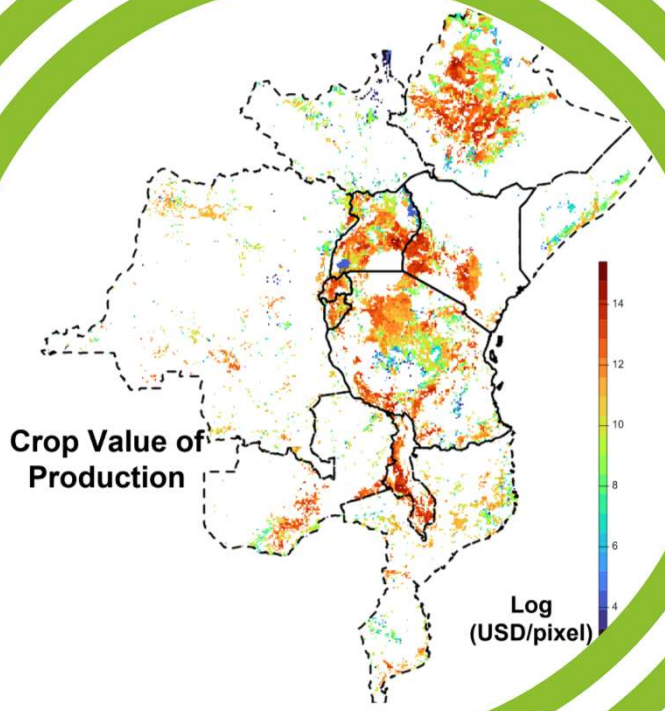
CGIAR | AICCRA
Accelerating the Impact of CGIAR Climate Research for Africa

Economic & Financial Analysis Tool for Climate Change Adaptation Proposals

User Guide



Pete Steward | 16 Dec 2022
p.steward@cgiar.org

What is this tool for?

The AICCRA EFA tool is designed to provide the high level Economic and Financial analysis (EFA) needed to inform programme development and evidence large-scale funding proposals.

It is suitable for macro-scale planning, for example Global Climate Fund (GCF) proposals. In fact, this tool uses the approach employed in the EFA used to support the AICCRA project. We suggest you read the AICCRA EFA to understand how this tool can be employed.

The approach is simple and pragmatic. You choose countries, farming systems, one or more crops or livestock types for your project. Then you set some simple technology performance and project economic parameters. Tables and maps are output that can be saved and inserted in your proposal.

Download & Installation

Get R & RStudio

The tool runs in R-Studio using an interactive R markdown script.

You will need to download and install R and RStudio.

Download R

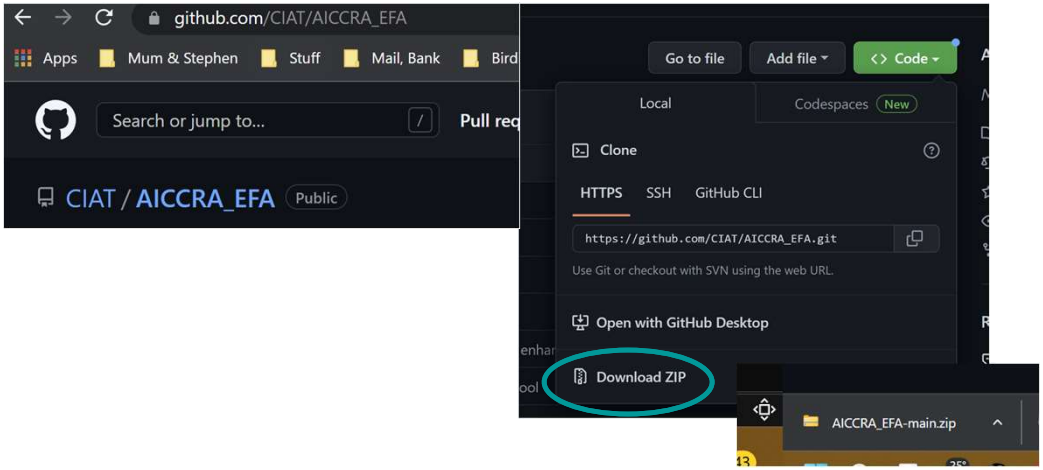
Download RStudio

A user guide for installation.

Get the AICCRA EFA tool

The tool is hosted on github: https://github.com/CIAT/AICCRA_EFA

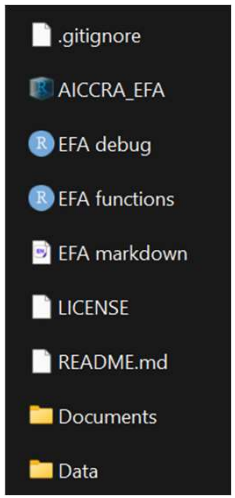
Download the tool as a .zip folder to your local machine



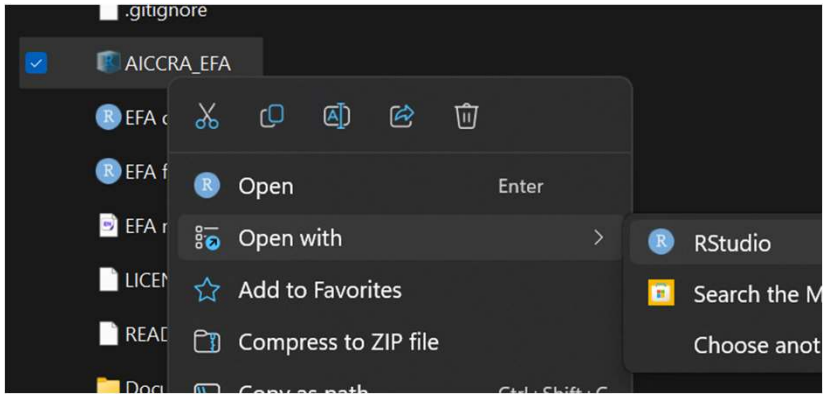
Running the script

Unzip & open the project

- Unzip the downloaded folder
  - You should see the files as per the image left

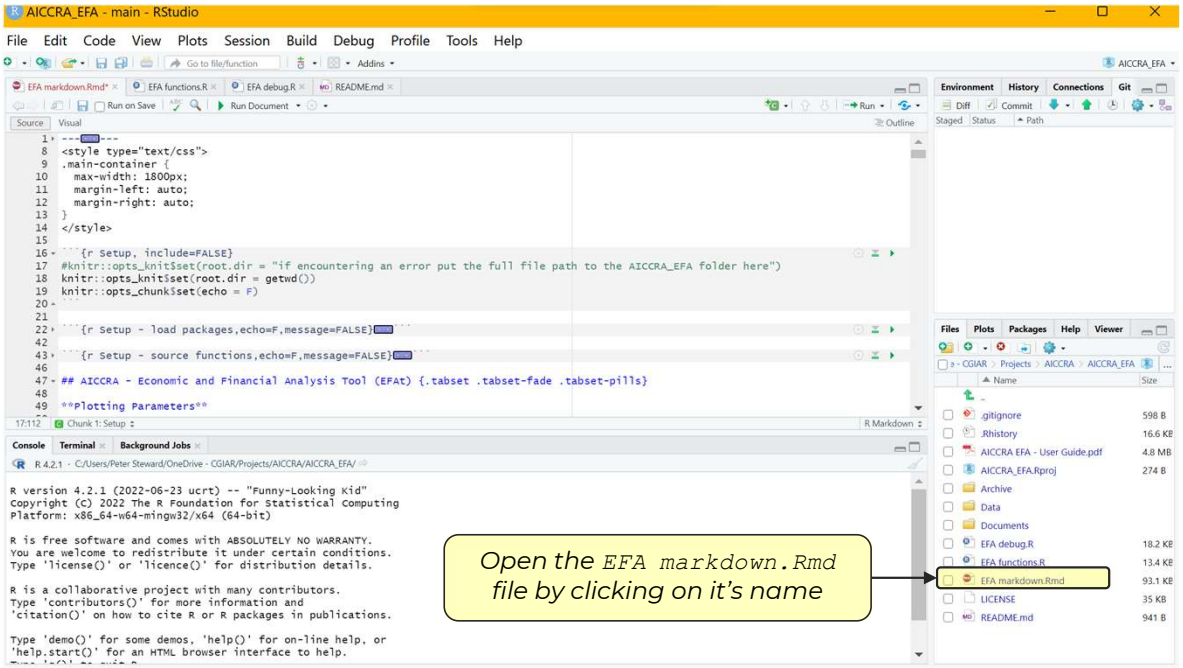


- Open the AICCRA_EFA.Rproj file using RStudio



Running the script

Open the R Markdown file



You should see this Rstudio window when you open the .Rproj file.

Next open the ERA markdown.Rmd file

Running the script

How to fix working directory issues

If you get errors like: **Error:** cannot change working directory

Error: Cannot open "/private/var/folders/32/pjhmw8j520j0v3v391nq3c6r0000gn/T/Rtmp7zRNL6/file1123b2d0c2c92/Data/CGIAR_region/CGIAR_countries_simplified.shp"; The source could be corrupt or not supported. See `st_drivers()` for a list of supported formats.

