ISINAPSYS
[Organización que Aprende]®

Urban Dynamics Learning Lab.

Published for:

The 32nd International Conference of the System Dynamics Society, Delft, Netherlands

July 20 – July 24, 2014

Good Governance in a Complex World

AUTHORS

Pedro Dagoberto Almaguer Prado. Ing.	pedrodago@gmail.com	Author
Beatriz Eugenia Navarro Vázquez, Lic.	bety.5505@gmail.com	Collaborator
Ruth Raquel Almaguer Navarro	ruth_ran@hotmail.com	Design
Ramiro Luis Almaguer Navarro, Lic.	rmalmaguer@gmail.com	Modeling
Pedro Dagoberto Almaguer Navarro, Lic.	pan.dago82@gmail.com	Collaborator

March 12, 2014

OBJECTIVE:

The growth or decline of cities is a very current issue in which we can help our authorities taking better decisions in urban policies. It involves complex and non linear interconnections that should be studied by methods that iluminate the feedback cycles that underline the urban dynamics and cause decisions be counterintuitive.

In this activity, the students will discover the cause-effect cycles that link the use of the soil with the building construction for bussiness, houses for people, and at the same time, with the dynamic wroght of population in the Phase I. And after that, to connect with water, food cultivation, pasture for animals, the animals and their milky products, as well as their meat and articles for the human consumption; the income production and its relation with predators and hunters in Phase II. All together to develop better policy decisions for a sustainable long-term educational proyect.

Key Words - Ecology and Environment, Urbanism, Sustainability, model, simulation

Contents

Table of illustrations

INTRODUCTION

The study of urban growth or decay, is a key element for the design of policies to keep a community in harmony with its environment that also be attractive to potential residents that find a job, a stable economy, a good place to live, and, at the same time, to make it a solid foundation to generate taxes for the city and benefit the whole community.

Jay Forrester wrote a controversial book "Urban Dynamics". In this book, he marked many of the wishes of those who plan the cities and trayed to stop the urban decay at the end of the 20th century. The book shows how and why they took wrong decisions. The writer suggested that some of the policies implemented to stop the urban decay, instead of help, intensified it. (Where have I heard that? It happened in our America, our cities as Monterrey, México, D.F., Monclova, Saltillo, and smaller cities like Muzquiz, Coahuila or Reynosa in Tamaulipas, etc.).

What basically happens is that issues of increasing and decreasing urban growth, involve complex interconnections that are unlinear and as such, should be studied by computer simulation methods that iluminate the multiple feedback cycles that involve such dynamics; using simulation to study policies and change provided conclusions that stimulate heated discussions between the leaders of the city, causing many times counter-intuitive results, where logic seems to have no logic.

The concern with the growth or decline of a city, is usually focused on the economical changes, in this case, we chose the increasing or decreasing of the current physical construction of buildings that support the bussiness activity as an indicator of the economic health of a city. I suggest to extend this vision to encompass social and environmental issues such as population density, or overcrowding, the dwelling size, underemployment and unemployment, cultivation and food supply, animal products and the use of water to obtain indicators about the quality of life and the sustainable management of resources.

Given the problems caused by natural disasters like the hurricane "Alex", that hit the city of Monterrey, N.L. Mexico, the wrong decisions taken in matter of urbanism were underlayed. Those decisions have been taken during years by our local and state government. It's transcendental to bring practical science to the leaders of our cities. To put all the pieces togehter and desing new policies or strategies that help us to visualize the impact of our decisions on time, and find as a main goal, the sustainable growht of the city, by the enormous advantages of doing things in a coordinated agreement, respecting environment, economy and society.

That's the target of this **learning lab**, wich aims to provide an urbanic sustainable education to those who plan and are responsible for the growht of our cities.

Steps for the development of learning jab.

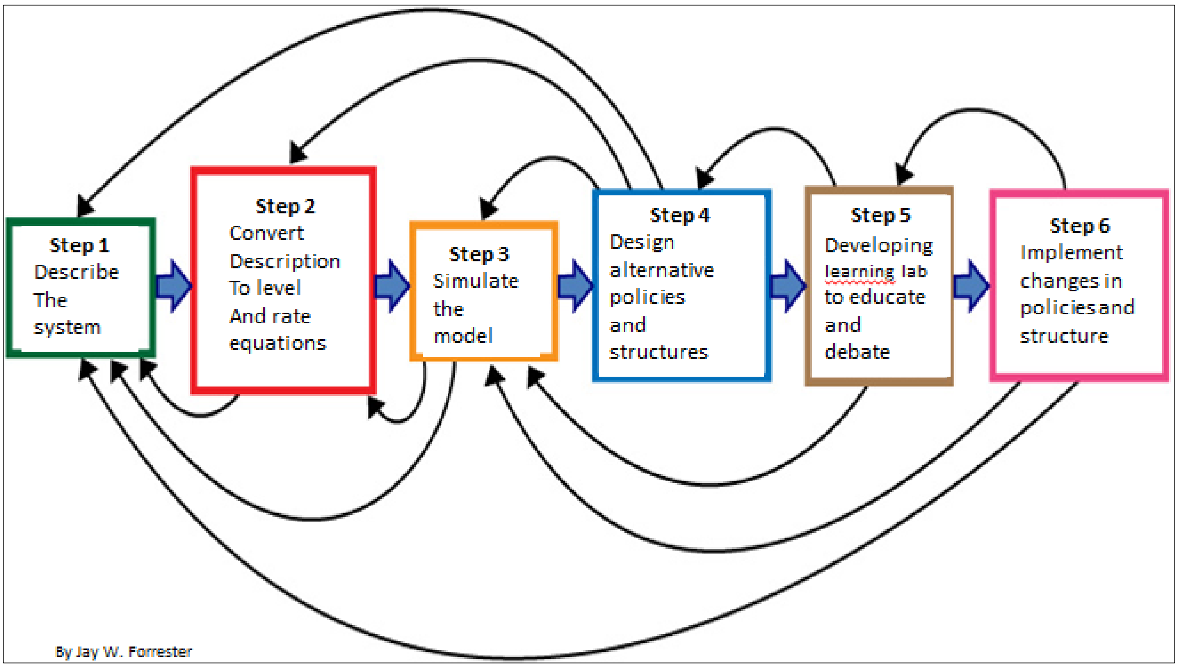
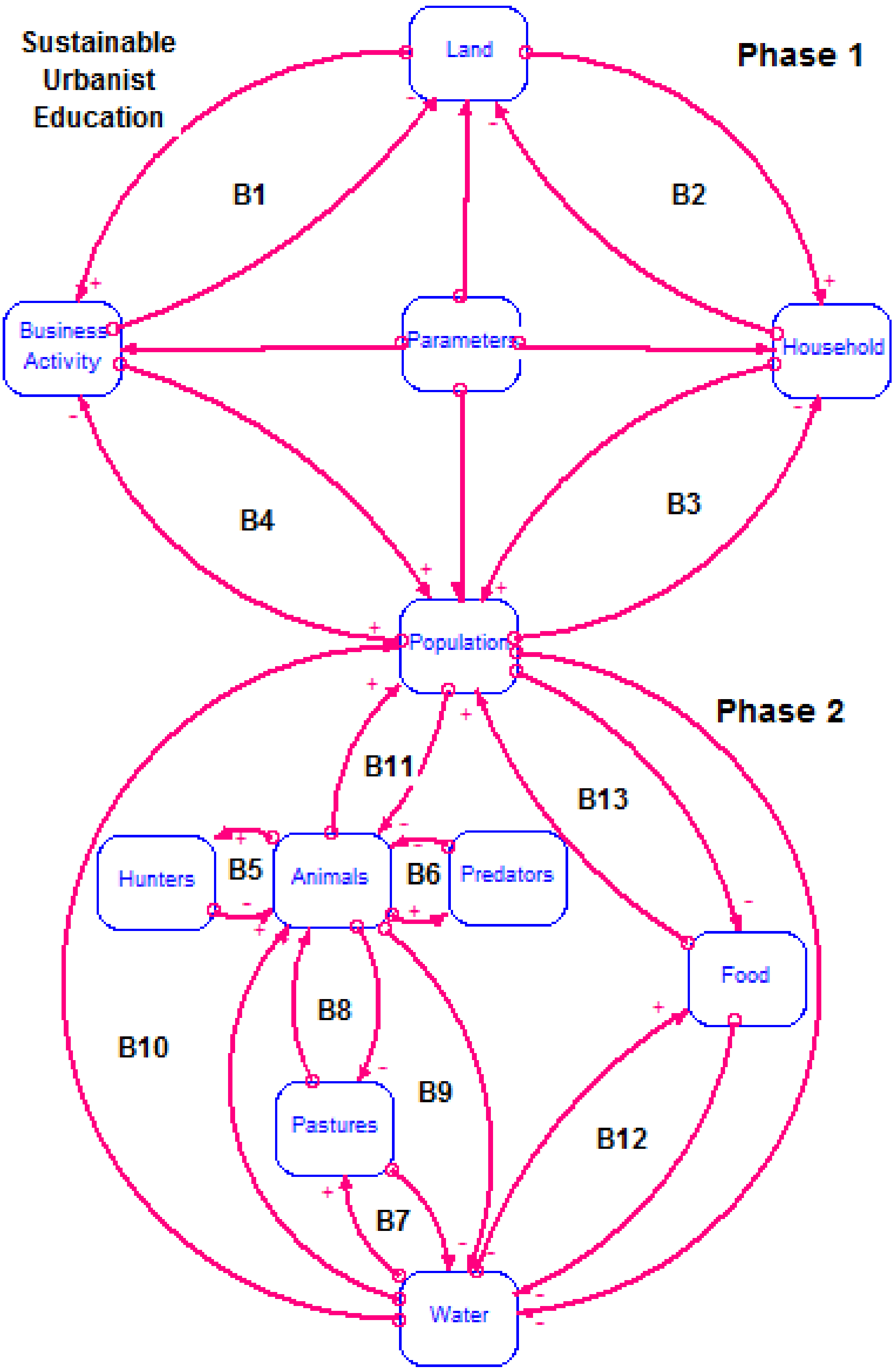


