USTH - Project MI 2.05
Subject 2: Impacts of economic migration

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1 Introduction

1.1 Context

The drop in revenues in certain categories of farmers may force them to migrate and find other activities elsewhere, leaving their parcels unoccupied. We make the assumption that empty parcels become available for the other farmers, who can buy and use them.

1.2 Goal

Adapt the behavior of the farmers so that they have (1) a probability to migrate with respect to their revenue; (2) a probability to buy empty parcels in their neighborhood if their capital is sufficient. Explore the impact of these changes on the global land-use.

1.3 Project Archive

Project URL: https://github.com/caoquan95/GAMA-project

There are 3 folders in the project:

1. GAMA - Contains GAMA code
2. Java - Contain Java code for the Calibration
3. R - Contain R code for the Sensitivity Analysis
4. Report.pdf - The report of the project

2 Plan

In order to simulate the economic migration, there are 3 aspects we need to implement:

1. Economic activities of the farmer: How the farmers spend their money, gain profit.
2. Lands selling activities: How the farmers sell their lands and migrate.
3. Land buying activities: How the farmers buy empty lands.

3 Modification

3.1 Economic activities of the farmer

We load the **cost** and **price** for each crop. Every year, the farmers will have to spend the money to buy crop. The cost that the farmers have to pay is the product of the crop and the parcel area which is owned by the farmers.

```
expense <- parcel_area * crop_cost
```

Every year, the farmers will gain the amount of money equal to the product of the price and the parcel area owned by the farmers. We add another parameter *risk_control* multiply to the original risk of the crop in order to control the profit of the farmers. if the risk is high, the farmers will be more likely to lose the money.

```
revenue <- parcel_area
    * crop_price * (1 - lu.risk * risk_control)
```

Therefore, the amount of money the farmers gain will be:

```
profit <- revenue - expense
```

We add a field money to the farmer and every year, we will add the profit to the money of the farmer.

```
money <- money + profit
```

The size of farmer represents his wealth. The richer he is, the bigger he is.

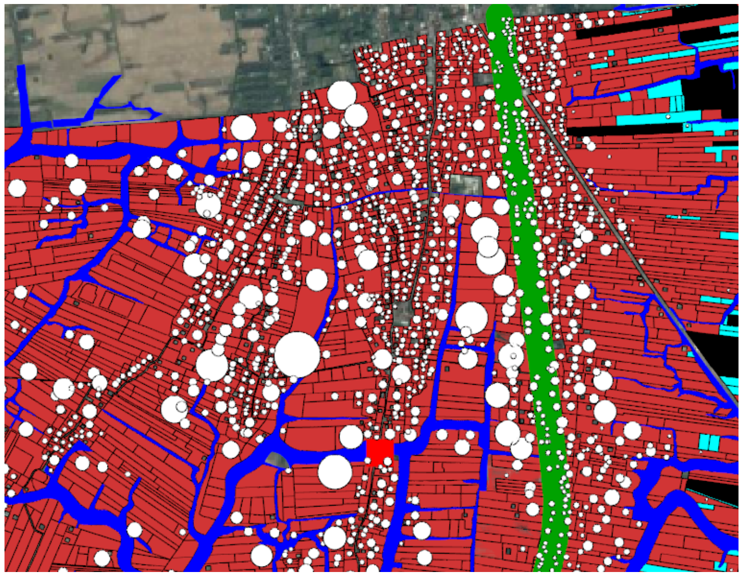

Figure 1: The richer he is, the bigger he is.

3.2 Lands selling activities

We change from **one farmer owns one parcel** to **one farmer owns many parcels**. We add a field named *sell_prob* to the farmer. The higher the *sell_prob*, the higher chance that the farmer will sell the parcel.

We add a parameter *sell_prob_change* which represents the amount of sell probability decrease after each successful year (profit > 0) or increase after each unsuccessful year (profit < 0).

Every year, if the farmer has positive profit, he will less likely to sell his lands and will be more likely to buy lands.

```
if (profit < 0) {
    sell_prob <- sell_prob + sell_prob_change;
} else {
    sell_prob <- sell_prob - sell_prob_change;
}
```

If the farmer has no money left, the sell probability will be 1.0. He will sell his parcels until his money if positive. If the farmer has no parcel left, He will migrate.

```
loop while: (flip(sell_prob) and length(my_parcels) > 0)
{
    // if the farmer have no money left,
    // he/she sells his/her parcel
    parcel p <- self.my_parcels[0];
    self.money <- self.money + p.price; //
    p.owner <- nil;
    remove p from: my_parcels;
```

```
    if (money > 0) {
        sell_prob <- 0.0;
    }
}

if (length(my_parcels) = 0)
{
    // farmer migrates when he/she owns no land
    self.migrated <- true;
}
```

The parcels that have no owner will have the color **black**.

