresponding to the scenario investigated
	Input data: Non-Spatial	Unknown	The model is driven by forecasts at a national or regional level in terms of variables such as population, agricultural production, infrastructure, etc. Regional demand, e.g. projections of housing, employment, etc.	Population and Employment projections (on different levels if desired)	Policy decisions and preferences for future land use
	Output data: Spatial representation	Maps/data of land change, including gains and losses, net change, persistence and specific transitions.	Maps of future land demand for different land use activities	Maps of future land use: Spatial raster data sets: - Change map, which provides the final land use state of each changed cell. - Population per cell map, which provides the final residential population - Employment per cell map, which provides the final employment. - Year map, indicates when a cell changed state	Mapping areas of land-use conflict according to policy decisions. Unclear allocation mechanism.
	Output data: Non-spatial	Unknown	Unknown	Metric data: Population and employment (amount of) distribution in different geographical areas, dependent on scenario design.	Metric data: Sum of land-use conflict (area) in different land-use categories. Sum of future built up land.

Model Classification

	Model name	*Model name*	*Model name*	*Model name*
	Land Change Modeler	**Land-Use Scanner**	**LEAM**	**LUSIS**
Evaluation possibilities	Indicators of land cover change on habitat including habitat status and assessment, habitat change analysis, gap analysis, and landscape pattern analysis. Impact assessment calculates biodiversity changes.	Mainly connected to separate model "Environmental explorer", but other indicators can also be calculated in order to compare scenarios.	Mainly indicators of environmental impact, stress indicators, water quality, green infrastructure	Unclear
How are planning goals and policies treated?	Unknown	Given input, basis for different land use output	Given input, by designing the setup of “Drivers” which affects suitability according to scenario. Allows for scenario testing	Given input, driven by planning policies which affects suitability according to scenario.
Time scale	Single time-step	Time step (limited n.o., usually 1-5)	Various time-steps, dependent on population and employment projections	Time step
Spatial scale, resolution and scalability of model	Country, Region Non-scalable 100x100 m cell size (typically)	Country, Region, Municipality Scalable 100x100 m cell size, up to 500x500 m dependent on size of study area	Region, municipality Scalable 30x30 m cell size.	Country, Region, Municipality Scalable 100x100 m cell size (typically)
Model engine and behavioural assumptions	Unclassifyable, close to cellular automata simulation based on geographical regression analysis of past land use change.	Unclear Logit-type approach based on discrete choice theory – probability.	Hybrid: Cellular automata, Rule-based	Multi-criteria analysis