Then you will need to edit the code on l17-18:

```
16 ```{r Setup, include=FALSE}
17 #knitr::opts_knit$set(root.dir = "if encountering an error put the full file path to the AICCRA_EFA folder here")
18 knitr::opts_knit$set(root.dir = getwd())
19 knitr::opts_chunk$set(echo = F)
20 ```
21
```

Add hash to l18, and remove hash from l17:

```
16 ```{r Setup, include=FALSE}
17 knitr::opts_knit$set(root.dir = "if encountering an error put the full file path to the AICCRA_EFA folder here")
18 #knitr::opts_knit$set(root.dir = getwd())
19 knitr::opts_chunk$set(echo = F)
20 ```
```

Insert the full path to your AICCRA_EFA folder on l17:

```
```{r Setup, include=FALSE}
knitr::opts_knit$set(root.dir = "C:/AICCRA_EFA")
#knitr::opts_knit$set(root.dir = getwd())
knitr::opts_chunk$set(echo = F)
```
```

This is an example, you will need to amend to where you have saved on your machine. Windows users please note path syntax uses a forward slash not a backslash (e.g., `C:/` not `C:\`)

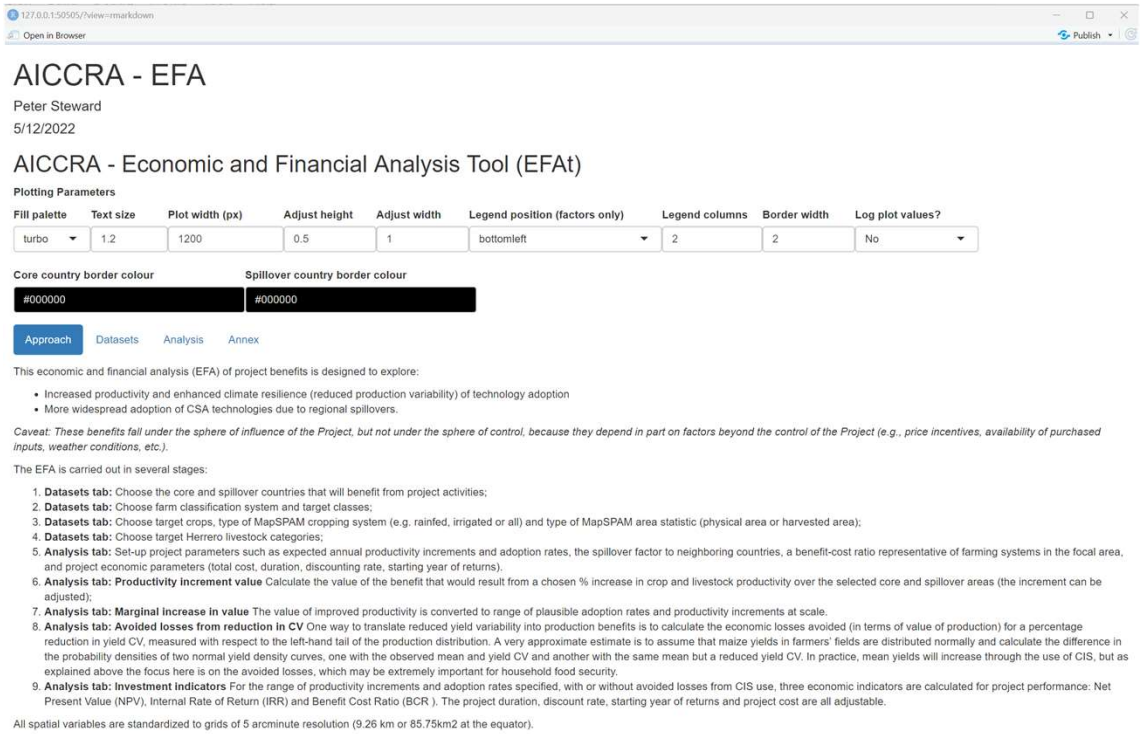
Running the script

Run the rmarkdown file

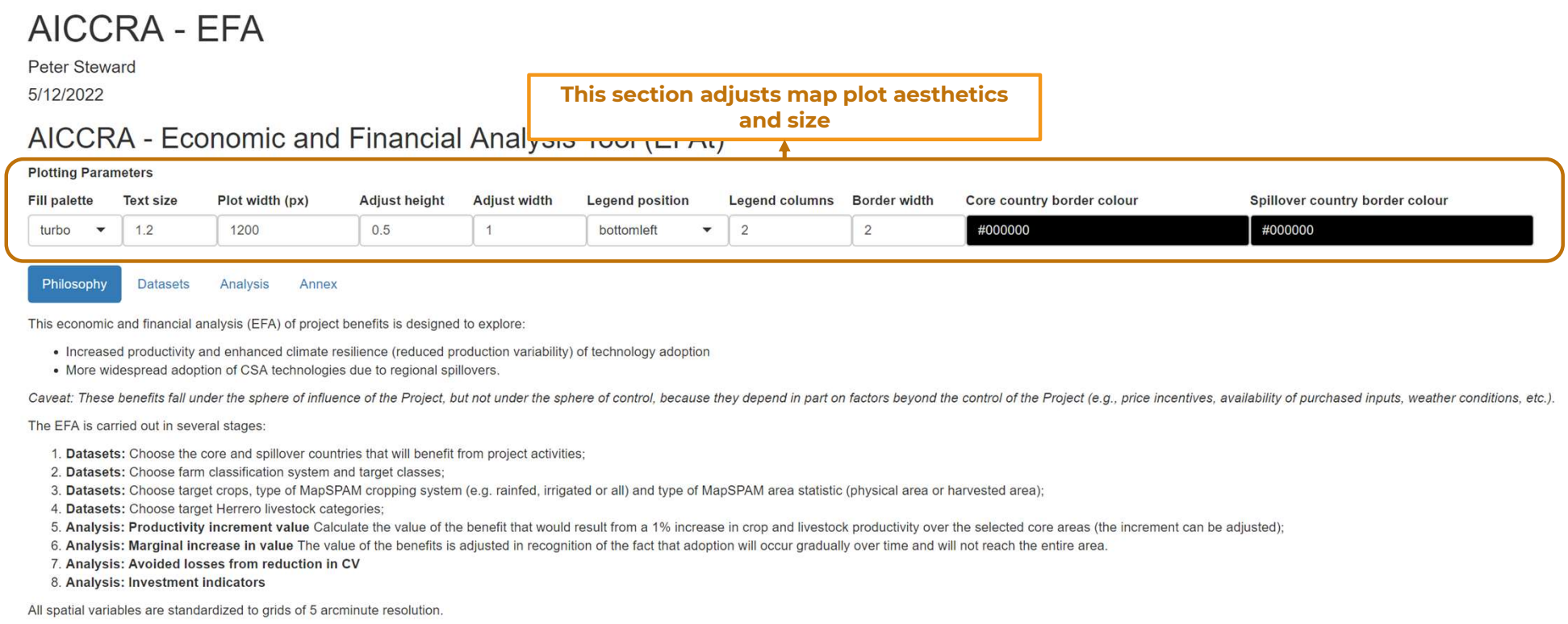
Run the markdown by selecting the Run Document command.

The first time you run the script it may take a while to open the tool as Rstudio will need to download several required packages. You may also need to update packages.