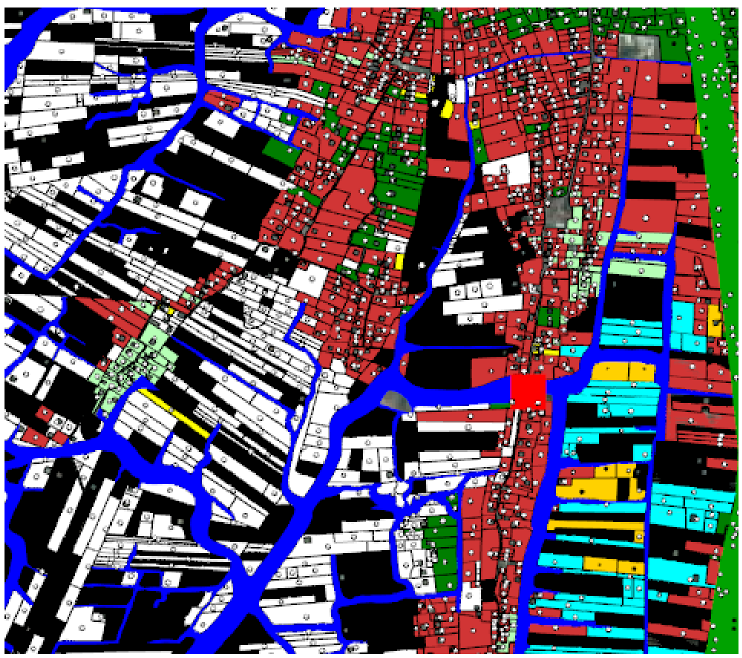

Figure 2: The parcels that have no owner will have the color **black**.

3.3 Land buying activities

The farmer looks at his vicinity to find the parcels without an owner to buy. If he has enough money, he will buy the land with the probability of

$$buy\_prob = 1 - sell\_prob$$

The distance that the farmers can look at to buy the parcels will be proportional to the **number of parcels** and the **size of parcels**, which is also proportional to the **wealth** he has.

```
can_purchase <- (parcel at_distance
    (50 * (length(my_parcels)) + size)
    where (each.owner = nil))
```

The parcels that have the same owner will be planted the same crop.

4 Result

4.1 Map and Charts

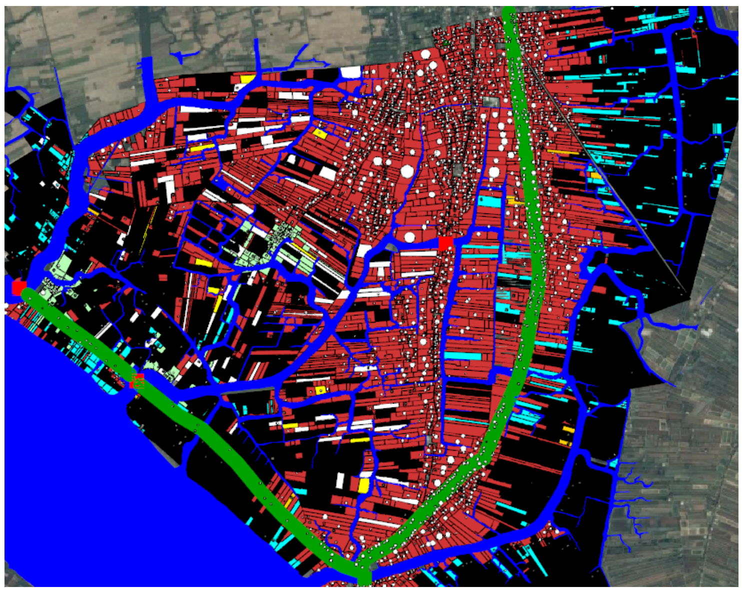

Figure 3: The map at the year of 2020 with risk_control is 1.5 and land_price is 10^5