Model Classification

		Model name	*Model name*	*Model name*	*Model name*
		Metronamica	**MOLAND**	**TELUM**	**UPLAN**
Background information	**Technical Platform/software**	Own developed software (Geonamica) [Parallel model to LUM MOLAND (RIKS)]	Own developed software (Geonamica) [Parallel model to LUM Metronamica (RIKS)]	Own developed software. Linked to ESRI ArcGIS software for display of results.	ArcGIS-based
	Data types	Raster grid	Raster grid	Vector	Raster grid
	Dependency of other software (if any).	Any GIS software for data preparation	Any GIS software for data preparation	(Any) travel demand model is needed in order to give input to LUM	ESRI extension Spatial analyst needed
	OP system	Windows	Windows	Windows	Windows
	Ownership, diffusion and any legal issues	Commercial software Licenced from RIKS, NL Free demo-version is available	Commercial software Licenced from RIKS, NL Developed by EU-Commission Joint research centre (JRC) and RIKS Maastricht. Unclear how to obtain model, and cost. MOLAND LIGHT (web-based) is free as demo-version. Developed in cooperation with PLUREL (Univ. of Copenhagen).	Free download Developed by New Jersey Institute of Technology (NJIT), USA	Free download University of California
	Modular or monolithic software	Modular (four sub-models, see Input data box)	Modular (four sub-models, see Input data box)	Monolithic (but travel demand model is needed in order to give input to LUM)	Monolithic
	Age, year of dev.	2010-	1998-	1996-	2007-
	Number of implementations (if any)	More than 10. Latest implementation in 2013 [Model used in Copenhagen in 2012]	More than 10. Latest implementation found in 2012 (Dublin) [Has been tested in the Helsinki Region in 1998]	More than 10 (only in USA). Latest implementation 2012	More than 10 Latest implementation in 2012
	User Manual/Support?	User manual is available + Support	Not found for full model, but case studies are available User manual for MOLAND LIGHT is available	User manual is available	User manual is available
Classification Variables	**Main field of application, markets covered**	Regional planning/planning support system. Policy oriented model. Future land use projections according to different policy scenarios.	Mainly regional planning. Future land use projections according to different policy scenarios.	Integrated Transportation-Land-Use planning. Land-Use impacts of new transportation infrastructure.	Regional and Sub-regional (municipality) planning. Policy-oriented model. Allows users to create and compare scenarios reflecting general plans.
	Input data: Spatial, thematic	Land-use in 24 classes	Land-use in 24 classes	Regional forecasts (and observed) on households and employment on Traffic Analysis Zones (TAZ). Future transportation system.	Seven major urban land-use classes (for allocation) “Attractors”, different land-use categories and spatial data which is used to make up the suitability layer. Restrictions for future land-use General plans
	Input data: Non-Spatial	Data input needed from other models: - Regional economic model (future regional employment) - Regional demographic model (Future regional population) - Transportation model (Accessibility) - Land claim model (Future regional land demand) = Input to CA-distribution model [Policy decisions that sets the basis for transition rules]	Data input needed from other models: - Regional economic model (future regional employment) - Regional demographic model (Future regional population) - Transportation model (Accessibility) - Land claim model (Future regional land demand) = Input to CA-distribution model [Policy decisions that sets the basis for transition rules]	Travel times from transport model Regional projections of future population and employment	Regional projections on housing and employment for allocation (converted to land demand)
	Output data: Spatial representation	Maps of future land use, divided into several land-use classes	Maps of future land use in different classes (Maps and quantitative data on land allocation qualities)	Maps of future location (and relocation) of forecasted employment and households on aggregated (TAZ). Future employment and household density by zone.	Maps of future urban land use, according to scenario
	Output data: Non-spatial	Metric data: Metronamica comes with a set of predefined spatial indicators revealing, for example, the expansion of urban areas, habitat fragmentation and the distance from residential location to the nearest recreation site.	Metric data: E.g. quantitative data of land-use change for different areas, loss of green area etc.	Metric data: Calculates the amount of households and employment that are allocated. Amount of land demand for future urban areas. Land consumption by zone.	Metric data: Total amount of land demand, land consumption, cost for development, environmental impact, degree of compliance to existing plans etc.

Model Classification

	Model name	*Model name*	*Model name*	*Model name*
	Metronamica	**MOLAND**	**TELUM**	**UPLAN**
Evaluation possibilities	Impact assessment (e.g. effects of new transport system, changing population structure, environmental concerns, land demand etc.). Sustainability of planning policy (compact growth vs urban sprawl)	Different measures of spatial distribution qualities	Mainly connected to land-use changes in response to new infrastructure investments: “New urban configuration”	Several opportunities. Calculation of green-gas emissions can be calculated in the post-model “Greenhouse Gas Calculator”
How are planning goals and policies treated?	Given input to suitability analysis according to policy decisions, which determine the transitions rules.	Given input. Policy decisions sets the basis for transition rules, which determine the transitions rules.	Poorly handled, main study is impact of improved infrastructure investments on land-use change patterns.	Given input to drive suitability (which drives allocation)
Time scale	Year by year	Year by year	Time-step (usually 5 years)	Time step
Spatial scale, resolution and scalability of model	Country, Region, local, (cell size accordingly) Scalable 100x100 m cell size (typically)	Country, Region, local, cell size accordingly Scalable 100x100 m cell size (typically)	Region, Municipality Scalable Resolution dependent on size of TAZ	Region, Municipality Scalable 100x100 m cell size
Model engine and behavioural assumptions	Cellular Automata (Constrained) Transition rules determine cell change, based on Suitability, Accessibility, Zoning (restrictions, plans etc.), Local dynamics (quality of neighbourhood)	Cellular Automata (Constrained) Transition rules determine cell change, based on Suitability, Accessibility, Zoning (restrictions, plans etc.), Local dynamics (quality of neighbourhood)	Input-Output Econometric model.	Rule-based simulation

