Simulating outcomes of the effects of land consolidation to support farmer's decision for improved livelihood

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Introduction

This document is part of the supplementary resources and contains describes the model used to simulate outcomes of the effects of land consolidation for farmers in Kenya. This model is a result of the transcription of a conceptual model that was co-created and developed with the stakeholders during data collected in March 2024. We coded and programmed the model in using `decisonSupport` package (Luedeling et al. 2022) in R Core Team (2022). This document was generated using `Rmarkdown` and `knitr` libraries (Xie, Dervieux, and Riederer 2020; Xie 2022).

Data input table: `FarmerLC_inputdata.csv`

```r
#install.packages("decisionSupport")
library(decisionSupport)

set.seed(254)
```

```r
make_variables <- function(est, n=1){
  x <- random(rho = est, n = n)
  for(i in colnames(x))assign(i, as.numeric(x[1,i]), envir = .GlobalEnv)
}
make_variables(decisionSupport::estimate_read_csv("Input_tables/FarmerLC_inputdata.csv",
                                                   sep = ";"))
```

Function

```r
farmer <- function(x, varnames)
  {

# A) farmer benefits without intervention ####
# We use maize equivalent of farm yield and the value of natural capital (trees)
# to calculate pre intervention benefits that a farmer has and will have during
# the project period.

# ex-ante risks to farmers crops
natural_hazard
```

```r
pest_disease_risk
farmer_inadequate_funds_risk
late_planting_risk
health_risk

prop_maize_yield_lost_hazard <- chance_event(natural_hazard,
                  yield_loss_drought/100, 0, gen_CV, n=n_years, one_draw = FALSE)
prop_maize_yield_lost_disease <- chance_event(pest_disease_risk,
                  yield_loss_disease/100, 0, gen_CV,n=n_years, one_draw = FALSE)
prop_maize_yield_lost_input_constraint <-
  chance_event(farmer_inadequate_funds_risk, yield_loss_due_to_input_constraint,
             0, gen_CV, n=n_years, one_draw = FALSE)
prop_maize_yield_lost_management <-
       chance_event(min(late_planting_risk, health_risk),
       yield_loss_due_to_management, 0, gen_CV, n=n_years, one_draw = FALSE)

#effects of all the above risks
farm_risks <- sapply(c(prop_maize_yield_lost_hazard +
         prop_maize_yield_lost_disease + prop_maize_yield_lost_input_constraint
         + prop_maize_yield_lost_management),function(x) min(x,1))

farmer_yield_t_ha <- vv(maize_yield_t_ha, gen_CV, n_years) * no_of_seasons

adjusted_farmer_yield_t_ha <- farmer_yield_t_ha * (1 - farm_risks)


crop_benefit <-
  adjusted_farmer_yield_t_ha *  ha_per_hh * 1000 * # conversion to kg/ha
  vv(maize_price_kes_kg, gen_CV, n_years)

# natural capital
adjusted_value_of_assets <-vv(value_of_farm_assets, gen_CV, n_years,
                              relative_trend = inflation_rate)

# Food cost saved from food accessible from the farm
annual_saved_food_cost <- vv(saved_food_cost_pm, gen_CV, n_years,
                              relative_trend = inflation_rate) * 12

farmer_pre_interv_benefit <- crop_benefit + adjusted_value_of_assets +
                             annual_saved_food_cost

# B) Cost of the farmer before the intervention ####
# medical Bills from farm related stresses
 medical_bills <- prop_hhincome_spent_on_hospital/100 *
                    vv(hh_income_pa, gen_CV,n_years)

# production costs for the farm
 farming_costs <- vv(production_costs_saved_acre, gen_CV, n_years,
                     relative_trend = inflation_rate)*
                  ha_per_hh * ha_acre_conversion * no_of_seasons

 # planning cost involves legal fee and the cost of knowledge acquisition
 farmer_plan_cost  <- planning_cost
```

```r
  farmer_pre_interv_cost <- medical_bills + farming_costs + farmer_plan_cost

# C) Farmer  costs  with Intervention ####
 farmer_one_time_cost <- cost_of_disruption_kes + # Damages  on physical assets
                         hhupkeep_prior_to_first_payment
   # HH income needed to sustain the hh prior 1st payment


 # planning cost involves legal fee and the cost of knowledge acquisition
farmer_plan_cost  <- planning_cost

farmer_recurring_cost <- adjusted_value_of_assets + # loss
                    annual_saved_food_cost # Food unavailable from farm directly

farmer_cost_interv <-  farmer_one_time_cost +  farmer_plan_cost +
                  farmer_recurring_cost

# D) Farmer Benefits with Intervention ####
# farmer's annual compensation aka lessor fee
lessor_fee <-vv(compensation_income_pm_acre, gen_CV, n_years)* 2 *
            ha_per_hh * ha_acre_conversion

#off farm employments and wages
off_farm_income <-vv(off_farm_income_kes_pm, gen_CV, n_years) *12

#income saved: production costs for farming
production_costs_saved <- farming_costs
# hospital bills saved (proxy for long term health) from farm related stresses
medical_bills_saved <- medical_bills

# social cohesion benefit
# social cohesion is expressed as a factor of free time as a result of the
# the intervention. With the intervention, free time is associated with
# social cohesion through community participation and involvement.
# We quantify it by the cost of labour per hour

# First, risks that threaten social cohesion are vices e.g crime, drug use,
# theft and domestic conflict - They take up time that would otherwise be used
# for community cooperation or activities

social_time_risk <- max(vice_risk,