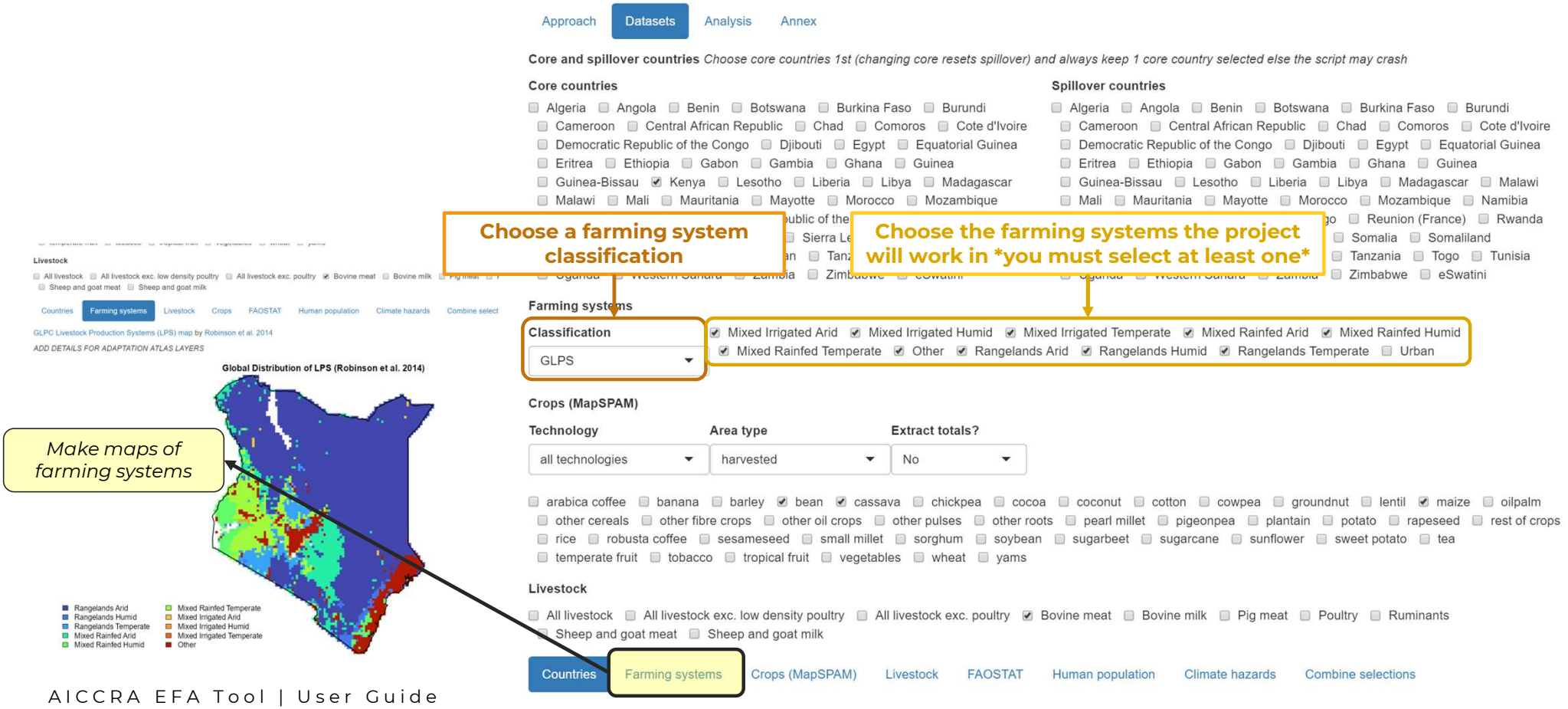
Running the script



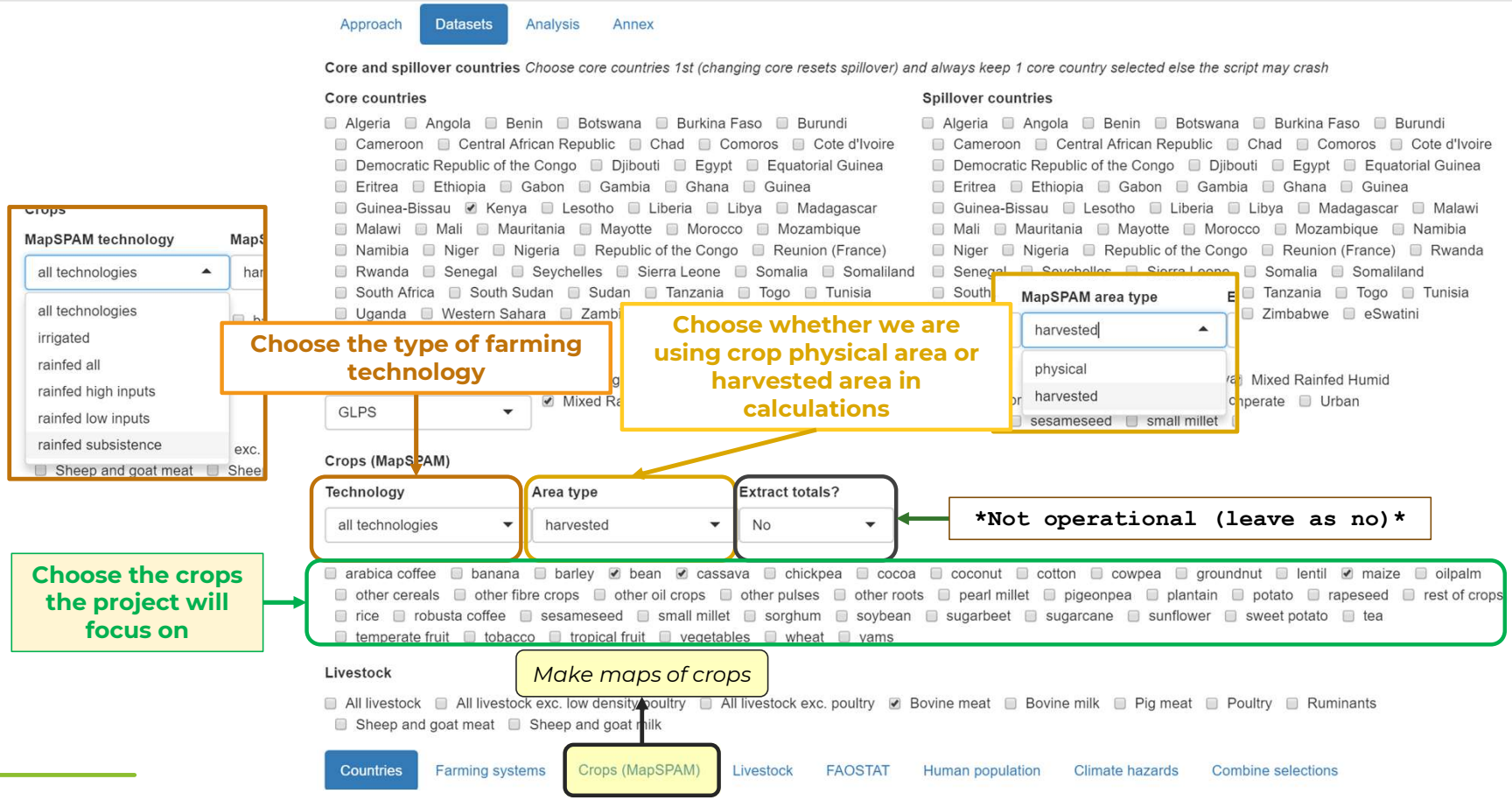
If the script has run successfully, you should see a new window that looks like the image left.


AICCRA - EFA
Peter Steward
5/12/2022
This section adjusts map plot aesthetics and size
Plotting Parameters
Fill palette
Text size
Plot width (px)
Adjust height
Adjust width
Legend position
Legend columns
Border width
Core country border colour
Spillover country border colour
turbo
1.2
1200
0.5
1
bottomleft
2
2
#000000
#000000
Philosophy
Datasets
Analysis
Annex
This economic and financial analysis (EFA) of project benefits is designed to explore:
Increased productivity and enhanced climate resilience (reduced production variability) of technology adoption
More widespread adoption of CSA technologies due to regional spillovers.
Caveat: These benefits fall under the sphere of influence of the Project, but not under the sphere of control, because they depend in part on factors beyond the control of the Project (e.g., price incentives, availability of purchased inputs, weather conditions, etc.).
The EFA is carried out in several stages:
1. Datasets: Choose the core and spillover countries that will benefit from project activities;
2. Datasets: Choose farm classification system and target classes;
3. Datasets: Choose target crops, type of MapSPAM cropping system (e.g. rainfed, irrigated or all) and type of MapSPAM area statistic (physical area or harvested area);
4. Datasets: Choose target Herrero livestock categories;
5. Analysis: Productivity increment value Calculate the value of the benefit that would result from a 1% increase in crop and livestock productivity over the selected core areas (the increment can be adjusted);
6. Analysis: Marginal increase in value The value of the benefits is adjusted in recognition of the fact that adoption will occur gradually over time and will not reach the entire area.
7. Analysis: Avoided losses from reduction in CV
8. Analysis: Investment indicators
All spatial variables are standardized to grids of 5 arcminute resolution.