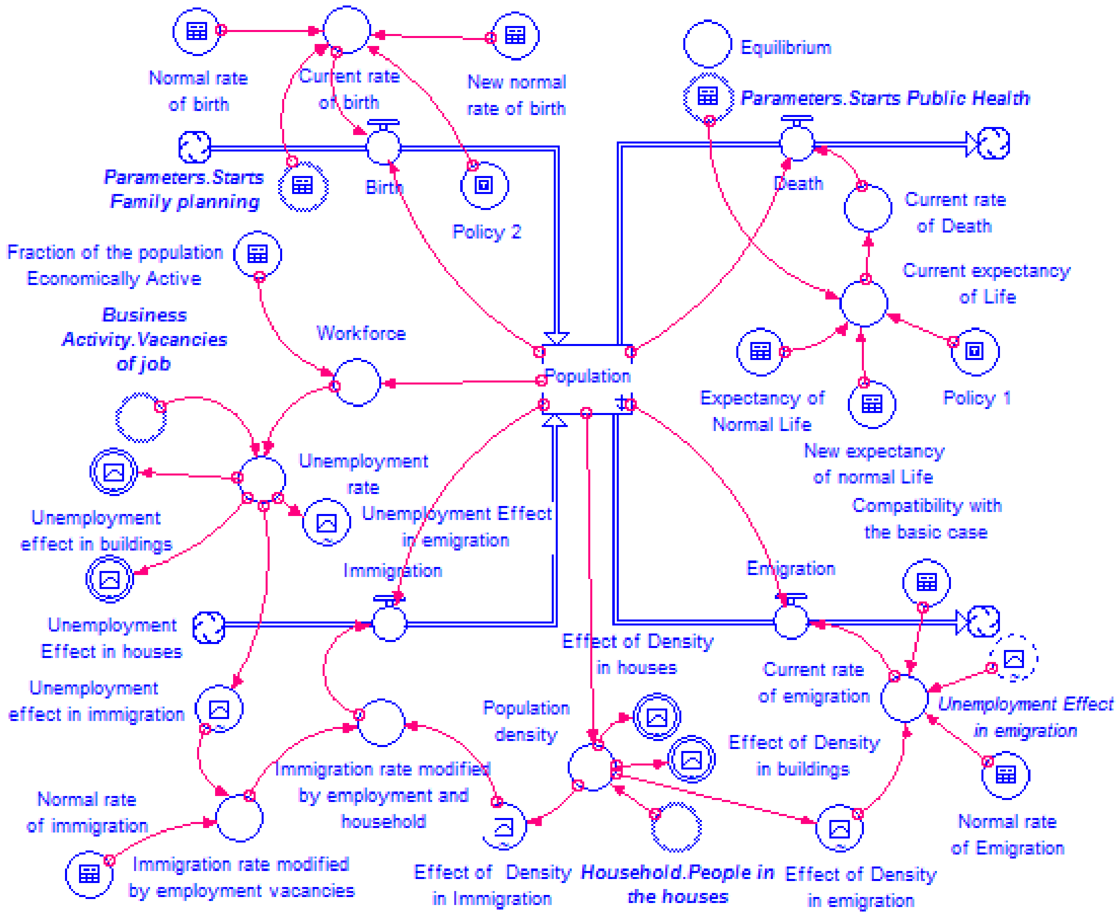
Figure 1: Steps for the development of learning laboratories and their results.

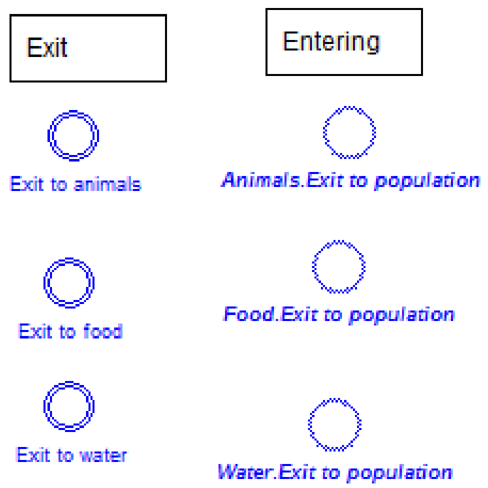
Urban dynamics – Cause-Effect Cycles and System Modules



Module of Dynamic (Phase I) detailed.

Population Dynamics.





Equations of the population model.

Population(t) = Population(t - dt) + (Immigration + Birth - Emigration - Death) * dt

INIT Population = 40000 {Gente}

INFLOWS:

Immigration =
Population*Immigration_rate_modified_by_employment_and__household
{Gente/year}

Birth = Population*Current_rate_of_birth {Gente/year}

OUTFLOWS:

Emigration = Population*Current_rate__of_emigration {Gente/year}

Death = Population*Current_rate_of_Death {Gente/year}

Compatibility_with_the_basic_case = 1 {No Units}

Current_expectancy__of_Life = if Policy_1=1 then
Expectancy_of_Normal_Life + STEP(New_expectancy_of_normal_Life-Expectancy_of_Normal_Life, Parameters.Starts_Public_Health)
else Expectancy_of_Normal_Life {1/year}

Current_rate_of_birth = if Policy_2=1 then
Normal_rate_of_birth+ STEP(New_normal_rate_of_birth-Normal_rate_of_birth,
Parameters.Starts_Family_planning)
else Normal_rate_of_birth {1/year}

Current_rate_of_Death = 1/Current_expectancy__of_Life {1/year}

Current_rate__of_emigration = if Compatibility_with_the_basic_case<>1 then {1 - si compatible, 0 no}

Normal_rate__of_Emigration*Effect_of_Density_in_emigration*Unemployment_Effect_in_emigration {1/year}

else Normal_rate__of_Emigration {1/Year}

Equilibrium = 1 {No Units}

Exit_to_animals = 0

Exit_to_food = 0

Exit_to_water = 0

Expectancy_of_Normal_Life = 66.6667 {year}

Fraction_of_the_population_Economically_Active = 0.35 {No Units}

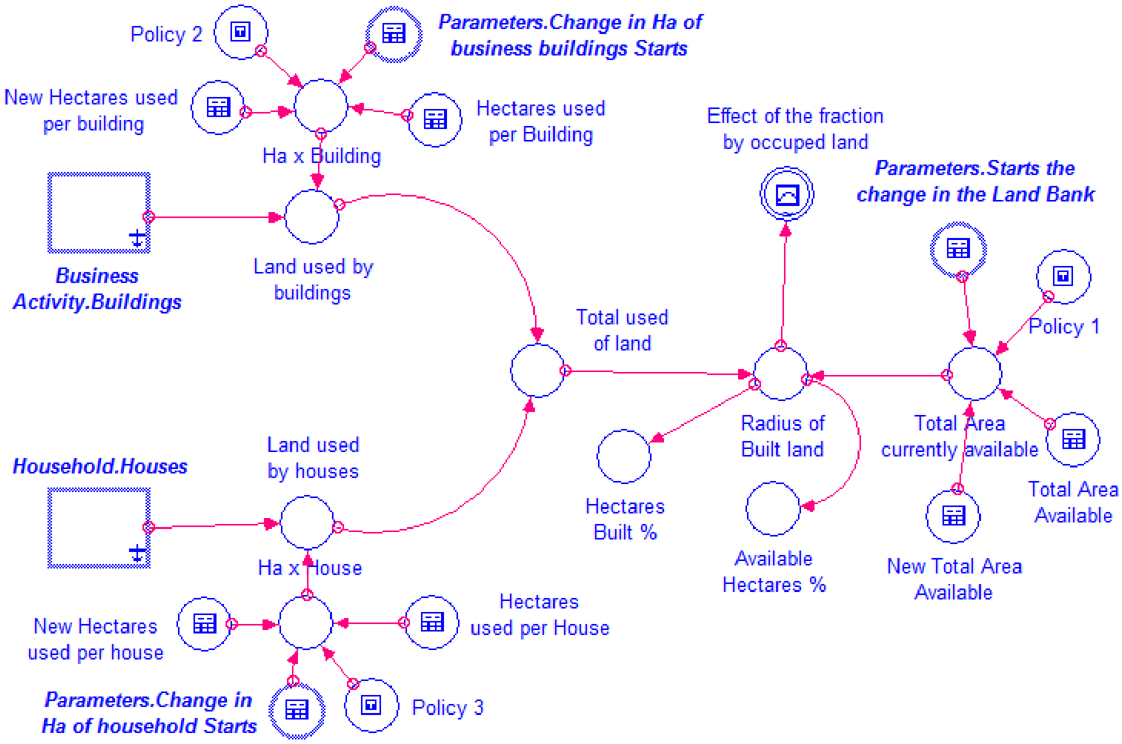
Immigration_rate_modified_by_employment_and__household =
Effect_of__Density_in_Immigration*Immigration_rate_modified_by_employment_vacancies {1/year}

Immigration_rate_modified_by_employment_vacancies =
Normal_rate_of_immigration*Unemployment__effect_in_immigration {1/year}