Model Classification

		Model name	*Model name*
		URBANSIM	**What-IF**
Background information	**Technical Platform/software**	Own developed software. Coded in Python, Open Platform for Urban Simulation (OPUS). Graphical interface facilitates access to complex internal operations by non-programmers.	Own developed software Stand-alone system from WhatIF? Inc.
	Data types	Raster, vector	Raster grid
	Dependency of other software (if any).	Python, GPL	Input and output data can be prepared/analysed in ArcGIS (built-in link for displaying output data)
	OP system	Windows, Linux and Macintosh OS X	Windows
	Ownership, diffusion and any legal issues	Free download (open source software using the GPL license) Developed by Paul Waddell (University of California, Berkeley)	Commercial software Licenced from WhatIF? Inc. Free demo-version is available for testing
	Modular or monolithic software	Modular	Monolithic
	Age, year of dev.	1998-	1996-
	Number of implementations (if any)	About 50. Widely used all around the world. Probably the most used land use model in the world.	More than 10. In the USA and worldwide. Latest implementation 2012
	User Manual/Support?	User manual is available Support via web community on model home page	User manual is available + support
Classification Variables	**Main field of application, markets covered**	Regional and urban planning. Accounts for total "urban system" interdependency: Transportation system, housing market, labour market, real estate, commercial, industrial and office space etc…	Regional and urban planning. Policy oriented model.
	Input data: Spatial, thematic	Excessive need for spatial data - Employment data - Household data - Parcel database - City and County General Plans - GIS Overlays for environmental features - Traffic Analysis Zones	Different land-use categories. Fixed land-use classes (optional number of in model set-up)
	Input data: Non-Spatial	Travel Model outputs, exogenous given Macroeconomic model outputs, exogenous given Other exogenous input: Population and employment estimates, Land development policies such as density constraints, environmental constraints, and development impact fees. Regional economic forecasts, Development Costs.	Regional population and employments projections. Assumptions on household size, density, growth rate etc.
	Output data: Spatial representation	Maps of future year distributions of population. Land use by type (user-specified). Densities of development by type of land use.	Maps of future land-use on different land-use classes, accordingly to model set-up. Physical distribution of households, employment etc.
	Output data: Non-spatial	Metric data: Future households by type (e.g. income, age of head, household size, presence of children, and housing type). Businesses by type (e.g. industry and number of employees). Units of housing by type. Other: Households by income, Employment by land use type, Acreage by land use, Real estate prices etc etc.	Metric data: Model reports generated for each run, including/summarizing all scenario-settings and predefined results/figures in tabular form.

Model Classification

	Model name	
	URBANSIM	**What-IF**
Evaluation possibilities	Several opportunities in various fields, e.g. Environmental: Greenhouse Gas Emissions, Pollution, Energy Use, Water Use	Model reports generated for each run, including/summarizing all scenario-settings and predefined results/figures in tabular form. Other impact indicators: Land demand for different land-use classes. Allocation quality according to scenario can be calculated, e.g. total amount of new urban areas, loss of green areas, amount of new urban areas in “good” locations etc.
How are planning goals and policies treated?	Given input when creating scenarios. Many types possible planning variables.	Given input for suitability preparation according to planning policy/scenario. Also as input to parameters such as assumed household size, density etc.
Time scale	Year by year (or optional time step)	Time-step (Usually 5 years)
Spatial scale, resolution and scalability of model	Country, Region, Municipality Scalable Resolution dependent on parcel size, or cell size, typically 100x100 m	Country, Region, Municipality Scalable 100x100 m cell size
Model engine and behavioural assumptions	Multi-agent-based micro-simulation Based on random utility theory and uses logit models for discrete choices.	Rule-based simulation