                        domesticconflict_risk)

adjusted_social_time <- vv(social_time_hr_day, gen_CV, n_years) *
                    (1-social_time_risk)
social_cohesion <- adjusted_social_time * vv(labour_cost_kes_hr, gen_CV,
                                        n_years, relative_trend = inflation_rate)

# Better childhood benefit = long term benefit is education
# quantified by child's contribution to family farm labour weekly
# and the value of hired labour

better_childhood <- child_farm_time_hr_week * children_per_hh *
                    n_weeks_child_farm_time *
```

```r
                            vv(labour_cost_kes_hr, gen_CV, n_years,
                                relative_trend = inflation_rate )

farmer_benefit_interv <-
  lessor_fee + off_farm_income + production_costs_saved +
  sale_of_hh_items_not_needed +  medical_bills_saved + social_cohesion +
  better_childhood

# E) Calculate net benefit ####
farmer_pre_interv_netbenefit_kes <- farmer_pre_interv_benefit -
                                        farmer_pre_interv_cost

result_pre_intervention <- farmer_pre_interv_netbenefit_kes/currency_change

farmer_interv_netbenefit_kes <- farmer_benefit_interv - farmer_cost_interv

result_intervention <- farmer_interv_netbenefit_kes/currency_change

# Calculate categorized costs and benefits ####
# Categories include 1) Food costs not saved
food_cost_saved_npv <- discount(annual_saved_food_cost, discount_rate,
                                calculate_NPV = TRUE)
# 2) Natural assets lost
natural_assets_npv <- discount(adjusted_value_of_assets, discount_rate,
                                calculate_NPV = T)
# 3) Planning cost
# planning_npv <- farmer_plan_cost
# 4) Household income prior 1st payout  + 5) Disruption cost
# one_time_npv <- farmer_one_time_cost
# 6) Compensation for land
lease_npv <- discount(lessor_fee, discount_rate, calculate_NPV = T)
# 7) Production costs saved
prdn_costs_npv <- discount(farming_costs, discount_rate, calculate_NPV = T)
# 8) Alternative employment
alt_income_npv <- discount(off_farm_income, discount_rate, calculate_NPV = T)
# 9) Better childhood
better_childhood_npv <- discount(better_childhood, discount_rate,
                                calculate_NPV = T)
# 10) Social cohesion
social_npv <- discount(social_cohesion, discount_rate, calculate_NPV = T)
# 11) Medical bills saved
medical_npv <- discount(medical_bills_saved, discount_rate, calculate_NPV = T)
# 12) Annual crop yield
crop_npv <- discount(crop_benefit, discount_rate, calculate_NPV = T)


# NPV ####
NPV_interv_kes <- discount(farmer_interv_netbenefit_kes, discount_rate,
                            calculate_NPV = TRUE)
NPV_intervention <-
  discount(result_intervention, discount_rate, calculate_NPV = T)

NPV_n_interv_kes <- discount(farmer_pre_interv_netbenefit_kes, discount_rate,
```

```r
                                calculate_NPV = TRUE)

NPV_n_intervention <-
    discount(result_pre_intervention, discount_rate, calculate_NPV = T)

# Benefit cost ratio ####
# without intervention
npv_farmer_pre_interv_benefit <- discount(farmer_pre_interv_benefit, discount_rate,
                                        calculate_NPV = T)

npv_farmer_pre_interv_cost <- discount(farmer_pre_interv_cost, discount_rate,
                                        calculate_NPV = T)
bcr_n_interv <-npv_farmer_pre_interv_benefit/npv_farmer_pre_interv_cost
# with intervention
npv_farmer_benefit_interv <- discount(farmer_benefit_interv, discount_rate,
                                    calculate_NPV = T)
npv_farmer_cost_interv <- discount(farmer_cost_interv, discount_rate,
                                    calculate_NPV = T)
bcr_interv <- npv_farmer_benefit_interv/npv_farmer_cost_interv

   return(list(Interv_NPV = NPV_intervention,
               Interv_NPV_kes = NPV_interv_kes,
               No_Interv_NPV = NPV_n_intervention,
               No_Interv_NPV_kes = NPV_n_interv_kes,
               NPV_decision_kes = NPV_interv_kes - NPV_n_interv_kes,
               NPV_decision_do = NPV_intervention - NPV_n_intervention,
               BCR_no_interv = bcr_n_interv,
               BCR_interv = bcr_interv,
               Food_money_saved = food_cost_saved_npv,
               Natural_assets = natural_assets_npv,
               Planning = farmer_plan_cost,
               Disruption_cost = farmer_one_time_cost,
               Lease = lease_npv,
               Production_costs = prdn_costs_npv,
               Alternative_income = alt_income_npv,
               Childhood = better_childhood_npv,
               Social = social_npv,
               Medical = medical_npv,
               Annual_yield = crop_npv,
               Cashflow_decision_do = farmer_interv_netbenefit_kes -
                                      farmer_pre_interv_netbenefit_kes))
}

mcSimulation_results <-  decisionSupport::mcSimulation(
  estimate = estimate_read_csv("Input_tables/FarmerLC_inputdata.csv",sep =";"),
  model_function = farmer,
  numberOfModelRuns = 1e4, #10000
  functionSyntax = "plainNames")
```

References

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