New_expectancy_of_normal_Life = 70 {year}

New_normal_rate_of_birth = .04 {1/year}
Normal_rate_of_birth = .03 {1/year}
Normal_rate_of_immigration = .08 {1/year}
Normal_rate__of_Emigration = .06 {1/year}
Policy_1 = 0 {No Units}
Policy_2 = 0 {No Units}
Population_density = if Household.People_in_the_houses>0 then Population/Household.People_in_the_houses else 100 {No Units}
Unemployment__rate = if Business_Activity.Vacancies_of_job>0 then Workforce/Business_Activity.Vacancies_of_job else 100 {No Units}
Workforce = Population*Fraction_of_the_population_Economically_Active {Gente}
Effect_of_Density_in_buildings = GRAPH(Population_density {no units})
(0.00, 0.2), (0.2, 0.32), (0.4, 0.8), (0.6, 0.96), (0.8, 0.99), (1.00, 1.00), (1.20, 1.00), (1.40, 1.03), (1.60, 1.11), (1.80, 1.37), (2.00, 2.00)
Effect_of_Density_in_emigration = GRAPH(Population_density {no units})
(0.00, 0.2), (0.2, 0.32), (0.4, 0.8), (0.6, 0.96), (0.8, 0.99), (1.00, 1.00), (1.20, 1.00), (1.40, 1.03), (1.60, 1.11), (1.80, 1.37), (2.00, 2.00)
Effect_of_Density_in_houses = GRAPH(Population_density {no units})
(0.00, 0.2), (0.2, 0.32), (0.4, 0.8), (0.6, 0.96), (0.8, 0.99), (1.00, 1.00), (1.20, 1.00), (1.40, 1.03), (1.60, 1.11), (1.80, 1.37), (2.00, 2.00)
Effect_of__Density_in_Immigration = GRAPH(Population_density {No Units})
(0.00, 1.40), (0.2, 1.29), (0.4, 1.18), (0.6, 1.11), (0.8, 1.03), (1.00, 1.00), (1.20, 0.99), (1.40, 0.96), (1.60, 0.86), (1.80, 0.67), (2.00, 0.4)
Unemployment_effect_in_buildings = GRAPH(Unemployment__rate {No Units})
(0.00, 0.2), (0.2, 0.32), (0.4, 0.8), (0.6, 0.96), (0.8, 0.99), (1.00, 1.00), (1.20, 1.00), (1.40, 1.03), (1.60, 1.11), (1.80, 1.37), (2.00, 2.00)
Unemployment_Effect_in_emigration = GRAPH(Unemployment__rate {No Units})
(0.00, 0.2), (0.2, 0.32), (0.4, 0.8), (0.6, 0.96), (0.8, 0.99), (1.00, 1.00), (1.20, 1.00), (1.40, 1.03), (1.60, 1.11), (1.80, 1.37), (2.00, 2.00)
Unemployment_Effect_in_houses = GRAPH(Unemployment__rate {No Units})
(0.00, 0.2), (0.2, 0.32), (0.4, 0.8), (0.6, 0.96), (0.8, 0.99), (1.00, 1.00), (1.20, 1.00), (1.40, 1.03), (1.60, 1.11), (1.80, 1.37), (2.00, 2.00)
Unemployment__effect_in_immigration = GRAPH(Unemployment__rate {No Units})
(0.00, 2.00), (0.2, 1.42), (0.4, 1.19), (0.6, 1.09), (0.8, 1.03), (1.00, 1.00), (1.20, 1.00), (1.40, 0.99), (1.60, 0.93), (1.80, 0.67), (2.00, 0.1)

Dynamic of the use of the soil



Equations of the land model.

Available__Hectares_% = (1-Radius_of_Built_land)*100 {no units}

Ha_x_Building = if Policy_2=1 then

Hectares_used_per_Building+STEP(New_Hectares_used__per_building-Hectares_used_per_Building, Parameters.Change_in_Ha_of_business_buildings_Starts)

else Hectares_used_per_Building {Hectáreas}

Ha_x_House = if Policy_3=1 then

Hectares_used_per_House+Step(New_Hectares_used_per_house-Hectares_used_per_House, Parameters.Change_in_Ha_of_household_Starts)

else Hectares_used_per_House {Hectáreas}

Hectares_Built_% = Radius_of_Built_land*100 {no units}

Hectares_used_per_Building = 0.2 {Hectáreas}

Hectares_used_per_House = 0.1 {Hectáreas}

Land_used_by_buildings = Business_Activity.Buildings*Ha_x_Building {Hectáreas}

Land_used_by_houses = Household.Houses*Ha_x_House {Hectáreas}

New_Hectares_used_per_house = 0.09 {Hectáreas}

New_Hectares_used__per_building = 0.19 {Hectáreas}

New_Total_Area_Available = 9500 {Hectáreas}

Policy_1 = 0 {No Units}

Policy_2 = 0 {No Units}

Policy_3 = 0 {No Units}

Radius_of_Built_land = if Total_Area_currently_available>0 then Total_used_of_land/Total_Area_currently_available else 100 {no units}

Total_Area_Available = 8500 {Hectáreas}

Total_Area_currently_available = if Policy_1=1 then

Total_Area_Available+ STEP(New_Total_Area_Available-Total_Area_Available, Parameters.Starts_the_change_in_the_Land_Bank)

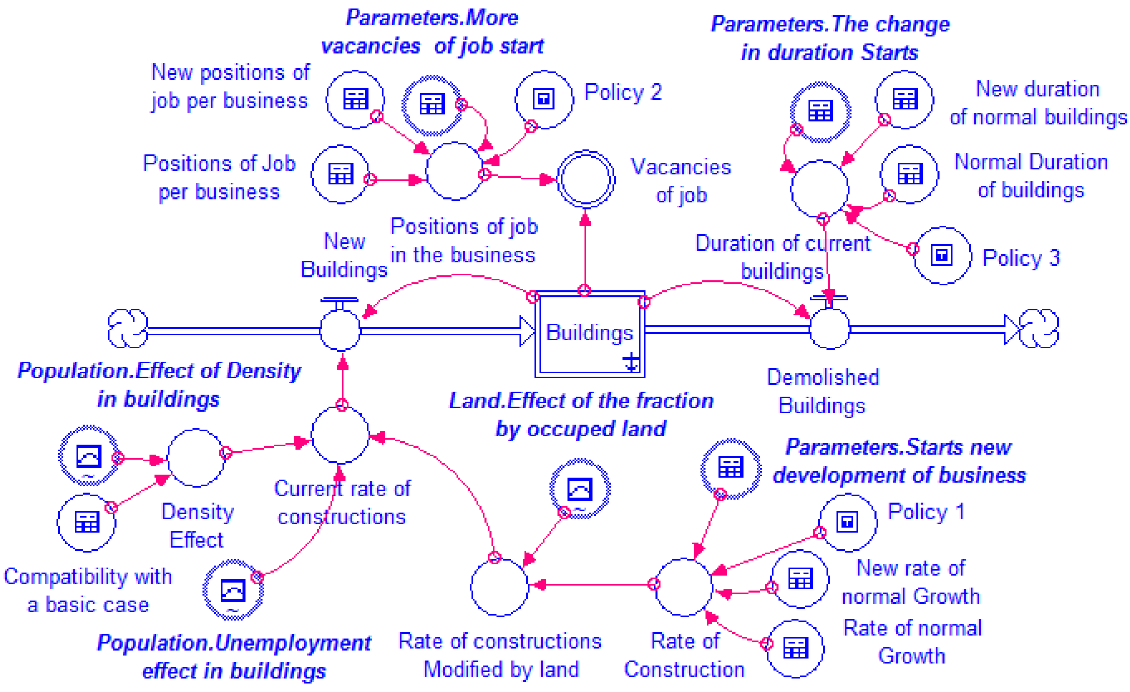
else Total_Area_Available {Hectáreas}

Total_used_of_land = Land_used_by_buildings+Land_used_by_houses {Hectáreas}

Effect_of_the_fraction_by_occuped_land = GRAPH(Radius_of_Built_land {no units})

(0.00, 1.00), (0.1, 1.00), (0.2, 1.00), (0.3, 1.00), (0.4, 1.00), (0.5, 1.00), (0.6, 1.00), (0.7, 0.975), (0.8, 0.925), (0.9, 0.825), (1, 0.00)

Dynamic of the Economical Activity



Equations of the business activity model.

Buildings(t) = Buildings(t - dt) + (New_Buildings - Demolished_Buildings) * dt

INIT Buildings = 1000 {Edificios}

INFLOWS:

New_Buildings = Buildings*Current_rate_of_constructions {Edificios/year}

OUTFLOWS:

Demolished_Buildings = Buildings/Duration_of_current_buildings {Edificios/year}

Compatibility_with_a_basic_case = 1 {No Units}

Current_rate_of_constructions = Rate_of_constructions__Modified_by_land*Population.Unemployment_effect_in_buildings*Density_Effect {1/year}

Density_Effect = if Compatibility_with_a_basic_case<>1 then Population.Effect_of_Density_in_buildings else 1 {No Units}

Duration_of_current_buildings = if Policy_3=1 then
Normal_Duration_of_buildings+STEP(New_duration_of_normal_buildings-Normal_Duration_of_buildings, Parameters.The_change_in_duration_Starts)
else Normal_Duration_of_buildings {years}

New_duration_of_normal_buildings = 45 {years}

New_positions_of_job_per_business = 20 {Trabajos/Edificios}

New_rate_of__normal_Growth = 0.10 {1/year}

Normal_Duration_of_buildings = 40 {years}

Policy_1 = 0 {No Units}

Policy_2 = 0 {No Units}

Policy_3 = 0 {No Units}

Positions_of_job_in_the_business = if Policy_2=1 then
Positions_of_Job_per_business+STEP(New_positions_of_job_per_business-Positions_of_Job_per_business, Parameters.More_vacancies__of_job_start)
else Positions_of_Job_per_business {Trabajos/Edificios}