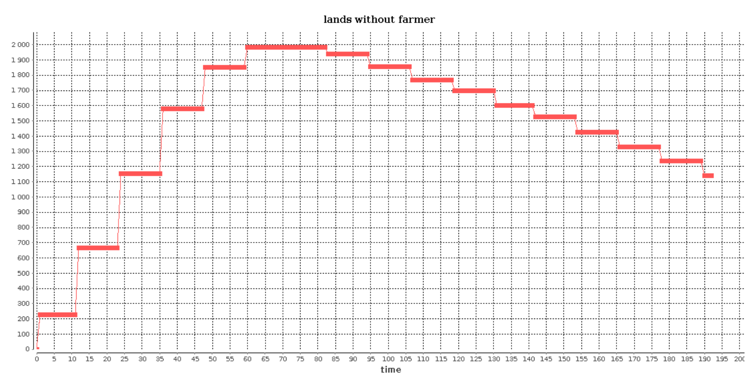

Figure 4: Number of parcels without owner

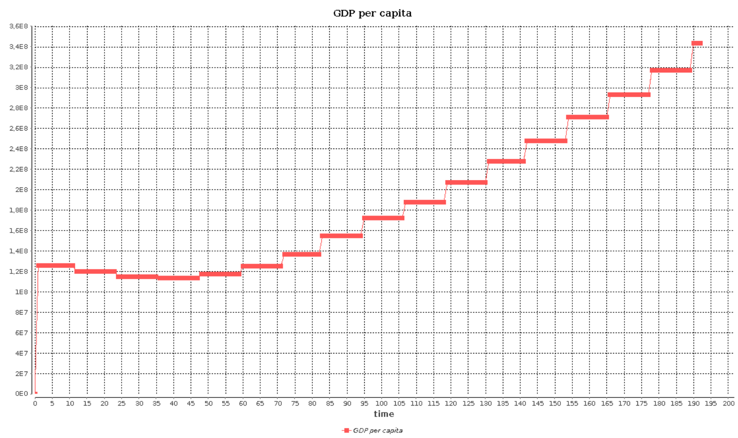

Figure 5: The GDP per capita

4.2 Sensitivity Analysis

4.2.1 CSV result

```
'Risk control','Land price','Prob change','GDP per capita','Farmer'
0.5,50000.0,0.1,781019465.0293307,2863.5
0.5,50000.0,0.30000000000000004,1081170587.3757622,2188.0
0.5,50000.0,0.5,1289258449.681106,1872.5
0.5,100000.0,0.1,574380282.0797641,2768.0
0.5,100000.0,0.30000000000000004,653635549.5318575,2100.0
0.5,100000.0,0.5,658030649.1198387,1787.0
0.5,150000.0,0.1,503962990.7847005,2736.5
0.5,150000.0,0.30000000000000004,505487701.88354015,2061.5
0.5,150000.0,0.5,505805604.2525884,1737.5
0.5,200000.0,0.1,480022298.90021497,2695.5
0.5,200000.0,0.30000000000000004,495546650.52352154,2027.5
0.5,200000.0,0.5,504628504.3982792,1742.5
1.0,50000.0,0.1,567669986.4856306,2730.0
1.0,50000.0,0.30000000000000004,725225944.2956557,2073.5
1.0,50000.0,0.5,781670503.519851,1725.0
```

4.2.2 R code for Variance Analysis

```
file <- "/home/quan/gama_workspace/ProjectUSTH-LUP/models/resVar.csv"
print(file)
dataexf <- read.table(file, header=T, sep=",", dec=".")
summary(dataexf)
aovexf <- aov(GDP.per.capita ~ Land.price * Prob.change * Risk.control,
data = dataexf)
summary(aovexf)
round(summary(aovexf)[[1]][2]/sum(summary(aovexf)[[1]][2])*100,2)
```

4.2.3 Variance Analysis Result

```
                                     Sum Sq
Land.price                            10.10
Prob.change                            1.64
Risk.control                          61.77
Land.price:Prob.change                 1.40
Land.price:Risk.control                8.21
Prob.change:Risk.control               2.14
Land.price:Prob.change:Risk.control    1.04
Residuals                             13.68
```

We can see that more than 60% of the variance is due to the **Risk.control** parameter. Therefore, this is the most important parameter. The **residual** accounts for 13.68% - pretty stable model. The Prob.change, which is the sell_prob_change - the value that the sell_prob change every year corresponding the profit of the farmer, almost has no impact on the model.

4.3 Calibration

From the previous subsection, we knew that the Prob.change does not have much impact on the model. Therefore, I will only calibrating the **Land.price** and **Risk.control** to maximize the **GDP per capita**.

4.3.1 GAMA headless experiment

```
experiment Headless type: gui {
    parameter "Risk control: " var: risk_control
        min: 0.5
        max: 2.5 step: 0.5;

    parameter "Land price:" var: land_price
        min: 5 * 10 ^ 4
        max: 2 * 10 ^ 5 step: 5 * 10 ^ 4;

    output {
        monitor "gdp" value: gdp;
    }
}
```

4.3.2 Result

After the calibration, we got the max GDP is 1.53E8 with the parameter set:

```
risk_control = 2.0
land_price = 150000
```

Some console output from Java program

```
——————————1——————————
risk_control = 0.5
land_price = 50000
FIN du process !!
GDP1.3933195092288885E8
—————————0——————————
risk_control = 1.0
land_price = 50000
FIN du process !!
GDP1.2830357605705802E8
```

```
----------1------------
risk_control = 1.5
land_price = 50000
FIN du process !!
GDP1.1339101308268021E8
----------2------------
risk_control = 2.0
land_price = 50000
FIN du process !!
GDP8.68021633640041E7
```