User manual- Energy Efficiency Calculator for Crops

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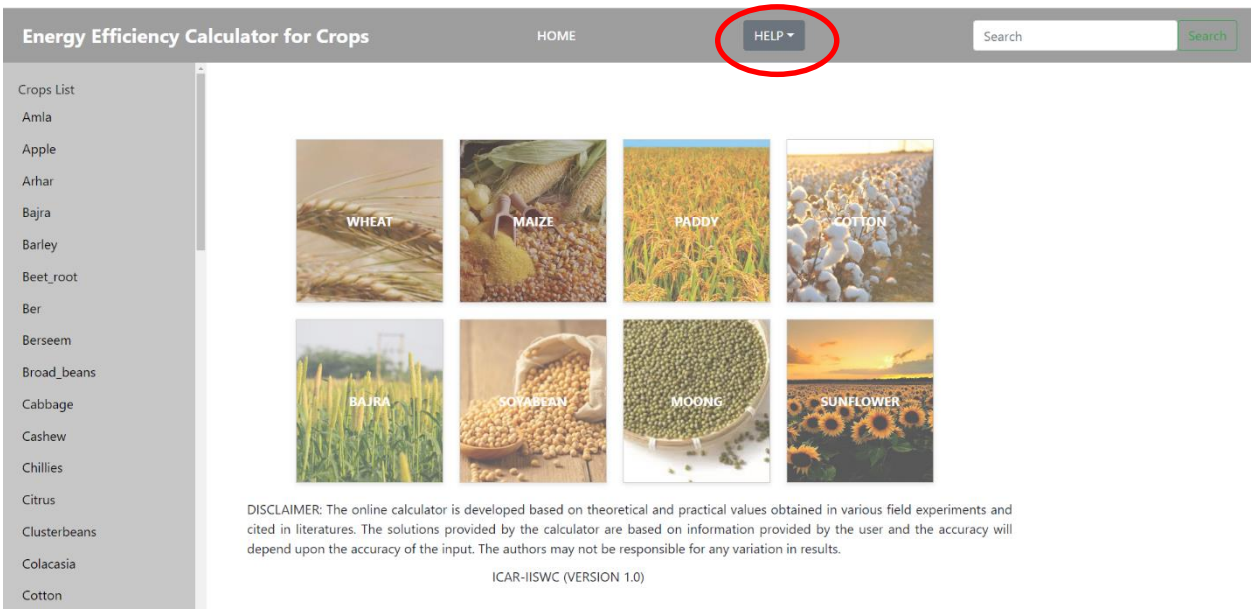
The online calculator automatically evaluates the energy efficiency of fifty-eight different crops by taking user inputs on energy investments, including direct (e.g., fuel, electricity) and indirect sources (e.g., fertilizers, pesticides), throughout the entire crop production process. It also accounts for energy returned through the total harvested yield. Using inbuilt energy equivalent coefficients, the software converts original unit data to energy (MJ/ha). It then generates energy efficiency metrics through seven indices. These metrics aid in exploring diverse methods to adopt energy-saving strategies in crop production, underscoring the importance of efficient energy use in agricultural practices.

Getting Started

Step1: The user can get started by browsing through the web address https://rewardiiswc.in/reactapp/index.html

Step 2: Energy Efficiency Calculator for Crops: When User enter into the **Energy Efficiency Calculator for Crops** following window will appear (read manual before use in HELP).