Set-up: Choose the farming systems the project will work in



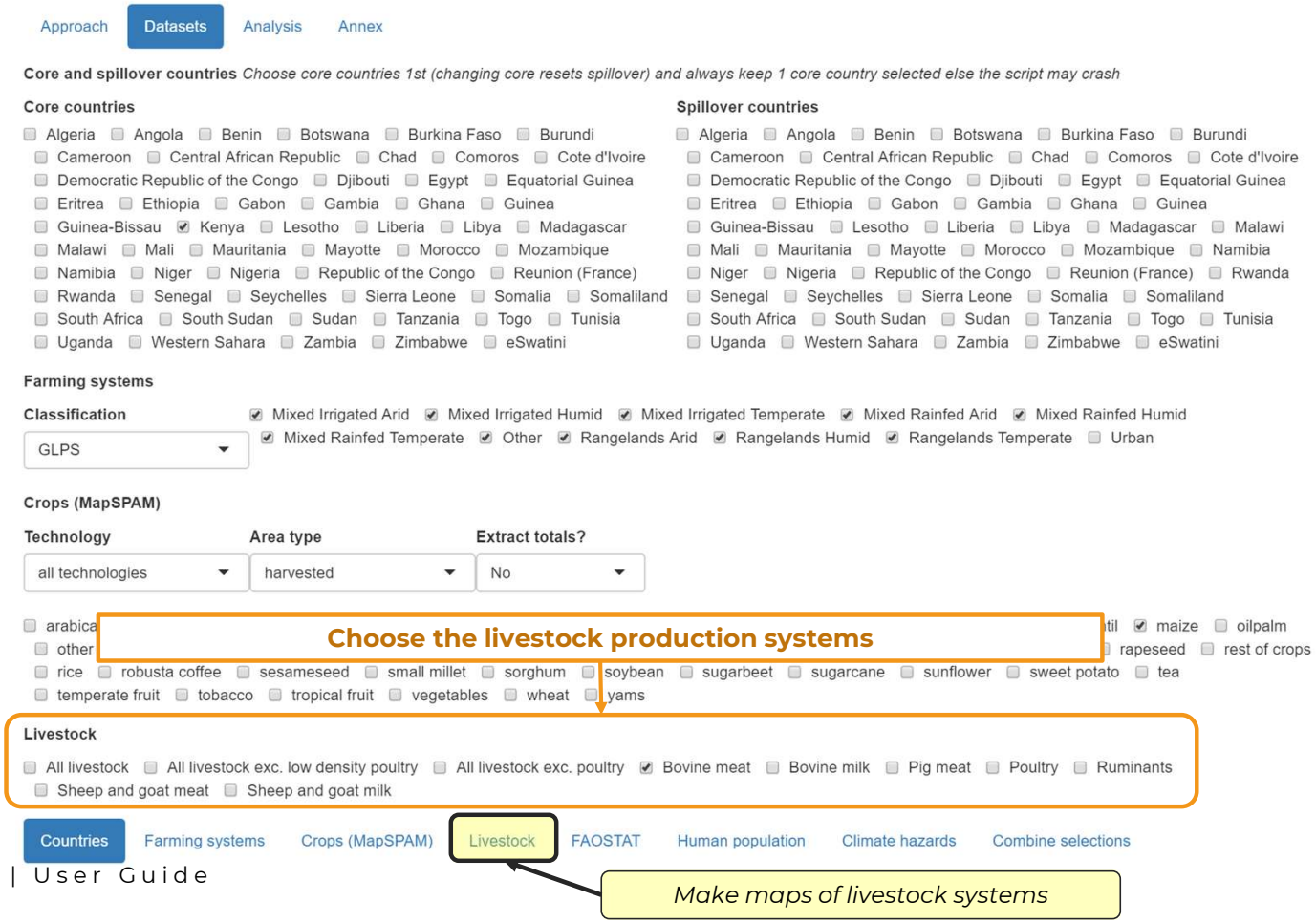
Set-up: Choose the crops the project will work with



Set-up: MapSPAM, crop technologies and area types explained

Maps of crop VoP, Area and Production are produced reflecting your `farming systems x crop x technology x area type` selections

Set-up: Choose the livestock production systems the project will work with (if any)



Set-up: View FAOSTAT data used to estimate variability in crop production

Approach | **Datasets** | Analysis | Annex

Countries | Farming systems | Crops (MapSPAM) | Livestock | **FAOSTAT** | Human population | Climate hazards | Combine selections

FAO data are used to estimate the national level variation in crop production over time. They are downloaded using the FAOSTAT::get_faostat_bulk function. Data can also be accessed from the FAOSTAT website and directly downloaded here.

Prepare data | **Raw data** | Coefficent of variation (CV) | Plot

To interpret these data please see the meta-data section under `Crops and livestock products` in thisFAOSTAT website and this pdf. The `SpamName` field converts the FAO crop name in the `item` column to the corresponding SPAM name.

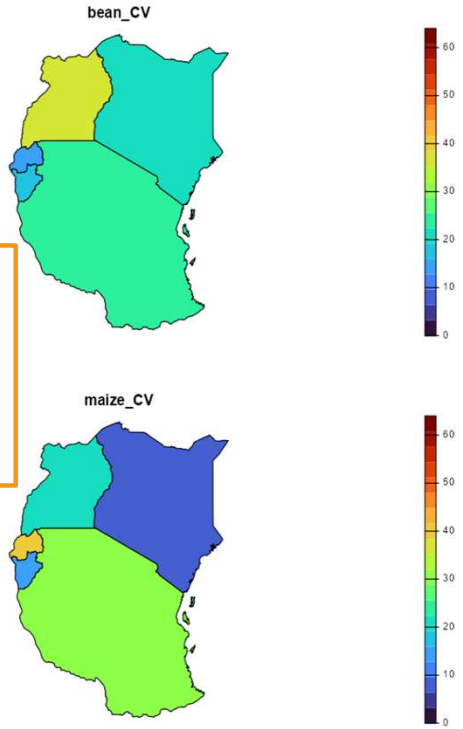
Copy | CSV | Excel | PDF | Print | Show 10 entries | Search:

	area_code	area	item_code	item	element_code	element	year_code	year	unit	value	flag
	A		A		All		A				
1	4	Algeria	486	Bananas	5419	yield	2001	2001	t/ha		
2	4	Algeria	486	Bananas	5419	yield	2002	2002	t/ha		
3	4	Algeria	486	Bananas	5419	yield	2003	2003	t/ha		
4	4	Algeria	486	Bananas	5419	yield	2004	2004	t/ha		
5	4	Algeria	486	Bananas	5419	yield	2005	2005	t/ha		
6	4	Algeria	486	Bananas	5419	yield	2006	2006	t/ha	11	Fc
7	4	Algeria	486	Bananas	5419	yield	2007	2007	t/ha	11	Fc
8	4	Algeria	486	Bananas	5419	yield	2008	2008	t/ha	9.2	Fc
9	4	Algeria	486	Bananas	5419	yield	2009	2009	t/ha	15.182	Fc
10	4	Algeria	486	Bananas	5419	yield	2010	2010	t/ha	18.917	Fc

Prepare data | Raw data | Coefficent of variation (CV) | **Plot**

Countries with no fill colour indicate either a crop is not grown in this country or there is no yield ir

Coefficient of variation



The CV map is useful for reality checking the CV reduction parameter used in the analysis. This value represents a reduction in CV from the adoption of a technology.

Set-up: Set technology performance parameters for the analysis

Do not use costs with livestock, use BCR

CIS = "Climate information services", this EFA tool was originally designed to estimate their value, but any technology that increases resistance to climate stresses and shocks can be considered

By what % will adoption of your technology improve yields?
Enter at least one value
* Up to 3 values allowed for sensitivity analysis*

What is the annual % adoption rate of your technology with the core project areas?
Enter at least one value
* Up to 3 values allowed for sensitivity analysis*

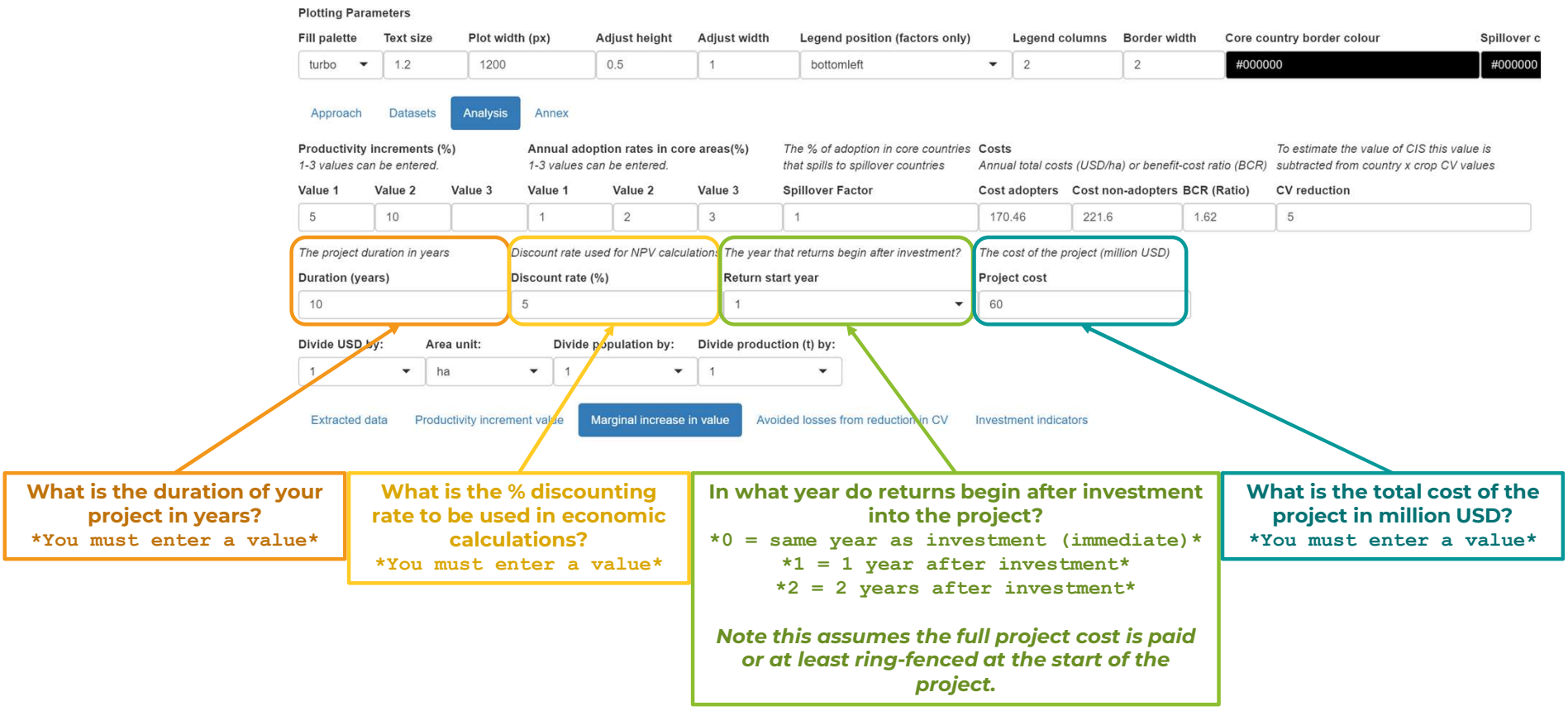
By what % does adoption of your technology spill over into your spillover countries (if any) from the core areas?
You must enter a value, this can be 0 if there is no spillover
Typically, this will be very low (<=1%)