Positions_of_Job_per_business = 16 {Trabajos/Edificios}

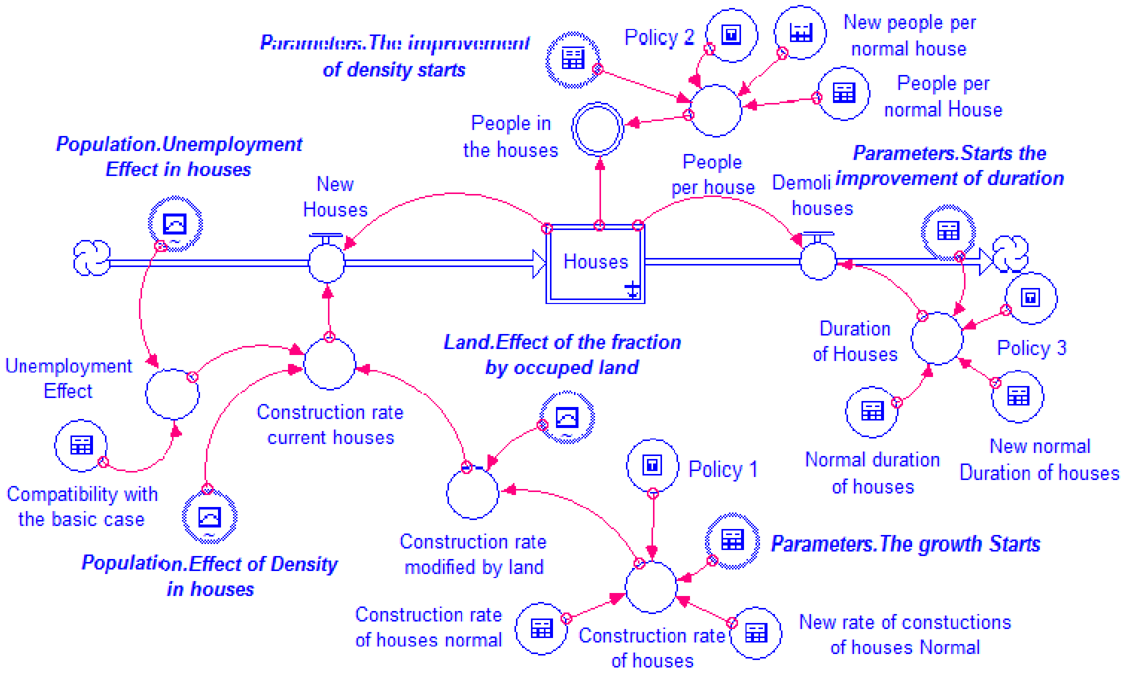
Rate_of_constructions__Modified_by_land = Rate_of__Construction*Land.Effect_of_the_fraction_by_occuped_land {1/year}

Rate_of_normal__Growth = 0.07 {1/year}

Rate_of__Construction = if Policy_1=1 then
Rate_of_normal__Growth+ STEP(New_rate_of__normal_Growth-Rate_of_normal__Growth, Parameters.Starts_new_development_of_business)
else Rate_of_normal__Growth {1/Year}

Vacancies_of_job = Positions_of_job_in_the_business*Buildings {Trabajos}

Dynamic of Housing Construction



Equations of the household model.

Houses(t) = Houses(t - dt) + (New_Houses - Demolished_houses) * dt

INIT Houses = 10000 {Casas}

INFLOWS:

New_Houses = Houses*Construction_rate__current_houses {Casas/year}

OUTFLOWS:

Demolished_houses = Houses/Duration_of_Houses {Casas/year}

Compatibility_with_the_basic_case = 1 {No Units}

Construction_rate_modified_by_land = Construction_rate_of_houses*Land.Effect_of_the_fraction_by_occuped_land {1/year}

Construction_rate_of_houses = if Policy_1>0 then
Construction_rate_of_houses_normal+ STEP(New_rate_of_constuctions_of_houses_Normal-Construction_rate_of_houses_normal, Parameters.The_growth_Starts)
else Construction_rate_of_houses_normal {1/year}

Construction_rate_of_houses_normal = 0.06 {1/year}

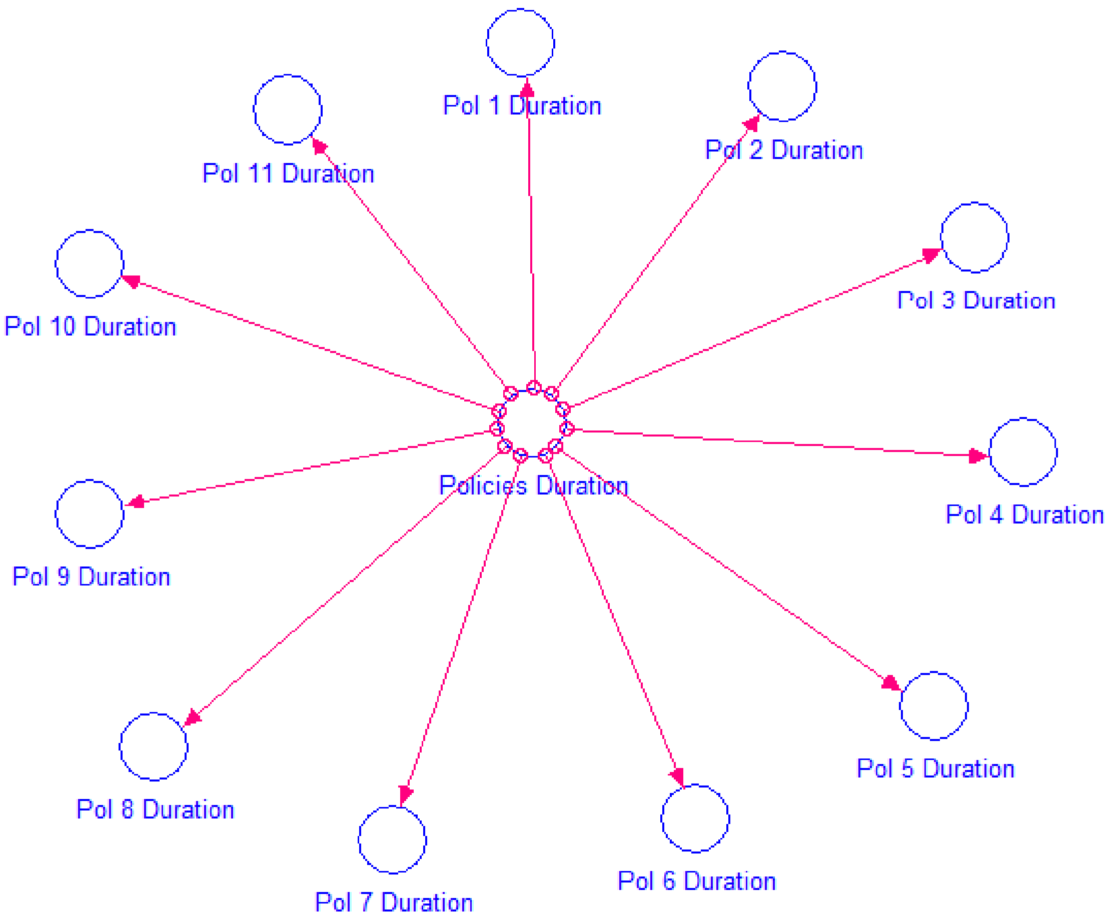
Construction_rate__current_houses = Construction_rate_modified_by_land*Population.Effect_of_Density_in_houses*Unemployment_Effect {1/year}

Duration_of_Houses = if Policy_3=1 then
Normal_duration_of_houses+STEP(New_normal_Duration_of_houses-Normal_duration_of_houses, Parameters.Starts_the_improvement_of_duration)
else Normal_duration_of_houses {1/year}

New_normal_Duration_of_houses = 35 {years}

New_people_per__normal_house = 15 {Gente/Casa}
New_rate_of_constuctions_of_houses_Normal = 0.08 {1/year}
Normal_duration_of_houses = 70 {years}
People_in_the_houses = Houses*People_per_house {Gente}
People_per_house = if Policy_2=1 then
People_per__normal_House+ STEP(New_people_per__normal_house-People_per__normal_House, Parameters.The_improvement_of_density_starts)
else People_per__normal_House {Gente/Casa}
People_per__normal_House = 4 {Gente/Casa}
Policy_1 = 0 {No Units}
Policy_2 = 0 {No Units}
Policy_3 = 0 {No Units}
Unemployment_Effect = if Compatibility_with_the_basic_case<>1 then Population.Unemployment_Effect_in_houses else 1 {No Units}

Parameter module

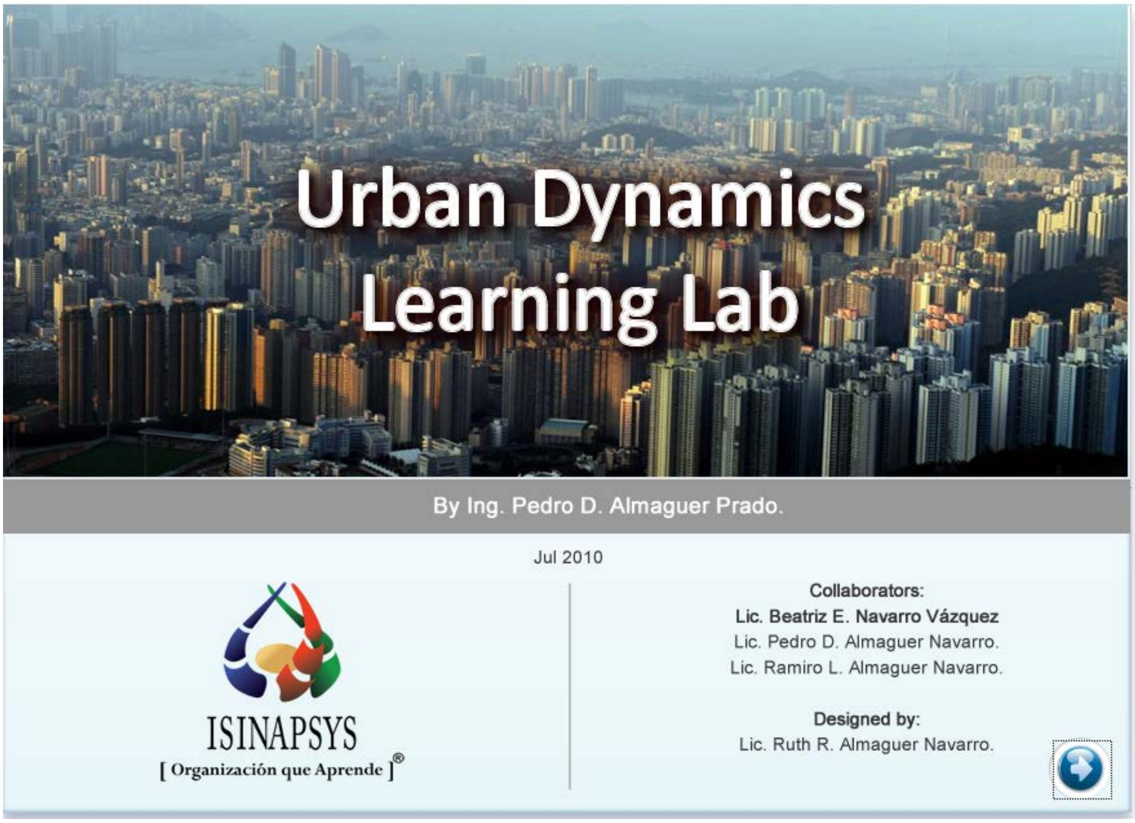


Equations of the parameters model.