Step 3: Select crop for which want to calculate energy efficiency

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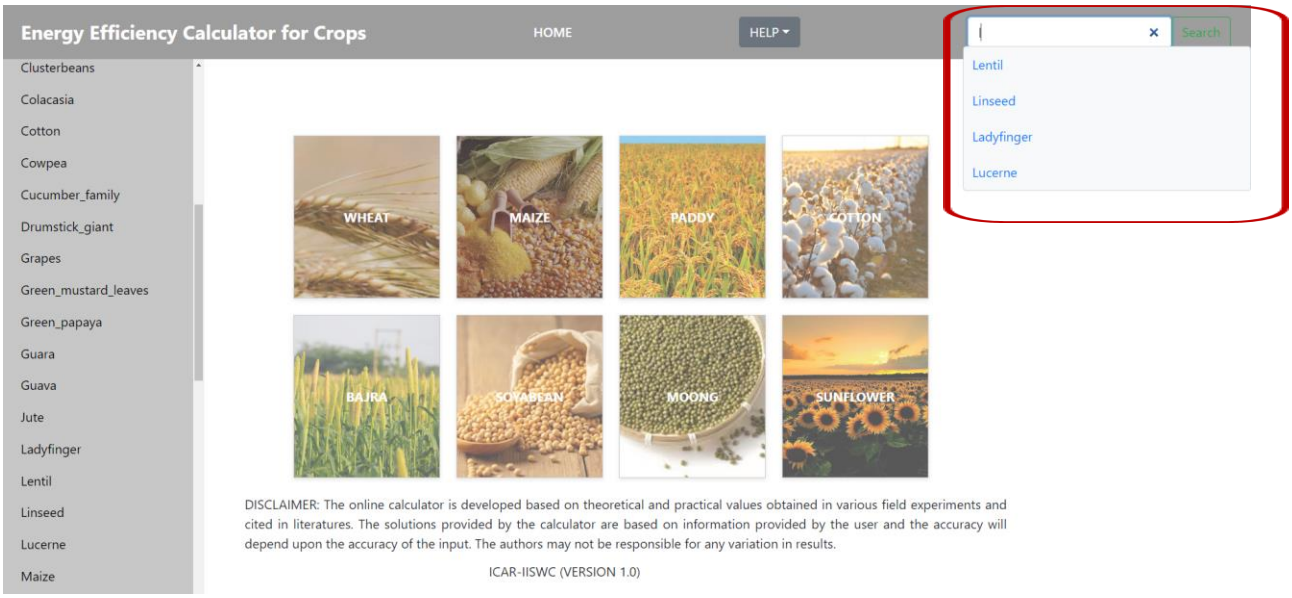
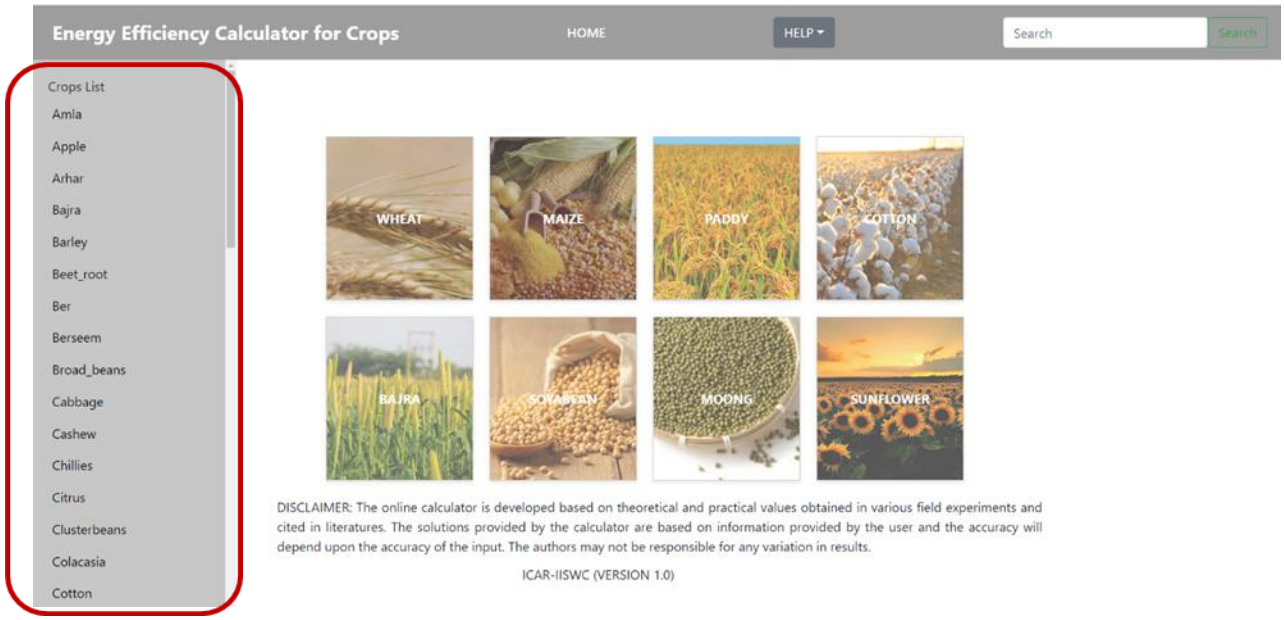
Sl.No	Crop List	Sl.No.	Crop List	Sl.No.	Crops List
1	Amla	**21**	Green_mustard_leaves	**41**	Peas
2	Apple	**22**	Green_papaya	**42**	Pineapples
3	Arhar	**23**	Guara	**43**	Potato
4	Bajra	**24**	Guava	**44**	Pumpkin
5	Barley	**25**	Jute	**45**	Rape seed
6	Beet_root	**26**	Ladyfinger	**46**	Sapotta
7	Ber	**27**	Lentil	**47**	Senji
8	Berseem	**28**	Linseed	**48**	Sesame
9	Broad_beans	**29**	Lucerne	**49**	Sorghum
10	Cabbage	**30**	Maize	**50**	Soybean
11	Cashew	**31**	Mango	**51**	Spinach
12	Chillies	**32**	Mash	**52**	Sugarcane
13	Citrus	**33**	Moong	**53**	Sunflower
14	Clusterbeans	**34**	Muskmelon	**54**	Sunnhemp
15	Colacasia	**35**	Mustard	**55**	Sweet_potato
16	Cotton	**36**	Napier	**56**	Tamarind
17	Cowpea	**37**	Oats	**57**	Tapioca
18	Cucumber_family	**38**	Paddy_(not_shelled_rice)	**58**	Tomato
19	Drumstick_giant	**39**	Peach		
20	Grapes	**40**	Pears		