What is the cost of the farming systems?
1) You can enter costs (USD/ha) for adopters and non-adopters of a technology for crops (does work for livestock use option 2).
2) You can also enter a typical benefit-cost ratio (BCR) for your target farming system(s) which is used to estimate the costs of production (note BCR method simply scales cost with increases in production).
You must enter a value

How much will adoption of your technology reduce climate variability? This value is subtracted from country x crop CV values and used to estimate yield loss reductions.
You must enter a value
Visualize country x crop CV in the Datasets/FAOSTAT/Plots tab

***Note** Defining costs does not work for livestock systems. This because cost are defined on per ha basis and the livestock areas used are for entire farming systems giving very low yields per unit area. We must use the entire farming system area because the spatial footprint of livestock production is not available for livestock (as it is from MapSPAM for crops). When using livestock, you will need to leave the costs blank and use the BCR option*

Set-up: Set project economic parameters for the analysis



What is the duration of your project in years?
You must enter a value

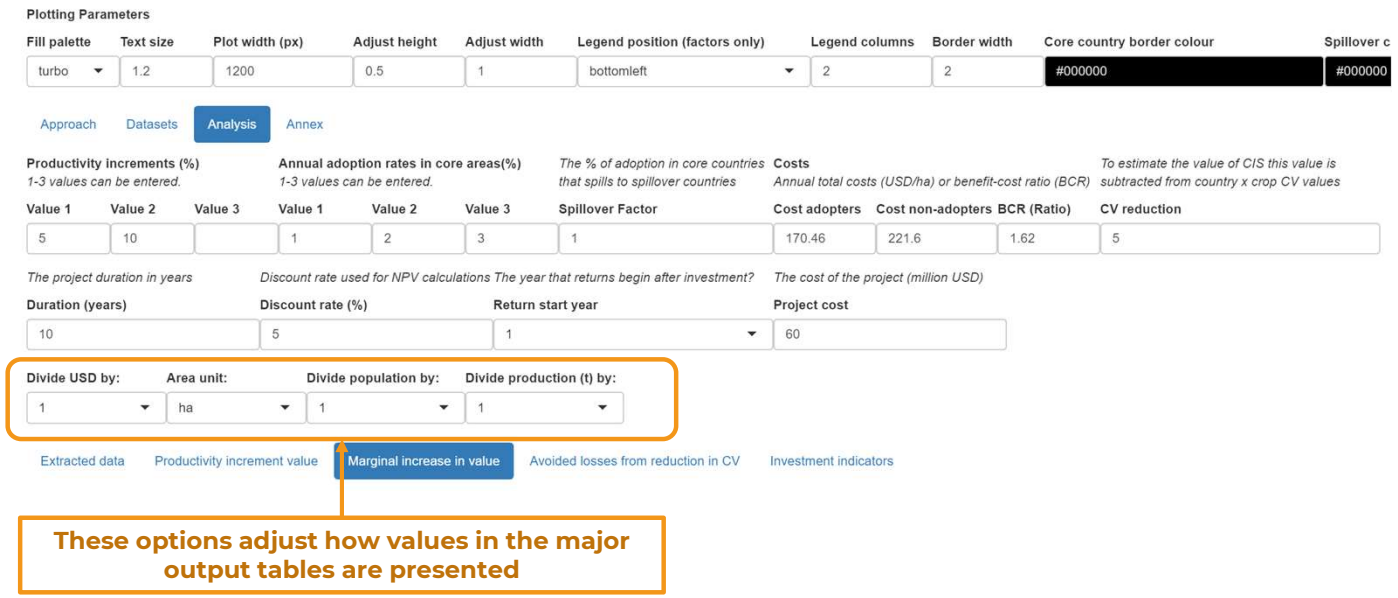
What is the % discounting rate to be used in economic calculations?
You must enter a value

In what year do returns begin after investment into the project?
0 = same year as investment (immediate)
1 = 1 year after investment
2 = 2 years after investment

Note this assumes the full project cost is paid or at least ring-fenced at the start of the project.

What is the total cost of the project in million USD?
You must enter a value

Display: Set value units for display of analysis outcomes



Results: Display crop/livestock statistics for country x farming systems

The `Extracted data tab` shows values summed by farming system x country (rows) for the crops and livestock systems (cols) you have selected (`Extraction tab`). Core and Spillover countries are presented in separate tabs.

Values presented are total area, human population, rainfall variability, value of production, area of production, yield and price.

Each row in the extracted data tables represents a farming system within a country. Explanation of table headings: `Area.ha` = area (ha); `Hpop` = human population; `RainCV.ln` = natural log of mean rainfall CV; suffix `vop` = commodity value of production (international USD); suffix `area` = commodity area of production (km2); suffix `yield` = commodity yield (ton/ha); suffix `price` = 2005 commodity price (international USD/ton).

Copy | CSV | Excel | PDF | Print | Show 10 entries | Search:

	Country	Farming_System	Area.ha	Hpop	RainCV.ln	Bovine meat_vop	Bovine meat_area	Bovine meat_prod	bean_vop	cassava_vop	maize_vop	bean_area	cassava_area	maize_area	bean_prod
1	Kenya	Rangelands Arid	39429801.735	6401885.239	3.579	10728910.185	39429801.735	5648.855	29498637.228	1548994.394	25564378.431	74615.6	1422.9	100741.501	49027.3
2	Kenya	Rangelands Humid	973035.198	215066.881	3.144	4255665.37	955952.57	2227.58	2949070.582	813887.3	4864362.053	7146.5	497.8	16987.1	4901.4
3	Kenya	Rangelands Temperate	2538173.264	802371.783	3.108	30917471.391	2538173.264	16061.462	18093076.129	16421.2	15906546.327	49250.1	10.9	69866.7	30071.1
4	Kenya	Mixed Rainfed Arid	5210448.936	3584663.205	3.316	9810554.711	5193403.352	5157.778	139676456.893	10735190.857	116906467.085	327269.1	7766.2	449417.301	232147.9

Results: Display farming system areas

The `Extracted data tab` also shows the % area of different farming systems for each country and for the total core or spillover area (`Farmings System Areas tab`).

**Note the totals are can sum to >100% as the total national areas comes from a shapefile and the farming system areas come from a raster.*

Extraction | Farming System Areas

Copy | CSV | Excel | PDF | Print | Show 10 entries | Search:

	Country	Mixed Irrigated Arid	Mixed Irrigated Humid	Mixed Irrigated Temperate	Mixed Rainfed Arid	Mixed Rainfed Humid	Mixed Rainfed Hyperarid	Mixed Rainfed Temperate	Other	Rangelands Arid	Rangelands Humid	Rangelands Temperate	Total
	All	All	All	All	All	All	All	All	All	All	All	All	All
1	Kenya	0.25	0.12	0.06	8.89	3.38		7.97	7.41	67.24	1.66	4.33	101.31
2	Tanzania	0.1		0.01	28.63	11.86	0.02	3.77	15.01	21.59	12.82	2.18	95.99
3	Total	0.16	0.04	0.03	21.06	8.61	0.01	5.38	12.1	39.11	8.54	3	98.04