Change_in_Ha_of_business_buildings_Starts = Starts_of_Policies {year}
Change_in_Ha_of_household_Starts = Starts_of_Policies {year}
More_vacancies__of_job_start = Starts_of_Policies {year}
Policies_Duration = 100 {year}
Pol_10_Duration = Policies_Duration {year}
Pol_11_Duration = Policies_Duration {year}
Pol_1_Duration = Policies_Duration {year}
Pol_2_Duration = Policies_Duration {year}
Pol_3_Duration = Policies_Duration {year}
Pol_4_Duration = Policies_Duration {year}
Pol_5_Duration = Policies_Duration {year}
Pol_6_Duration = Policies_Duration {year}
Pol_7_Duration = Policies_Duration {year}
Pol_8_Duration = Policies_Duration {year}
Pol_9_Duration = Policies_Duration {year}
Starts_Family_planning = Starts_of_Policies {year}
Starts_new_development_of_business = Starts_of_Policies {year}
Starts_of_Policies = 10 {year}
Starts_Public_Health = Starts_of_Policies {year}
Starts_the_change_in_the_Land_Bank = Starts_of_Policies {year}
Starts_the_improvement_of_duration = Starts_of_Policies {year}
The_change_in_duration_Starts = Starts_of_Policies {year}
The_growth_Starts = Starts_of_Policies {year}
The_improvement_of_density_starts = Starts_of_Policies {year}

Urban dynamics learning lab.

Cover of the learning laboratory for Urban Dynamics.



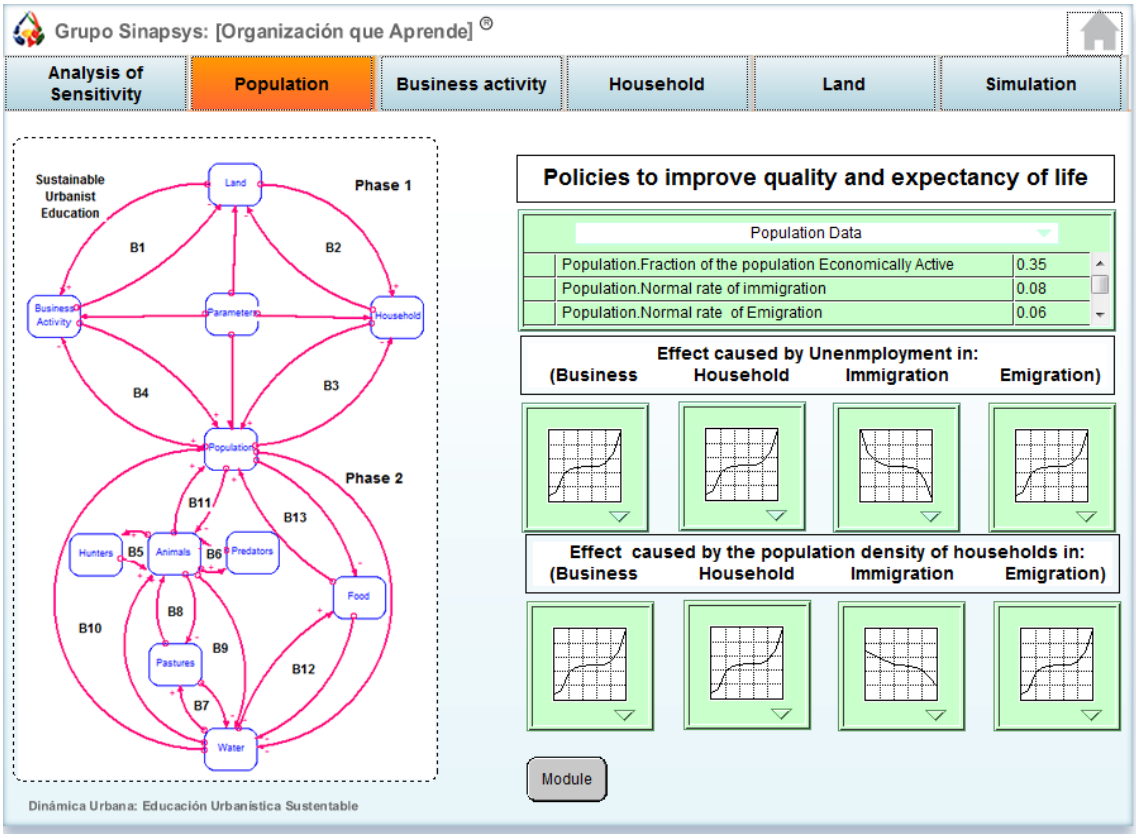
How this Learning Lab works

Until now, 11 polocies have been defined, and they affect the use of the ground, the creation of new bussiness and houses, the quality life of population. All these may be applied individually or combined, and at all time their effect can be visualized in the time for each of the elements of the system.

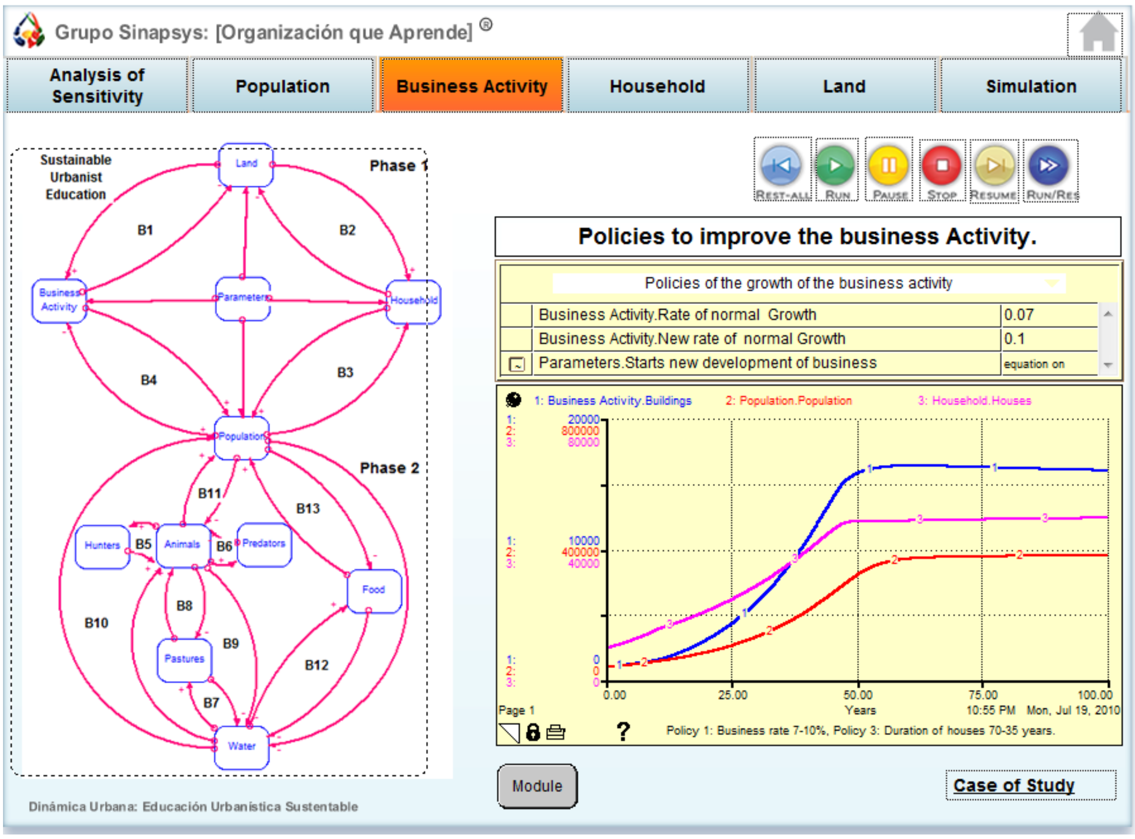
1. **Applied to Bussiness.** a. Growth. b. Job. c. Duration of the buildings. 2. **Applied to the use of the soil.** a. Land reservation. b. Hectares per bussiness. c. Hectares per dwelling.	3. **Applied to population.** a. Public health. b. Family planning. 4. **Applied to housing.** a. Construction. b. Population density. c. Duration of the houses.

It's not necessary to be a modeling expert to use this learning lab. Any person with studies from secondary, can handle this bussiness game and interpret their results graphically.