User can select a particular crop in three ways:

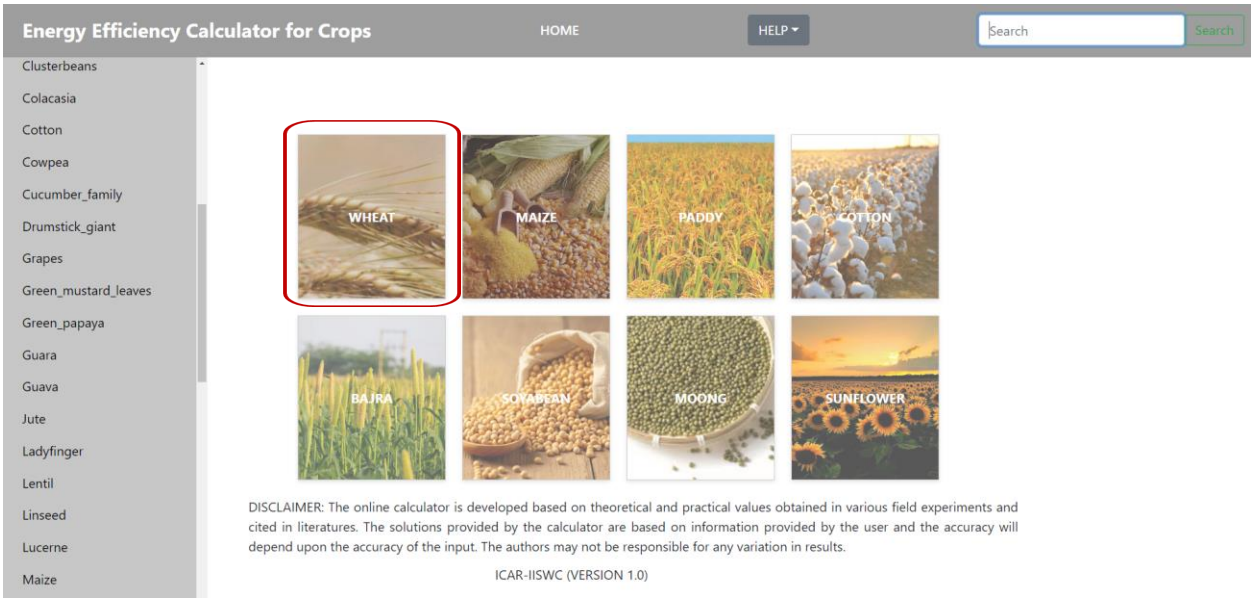
I. Search the crop by typing English name of the crop on search bar (top right of the screen)