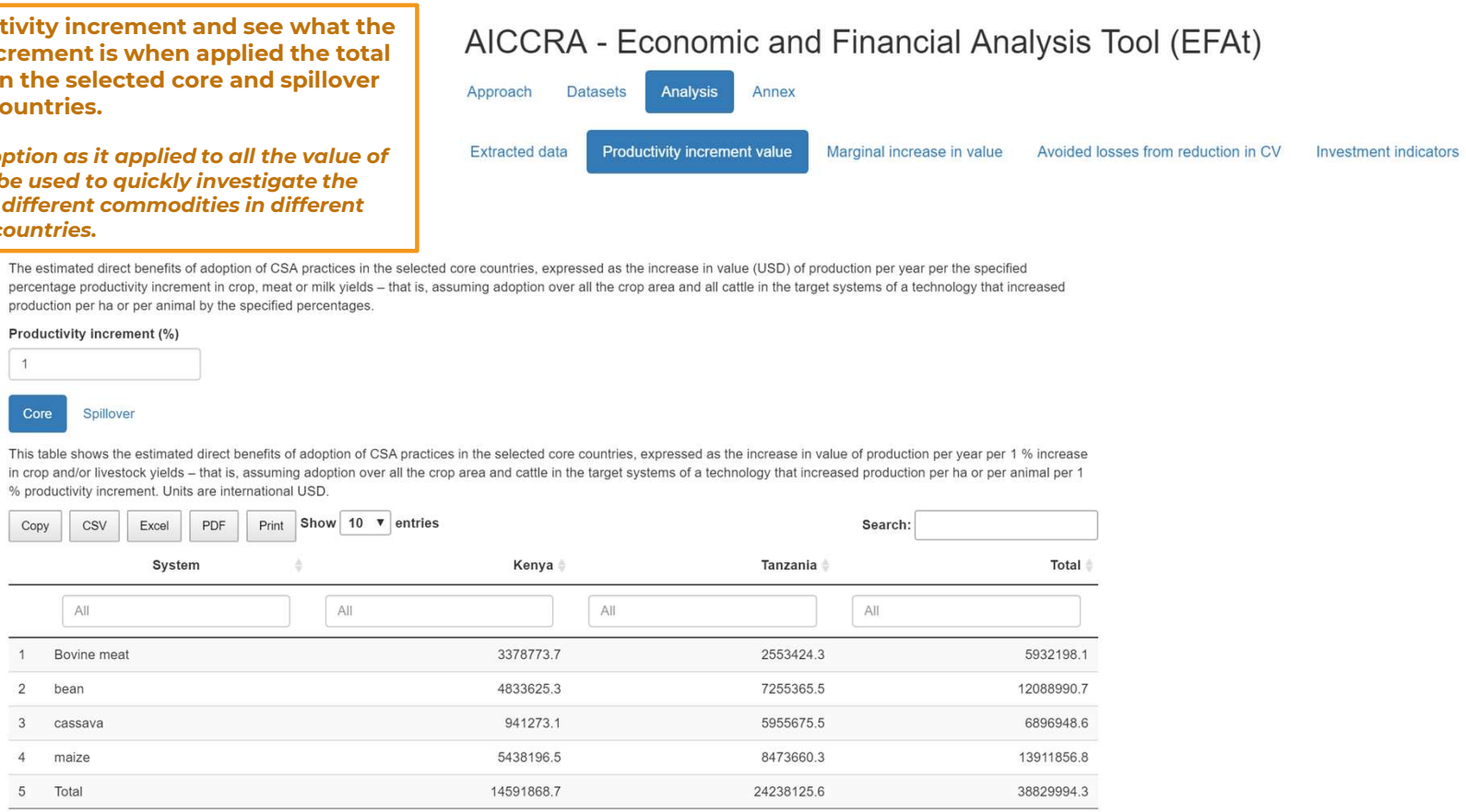
Showing 1 to 3 of 3 entries

Previous | 1 | Next

Results: Display farming system areas

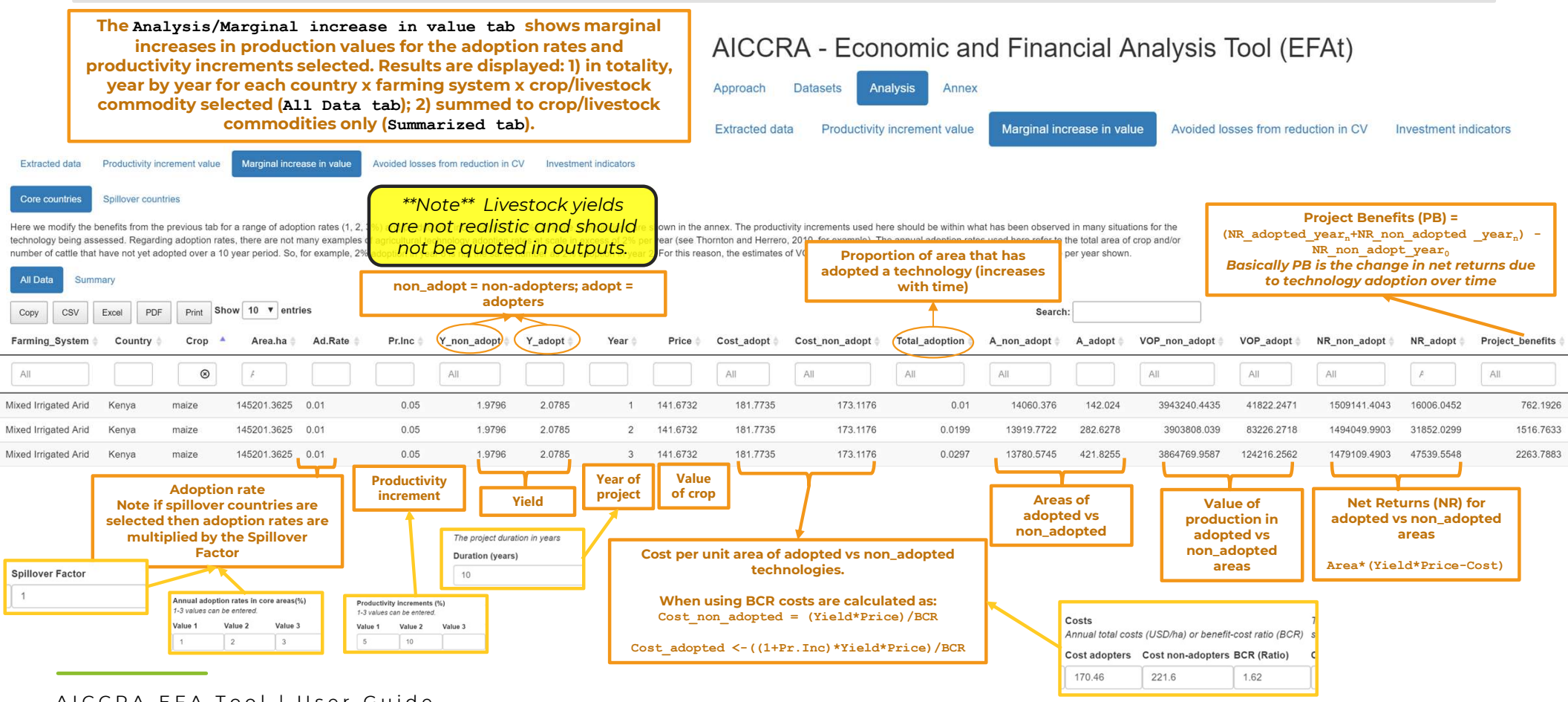
Here you can set a productivity increment and see what the estimated value of this increment is when applied the total value of crops/livestock in the selected core and spillover countries.

Note this assumes 100% adoption as it applied to all the value of production. This tab can be used to quickly investigate the potential of working with different commodities in different countries.



Results: Display marginal increases in production results

The **`Analysis/Marginal increase in value tab`** shows marginal increases in production values for the adoption rates and productivity increments selected. Results are displayed: 1) in totality, year by year for each country x farming system x crop/livestock commodity selected (**`All Data tab`**); 2) summed to crop/livestock commodities only (**`Summarized tab`**).



Results: Adjust units

AICCRA - Economic and Financial Analysis Tool (EFAt)

Approach | Datasets | Analysis | Annex

Extracted data | Productivity increment value | Marginal increase in value | Avoided losses from reduction in CV | Investment indicators

Each row in the table represents a commodity x farming system x country combination for different values of annual adoption rate and productivity increment.
Explanation of table headings: `Area.ha` = area of commodity (ha); `Ad.Rate` = annual adoption rate (proportion); `Pr.Inc` = productivity increment (proportion); `Y_non_adopt` = mean yield of non-adopters (t/ha); `Y_adopt` = mean yield of adopters (t/ha) as `Y_non_adopt*(1+Pr.Inc)`; `Year` = project year; `Price` = 2005 commodity price (international USD/ton); `Cost_adopt` = estimate of production cost per ha as `Price*Y_adopt/BCR of non-adopters`; `Cost_non_adopt` = estimate of production cost per ha as `Price*Y_non_adopt/BCR of non-adopters`; `Total_adoption` = total adoption of technology (proportion); `A_non_adopt` = area of non-adopters as `Area*(1-Total_adoption)` (km2); `A_adopt` = area of adopters (km2) as `Area*Total_adoption`; `VOP_non_adopt` = total value of production for non-adopters (international USD) as `A_non_adopt*Y_non_adopt*Price`; `VOP_adopt` = total value of production for adopters (international USD) as `A_adopt*Y_adopt*Price`; `NR_non_adopt` = net return for non-adopters as `A_adopt*(Y_adopt*Price-Cost_adopt)`; `NR_adopt` = net return for adopters as `A_non_adopt*(Y_non_adopt*Price-Cost_non_adopt)`; `Project_benefits` = marginal value of adoption (international USD) as `NR_non_adopt+NR_adopt-NR_non_adopt_t0` where `NR_non_adopt_t0` is the net return of the system before any technology adoption has occurred. For more information on how `Total_adoption` is calculated see the `MarginalInc` function found in the **Analysis::Data prep & analysis functions** tab.