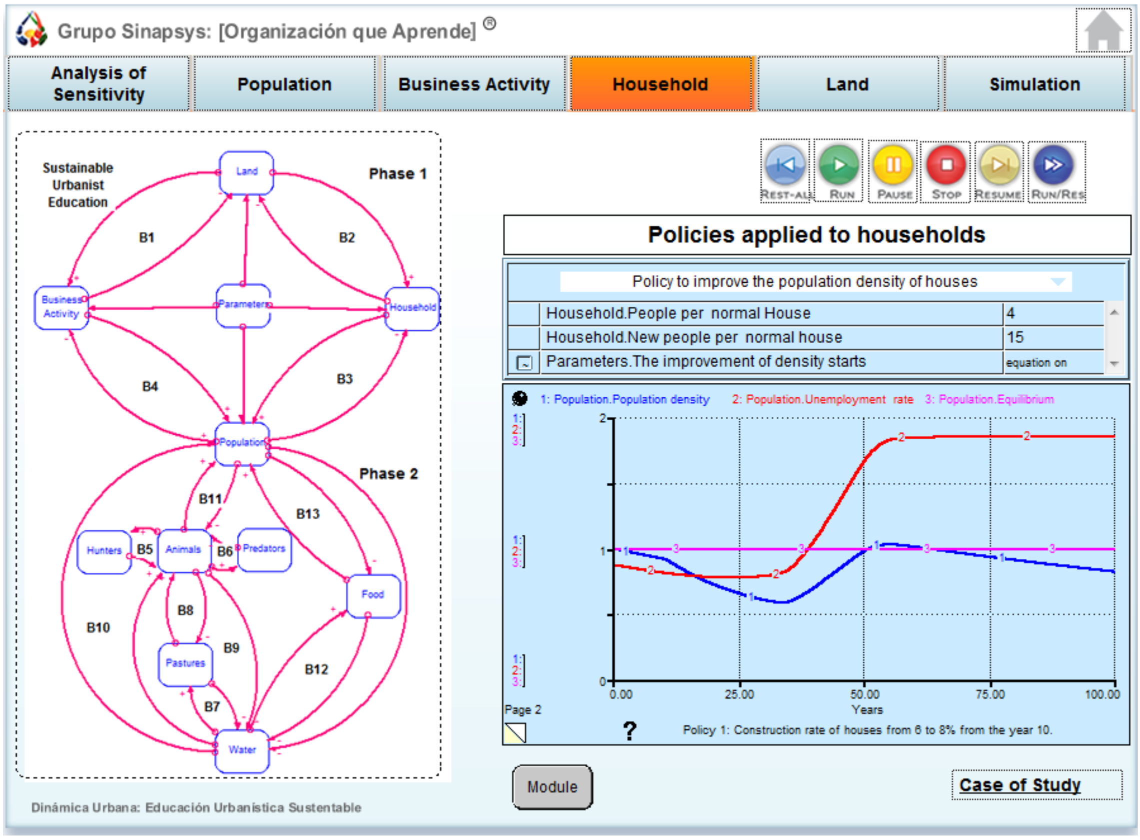
Module for the population Dynamics.



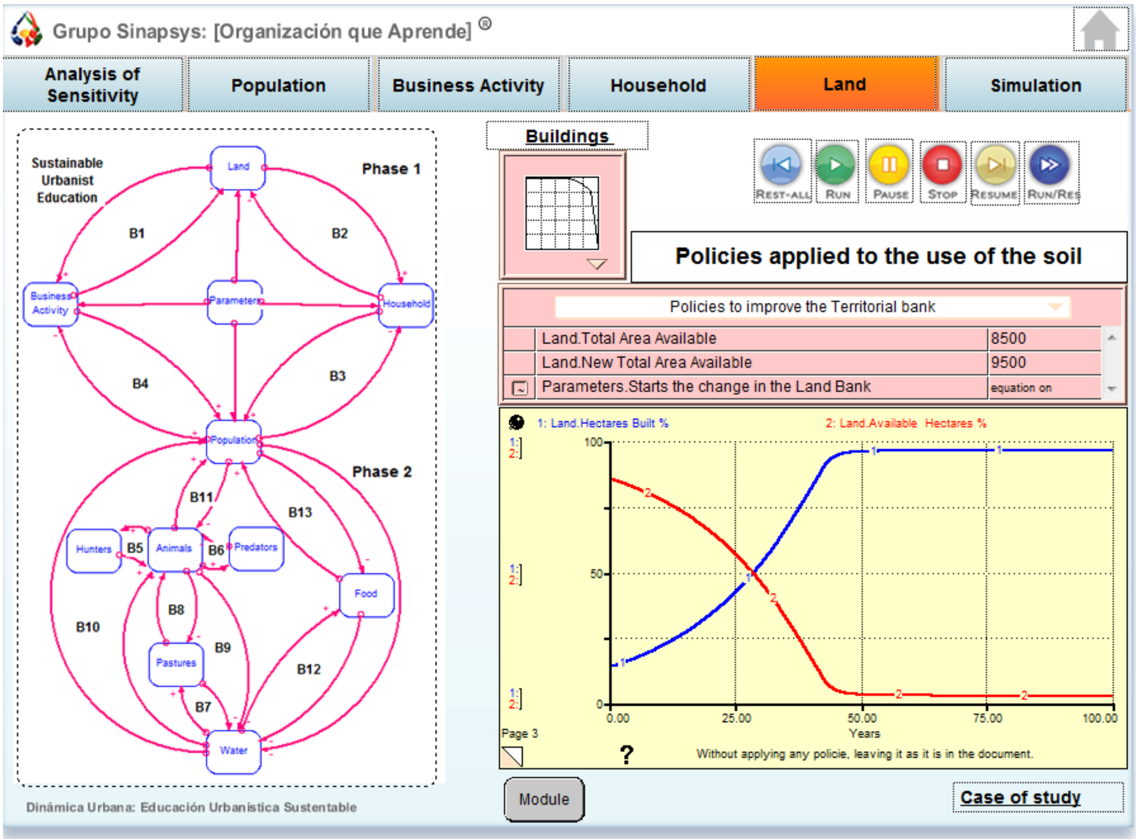
Module for the bussiness buildings



Module for the households for people.



Module for the use of soil.



Data of each module.

Housing	Data	Population	Data
Normal Rate of Housing Contruction {1/year}	0.06	Population {People}	40,000
Support for a fundamental case {No Units}	1	Fraction of population economically active {No Units}	0.35
People per normal house {People}	4	Normal Rate of Immigration {1/year}	0.08
Houses {Houses}	10,000	Normal life ecpectancy {year}	66.6667
Normal Rate of dwelling duration {year}	70	Balance {No Units}	1
Bussiness	**Data**	Normal Rate of births {1/year}	0.03
Normal Increasing Rate {1/Year}	0.07	Normal Emigration Rate {1/year}	0.06
Normal Rate of Building Duration {Year}	40	**Land**	**Data**
Jobs by company {Jobs/Buildings}	16	Available total launge (Hectares)	8,500
Buildings {Buildings}	1,000	Hectares used per building	0.20
		Hectares used per house	0.10

Note:

All data may be changed to adapt the simulator to the colony or city that most resembles your case of study.

Model simulation – eleven policies to improve the urban dynamics.

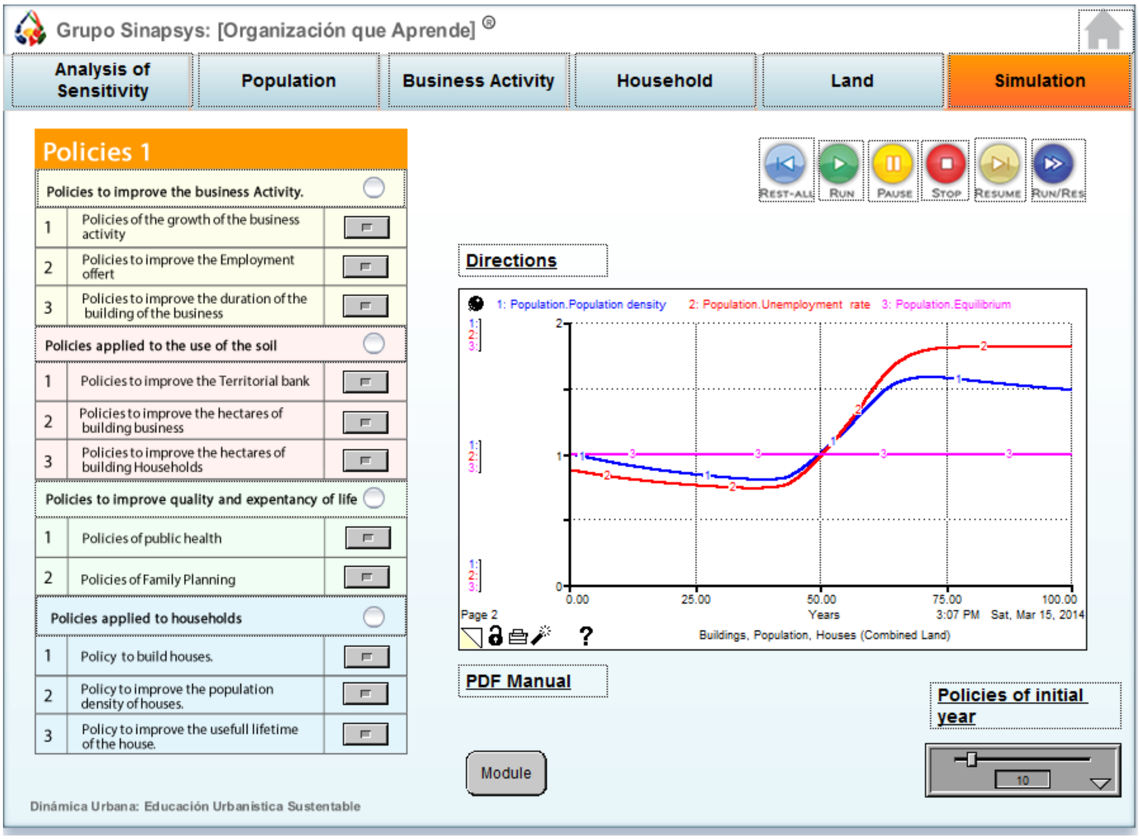


Figure 2: Graph of results about unemployment and population density, without applying any policy.

How to activate the policies of the model.