Core countries | Spillover countries

Here we modify the benefits from the previous tab for a range of adoption rates (1, 2, 3%) and productivity increments (5, 10%) at scale. Calculations are shown in the annex. The productivity increments used here should be within what has been observed in many situations for the technology being assessed. Regarding adoption rates, there are not many examples of agricultural technology adoption rates at scale in excess of 2% per year (see Thornton and Herrero, 2010, for example). The annual adoption rates used here refer to the total area of crop and/or number of cattle that have not yet adopted over a 10 year period. So, for example, 2% adoption in year 8 is not the same number as 2% adoption in year 2. For this reason, the estimates of VOP addition are not simple linear multiples of the adoption rate per year shown.

All Data | Summary

Copy | CSV | Excel | PDF | Print | Show 10 entries | Search:

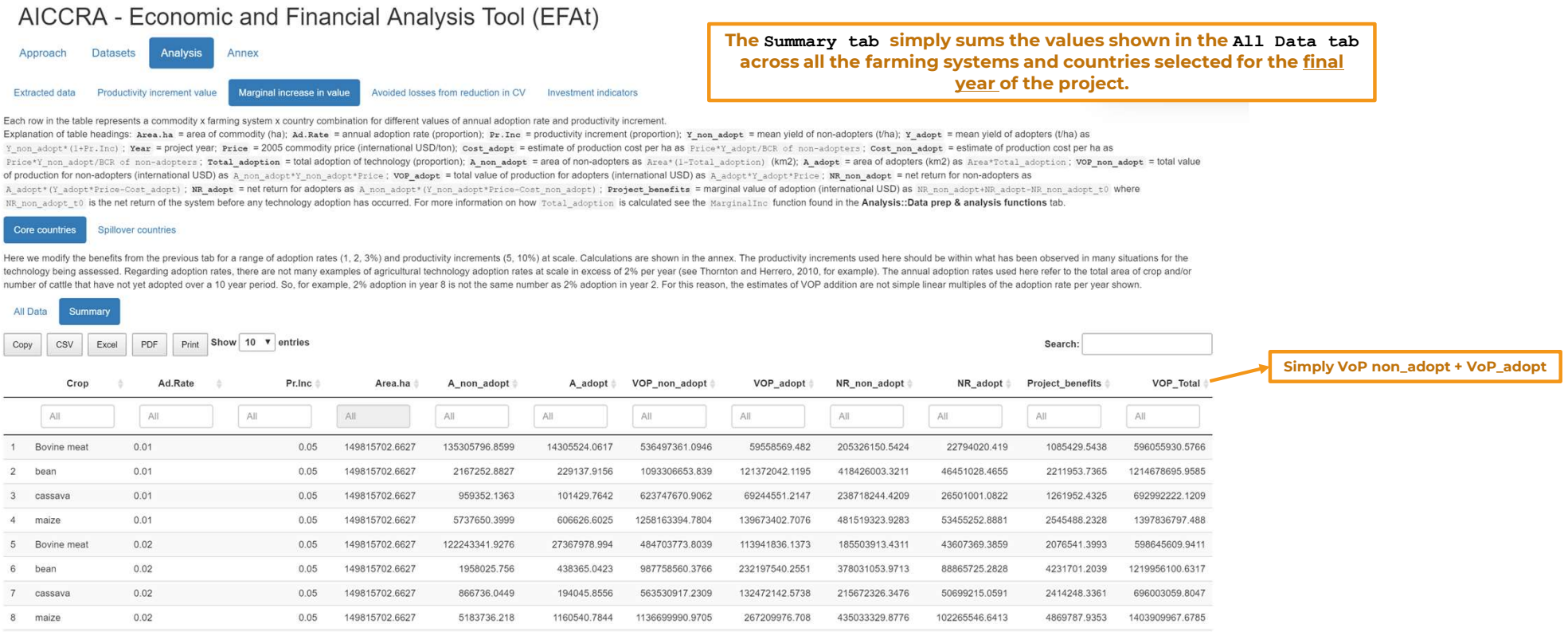
Farming_System	Country	Crop	Area.ha	Ad.Rate	Pr.Inc	Y_non_adopt	Y_adopt	Year	Price	Cost_adopt	Cost_non_adopt	Total_adoption	A_non_adopt	A_adopt	VOP_non_adopt	VOP_adopt	NR_non_adopt	NR_adopt	Project_benefits
All						All				All	All	All	All		All	All	All		All
Mixed Irrigated Arid	Kenya	maize	145201.3625	0.01	0.05	1.9796	2.0785	1	141.6732	181.7735	173.1176	0.01	14060.376	142.024	3943240.4435	41822.2471	1509141.4043	16006.0452	762.1926
Mixed Irrigated Arid	Kenya	maize	145201.3625	0.01	0.05	1.9796	2.0785	2	141.6732	181.7735	173.1176	0.0199	13919.7722	282.6278	3903808.039	83226.2718	1494049.9903	31852.0299	1516.7633
Mixed Irrigated Arid	Kenya	maize	145201.3625	0.01	0.05	1.9796	2.0785	3	141.6732	181.7735	173.1176	0.0297	13780.5745	421.8255	3864769.9587	124216.2562	1479109.4903	47539.5548	2263.7883

Divide USD by: 1 | **Area unit:** ha | **Divide population by:** 1 | **Divide production (t) by:** 1

Remember you can use these options to adjust the units of value, area and production

Extracted data | Productivity increment value | Marginal increase in value | Avoided losses from reduction in CV | Investment indicators

Results: Display marginal increases in production



The `Summary tab` simply sums the values shown in the `All Data tab` across all the farming systems and countries selected for the final year of the project.

Simply VoP non_adopt + VoP_adopt

Results: Display avoided losses in production from climate adaptative technologies

Approach | Datasets | **Analysis** | Annex

Annual productivity increments (%)			Annual adoption rates in core areas(%)			*The % of adoption in core countries that spills to spillover countries*	*Benefit-cost ratio 1.62 for "traditional" technologies*	*To estimate the v subtracted from*
1-3 values can be entered.			*1-3 values can be entered.*					
Value 1	Value 2	Value 3	Value 1	Value 2	Value 3	Spillover Factor	BCR of non-adopters	CV reduction
5	10		1	2	3	1	1.62	5

Extracted data | Productivity increment value | Marginal increase in value | **Avoided losses from reduction in CV** | Investment indicators

Core | Spillover

CV table | Marginal VoP inc. Non-CIS + CIS | Summary

This table is derived from the FAOSTAT data presented in the **Datasets::FAO** tab. Each row in the extracted data tables represents a crop within a country. Explanation of table headings: `N.Years` = number of years of FAO national yield data available; `Yield_Mean` = mean FAO crop yield (t/ha); `Yield_SD` = standard deviation of crop yield; `CV` = coefficient of variation for crop yield as `100*(Yield_SD/Yield_Mean)` ; `CVreduced` = value of CV following reduction in variability due to use of CIS; `AvoidedLossPerc` = reduction in yield losses due to climate variability from use of CIS (%). For more information on how `AvoidedLossPerc` is calculated see the `AvLoss` function in the `ERA functions.R` script.

Copy | CSV | Excel | PDF | Print | Show 10 entries | Search:

	Country	Crop	N.Years	Yield_Mean	Yield_SD	CV	CVreduced	AvoidedLossPerc
	All	All	All	All	All	All	All	All
1	Kenya	bean	20	0.553	0.121	21.811	16.811	-4.078
2	Kenya	cassava	20	11.227	2.944	26.221	21.221	-3.387
3	Kenya	maize	20	1.643	0.156	9.524	4.524	-10.87

Showing 1 to 3 of 3 entries

Number of years of FAO Data

Mean yield t/ha (FAO data)

Standard deviation of yield t/ha (FAO data)

Yield CV (FAO DATA)

Yield CV - CV reduction

Avoided loss % (negative value means losses are avoided, you can ignore the minus sign)

We estimate the economic losses avoided by adoption of a technology that enhances famers ability to resist climate stresses and shocks.

This is only implemented for crops not livestock.

We take the distribution of long-term average yields for a country x crop from FAOSTAT and modify the coefficient of variation (CV) by subtracting a fixed value from it. We then recalculate the left-hand tail of the yield distribution function (yield less than the long-term mean) using the reduced CV and calculate the % by which this reduce losses.

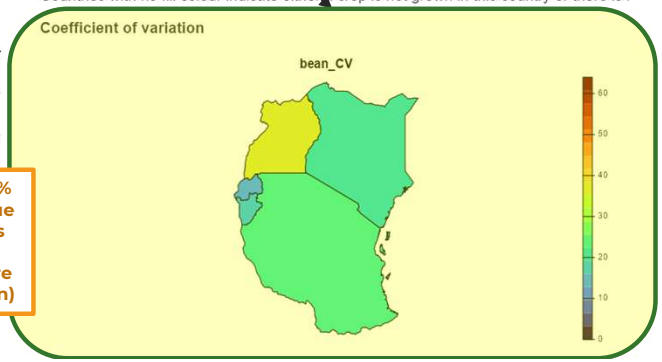
When deciding what CV reduction is appropriate use the `Datasets/FAOSTAT/Plot Tab` to visualize CV for your selected crops and regions.

Approach | **Datasets** | Analysis | Annex

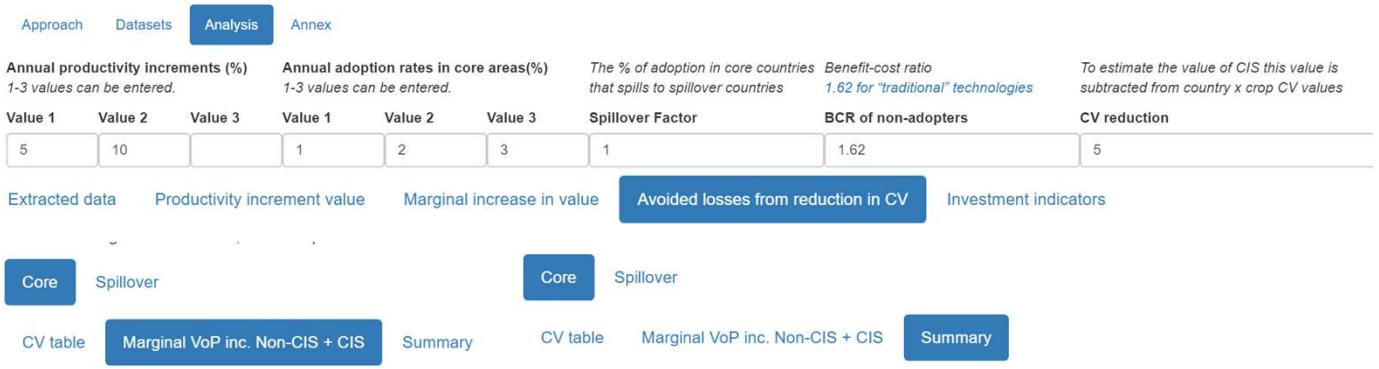
Countries | Farming systems | Crops (MapSPAM) | Livestock | **FAOSTAT**

Prepare data | Raw data | Coefficent of variation (CV) | **Plot**

Countries with no fill colour indicate either a crop is not grown in this country or there is



Results: Display avoided losses in production from climate adaptative technologies



The detailed and summary tables of costs and returns are the same as the previous tab (`Marginal increase in value`), but with 3 additional columns

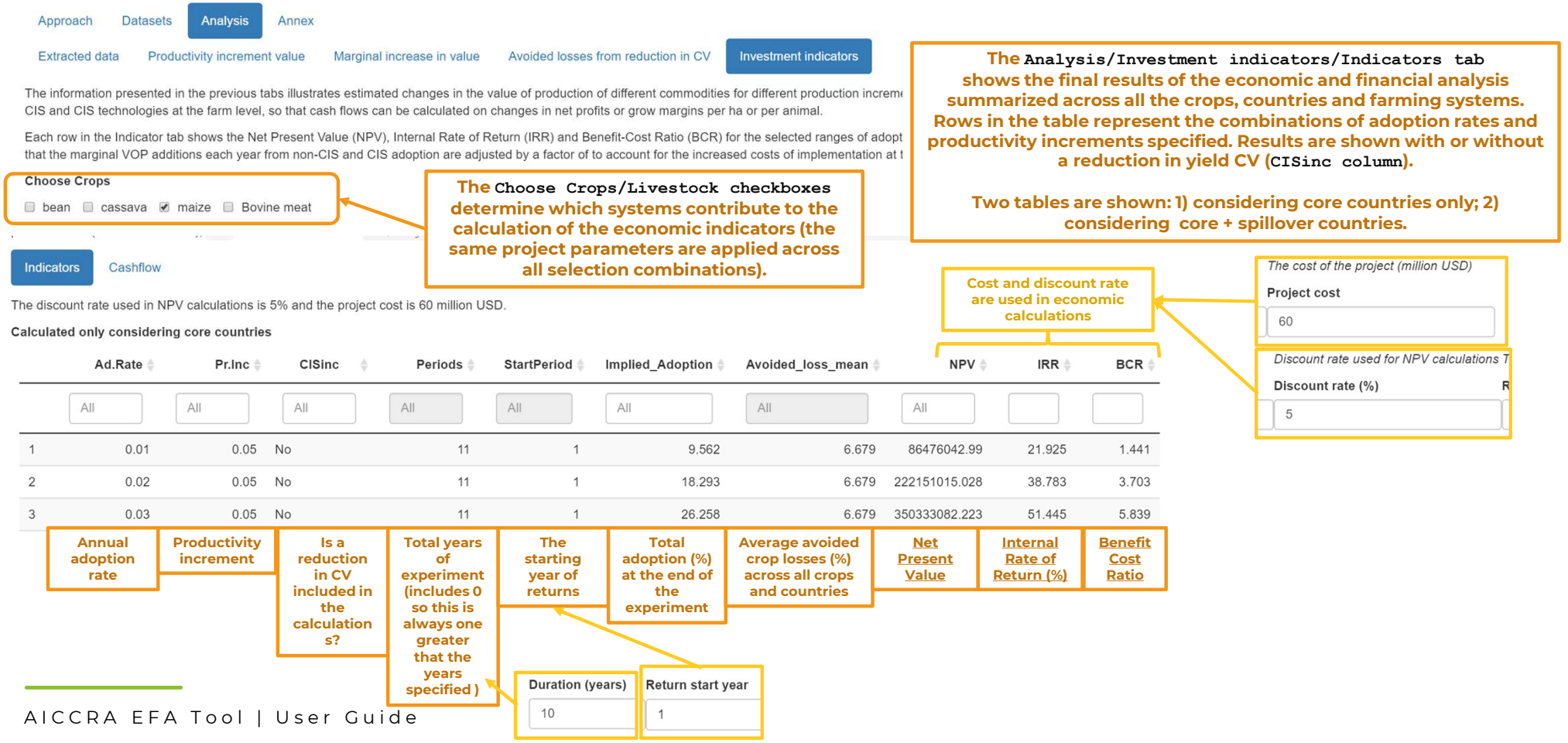
Project_benefits	AvoidedLossPerc	VOP_CIS	VOP_both
All	All		A
9254.643	10.87	4545.989	46368.237
18416.739	10.87	9046.519	92272.791
27487.215	10.87	13502.043	137718.299

Avoided loss %

Value of avoided loss in adopted areas.

Value of production in adopted areas (from productivity increment) + value of avoided loss in adopted areas

Results: Display investment indicators (BCR/IRR/NPV)



Results: Display investment indicators (BCR/IRR/NPV)

AICCRA - Economic and Financial Analysis Tool (EFAt)

Approach | Datasets | **Analysis** | Annex

Extracted data | Productivity increment value | Marginal increase in value | Avoided losses from reduction in CV | **Investment indicators**

The information presented in the previous tabs illustrates estimated changes in the value of production of different commodities for different production increme
CIS and CIS technologies at the farm level, so that cash flows can be calculated on changes in net profits or grow margins per ha or per animal.

Each row in the Indicator tab shows the Net Present Value (NPV), Internal Rate of Return (IRR) and Benefit-Cost Ratio (BCR) for the selected ranges of adopt
that the marginal VOP additions each year from non-CIS and CIS adoption are adjusted by a factor of to account for the increased costs of implementation at t

Choose Crops

☐ bean ☐ cassava ☑ maize ☐ Bovine meat

Indicators | **Cashflow**

Core only | Core + Spillover

Copy | CSV | Excel | PDF | Print | Show 10 entries | Search:

	Farming_System	Country	Crop	Ad.Rate	Pr.Inc	Year	Total_adoption	AvoidedLossPerc	CISinc	Cashflow
	All	All	All	All	All	All	All	All	All	All
1	Mixed Irrigated Arid	Kenya	bean	0.01	0.05	1	0.01	4.092	No	-3784.368
2	Mixed Irrigated Arid	Kenya	bean	0.01	0.05	2	0.02	4.092	No	-7530.892
3	Mixed Irrigated Arid	Kenya	bean	0.01	0.05	3	0.03	4.092	No	-11239.952
4	Mixed Irrigated Arid	Kenya	bean	0.01	0.05	4	0.039	4.092	No	-14911.92

Adoption rate — **Productivity increment** — **Year of project** — **Proportion of farming system that has adopted a technology** — **Avoided crop losses (%)** — **Is a reduction in CV included in the calculations?** — ***Cashflow is the change in net returns due to technology adoption (i.e., project implementation) over time***

The `Analysis/Investment indicators/Cashflow tab` shows the non-summarized economic analysis cashflows by farming system x country x crop x year. Cashflow tables contains the same data as per the `Analysis/Avoided losses from reduction in CV` marginal increases in VoP tables. The `Cashflow` field here is analogous to the `Project_benefits` field in the previous tabs, but it has been amended to include the value of avoided losses from reduction in CV (or not, as indicated by the `CISinc` field).

Two tables are shown: 1) considering core countries only; 2) considering core + spillover countries.

We need your feedback!

Please let us know of any bugs or issues you find or any improvements/expansions that you require at the email address below.

Pete Steward | p.steward@cgiar.org

CGIAR | AICCRA
Accelerating the Impact of CGIAR Climate Research for Africa