The planner or city leader can acces to any of the policies designed individually or combined at convenience. If the person needs to change the data of the model, it must be done in the tab for land, household, bussiness or population. Once everything is ready, simply pull the button "Run" and immediately, the impact in the time of the decisions taken will be shown. To do so, there are three graphs that we'll explain below on a time horizon of 100 years.

Interpretation of the graphic result about unemployment and population density.

1. If the unemployment rate is greater than 1, it means that there is unemployment. For values less than 1, that means underemployment (supply is greater than demand and workers are missing).
2. If the population density is greater than 1, it means that there is overcrowding in the houses. For values less than 2 means that there are fewer people per household than the planned target as the optimal value for an acceptable quality of life.
3. If either of the two values gives 1, means that everything is balanced, not surplus or shortage jobs, or that people live without overcrowding at home, not more nor less people is living in the house, only the fair number of people per household.

Graphic results for Buildings, population and Household, without applying any policy.

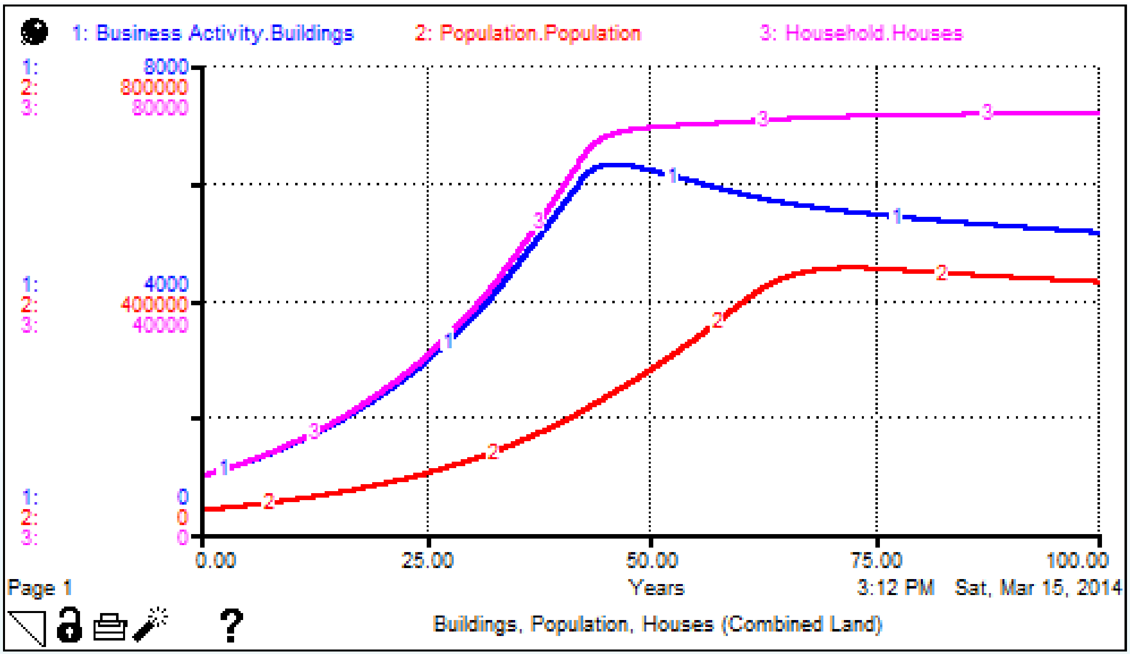


Figure 3: Results for buildings, population and household, without applying any policy.

Percentage of built and available hectares, without applying any policy.

Figure 4: Percentage of built and available hectares, without applying any police.

Note: From the graph above, it's clear that the land reserve is exhasuted from the year 50 or a little before, from that date the potential that bussiness and household have for growing, finishes.

Sensibility Analysis.

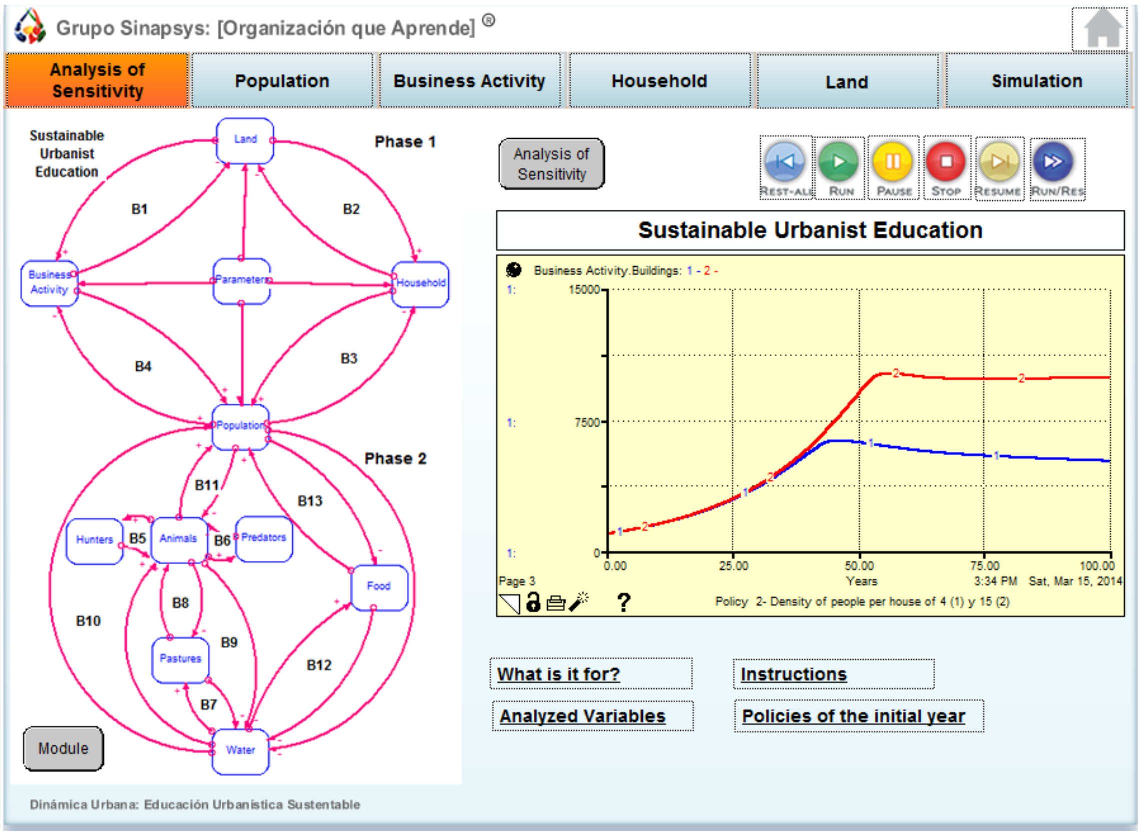


Figure 5: A simple way to see the results before and after applying a given policy.

What is the use of the sensibility analysis?

One of the most powerful attributes of our learning lab is to make the sensibility analysis over any kind of variables or policies designed in the model to visualize the impact of its results before and after a change in any other variable that may be studied.

For instance

From the graph above, if we study what could happend before and after applying the policy of increasing the population density per house from 4 to 15 since the year 10 to the end of the simulation.

Clearly we can see that applying the policy of building townhouses that allowes the number of persons per house increases from 4 to 15, will favor the rise of the comercial activity when the number of buildings expands and therefore, this will bring greater opportunities of job. Although, it's necessary to remember that not always what we think with our logical and intuitive reasoning is what will happen. To say the truth, this kind of problems where everything is interconnected, gives headaches trying to anticipate to what we beleive will happen as it's shown in the next graph, where we can visualize what will happen with the unemployment before and after applying the same change from 4 to 15 people per house.

Policy 2- Density of people per house from 4 (1) to 15 (2), What happens to unemployment

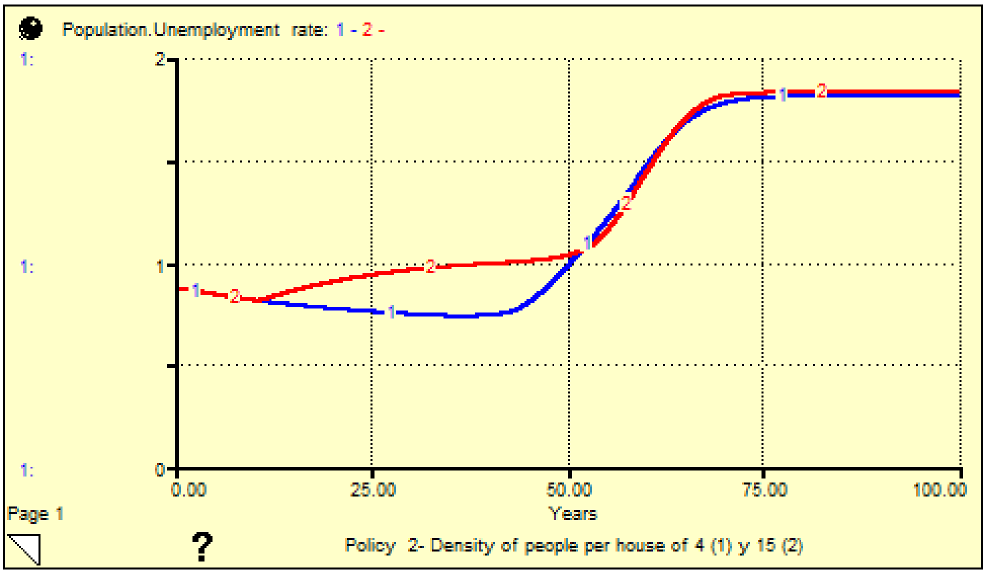


Figure 6: What happens to unemployment, changing the number of people per house from 4 to 15.

When it was indicated that the implementation of this policy was good, and really is. Let's see the graph (2) from the year 10 to 50, there isn't unemployment, but, something from year 50 and on, where before and after seems not to affect, everything continues the same way with a high rate of unemployment. (This is deduced from a rate of unemployment, higer than 1 from the year 50 forward.)

Now, let's examine what happens in detail from the year 50 and forward. To this, let's see the next graph that shows the percentage of hectares available to construct buildings for housing and bussiness.

Available hectares before and after the policy to continue building.

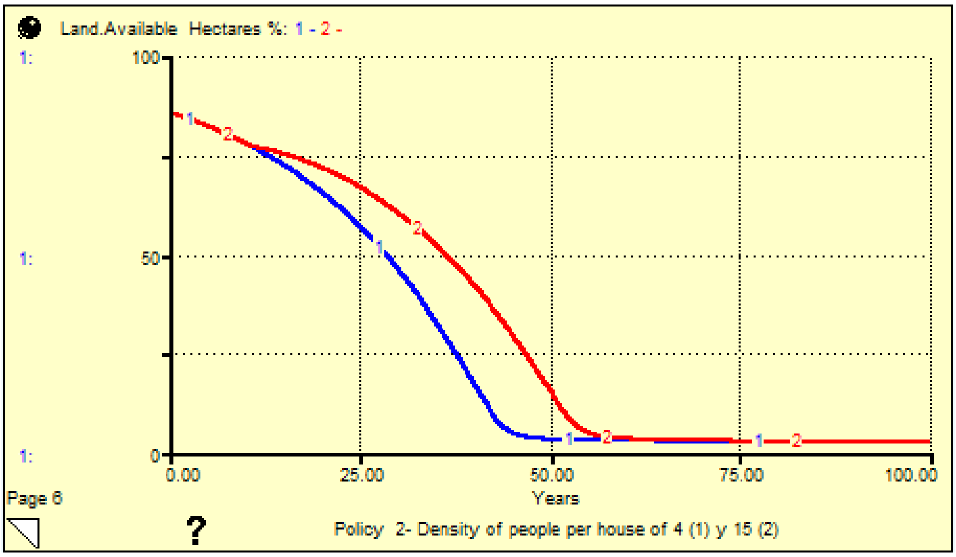


Figure 7: Available hectares before and after the policy to continue building.

As can be seen in the graph above, it's clear that even the policy to increase the population of density per house from 4 to 15 is good, becasue it slows the depletion of the land reserve, it finishes a few years after the year 50, this means that there is no more area to construct new buildings to bussiness and the job offers don't increase, it explains why unemployment continues growing, therefore the policy of increasing the density of population per house, worked only a few years, in long term it didn't give sustainable results.

If now we examine the overcrowding defined as:

Population Density = $\frac{Población}{(Viviendas\ x\ Gente\ /\ casa)}$ {Unitless}

Let's put numbers to better understand this definition of population Density. Let's supose that the population is 1000, homes are 100 and the people per house we desire as target to have an optimal life quality is 4, therefore we obtain:

Population Density = $\frac{1000}{(100\ x\ 4)} = \frac{1000}{400}$ = 2.5 {Unitless}

Analyzing the results, we can say that for greater values than 1, there is overcrowding, most people than expected is living in the houses, so the quality of life is not good. Let's see the graph.

After applying the policy there is overcrowding. See line (2)

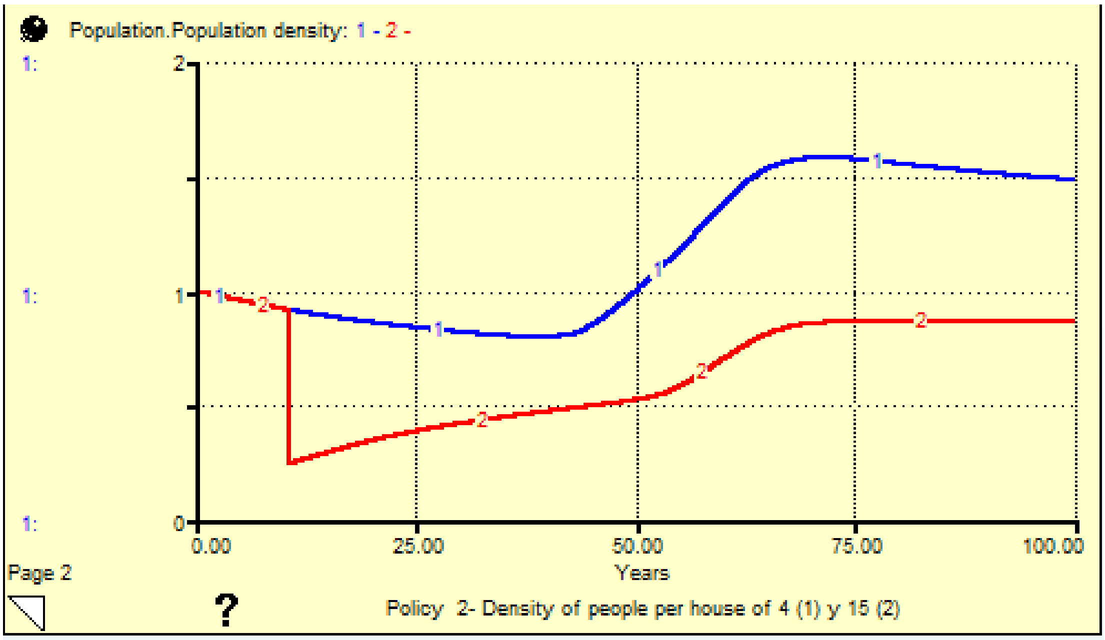


Figure 8: After applying the policy there is overcrowding. See line (2)

How stunning, based on the graph above, it tell us that to apply the policy of constructing TownHouses the overcrowding is over, but the unemployment increases, although apparently the offer of employmetn grows, finally the reserve is exhausted and there isn't sustainability as the ultimate goal we want to achieve.

Reflection, Remedy or Heal:

Solutions that produce more Problems:

They suggest a fast remedy, the patch helps instantly, but does nothing to solve the underlaying problem. **To mend,** **means to apply an endless series of patchs that never really fix something.**

Fully Solutions

To heal will **try to solve in depth in the motives and not in the effects.** It entails a deep change in the attitude. To heal is strictly necessary to discern the hidden patterns that link all the different elements and consider them as a part of the solution.

Conclusion

How stunning is to develop these learning labs to bring them into the power of the liders and planners of our cities for they to learn and visualize the impact their decisions affect in time. And to develop new policies and strategies whos goals be to produce a sustainable growth in the city, taking into account the huge advantages of doing things in a coordinated agreement, respecting the environment, the economy and the society.

Apendix "A" - Equations of the other modules (Phase 2).

Note: Phase 2 of the model, will be developed in detail soon, article Urban dynamics learning lab II.

HUNTERS
Exit = 0

ANIMALS
Exit_to_Hunt = 0
Exit_to_pastures = 0
Exit_to_population = 0
Exit_to_predators = 0
Exit_to_water = 0

PREDATORS
Exit_to_animals = 0

PASTURES
Exit_to_animals = 0
Exit_to_water = 0

FOOD
Exit_to_population = 0
Exit_to_water = 0

WATER
Exit_to_animals = 0
Exit_to_food = 0
Exit_to_pastures = 0
Exit_to_population = 0

Bibliography

Nomads, Land Use and Humanitarian Aid in the Sahel Region of Africa. [Online] / auth. Lindow Debbie [et al.]. - A STELLA II MODEL FOR USE IN THE CLASSROOM, EDITED BY ANDREW JONCA, RON ZARAZA CC-STADUS INSTITUTE SUMMER 1993, 1993. - 2010.

System Dynamics, Systems Thinking, and Soft OR, 4 pp. [Online] / auth. Forrester Jay W.. - 1992. - 2010.

Alcohol en el sistema sanguíneo [Journal] / auth. Almaguer Prado Pedro D. and Almaguer N. Ruth R.. - Monterrey : [s.n.], 2010.

Industrial Dynamics. Portland, OR: Productivity Press. 464 pp. [Online] / auth. Forrester Jay W.. - 1961. - 2010.

Introduction to urban dynamics [Book] / auth. Alfeld Louis Edward and Graham. Alan K.. - Cambridge, Mass : Wright-Allen Press , 1976 .

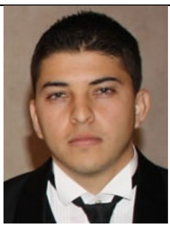
Modeling Dynamic Systems [Book] / auth. Diana and Fisher Diana M.. - [s.l.] : STELLA, 2007.

Sahel: Modelando un estilo de vida sustentable [Journal] / auth. Almaguer Prado Pedro D. and Almaguer N. Ruth R.. - Monterrey N.L. : [s.n.], 2009.

The Fifth Discipline. New York: Doubleday. [Online] / auth. Senger Peter M.. - 1990. - 2010.

Urban Dynamics [Book] / auth. Forrester Jay W.. - [s.l.] : Pegasus.

Author's and collaborators' data:

	**Autor's Name:** **Almaguer Prado, Pedro Dagoberto** **Place of birth:** Múzquiz, Coahuila, México. **Education:** **Ingeniero Químico y de Sistemas** (ITESM) 1980 (Degree in Chemical Engineering and Systems) **Professor:** As student he taught Mathematics at a Professional level in the Mathematics Department ITESM 1979-1980. Professor of Chemical Engineering Department ITESM 1980-1985. **Homepage:** http://www.gruposinapsys.com **E-mail:** pedrodago@gmail.com
	Collaborator: **Pedro Dagoberto Almaguer Navarro** Education: Licenciado en Mercadotecnia (Degree in Marketing) E-mail: pan.dago82@gmail.com
	Modeling: **Ramiro Luis Almaguer Navarro** Education: Licenciado en Administración de Empresas (Degree in Bussiness Administration) E-mail: rmalmaguer@gmail.com
	Design: **Ruth Raquel Almaguer Navarro** Education: Diseño Gráfico (Graphic Design) E-mail: ruth_ran@hotmail.com
	Collaborator: **Beatriz Eugenia Navarro Vázquez** Education: Licenciado en Comercio Internacional (International Trade Degree) E-mail: bety.5505@gmail.com