II. Click on a crop name from the list of fifty-seven crops (accessible via a) on the left side of the screen.



III. Click on crop icon to select the crop (Only few popular crops available in the option)



Step 4: After selecting crop, a new window will appear as:

For example, selected crop is wheat, then new window asking for user input value. Scroll down the window to view the entire form.

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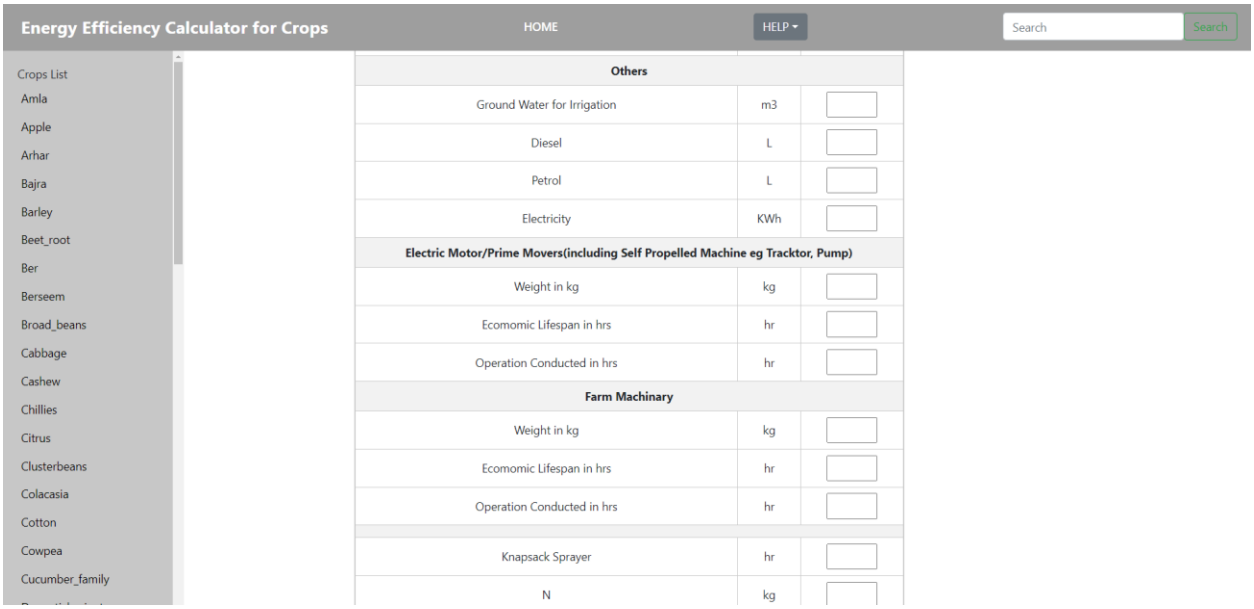
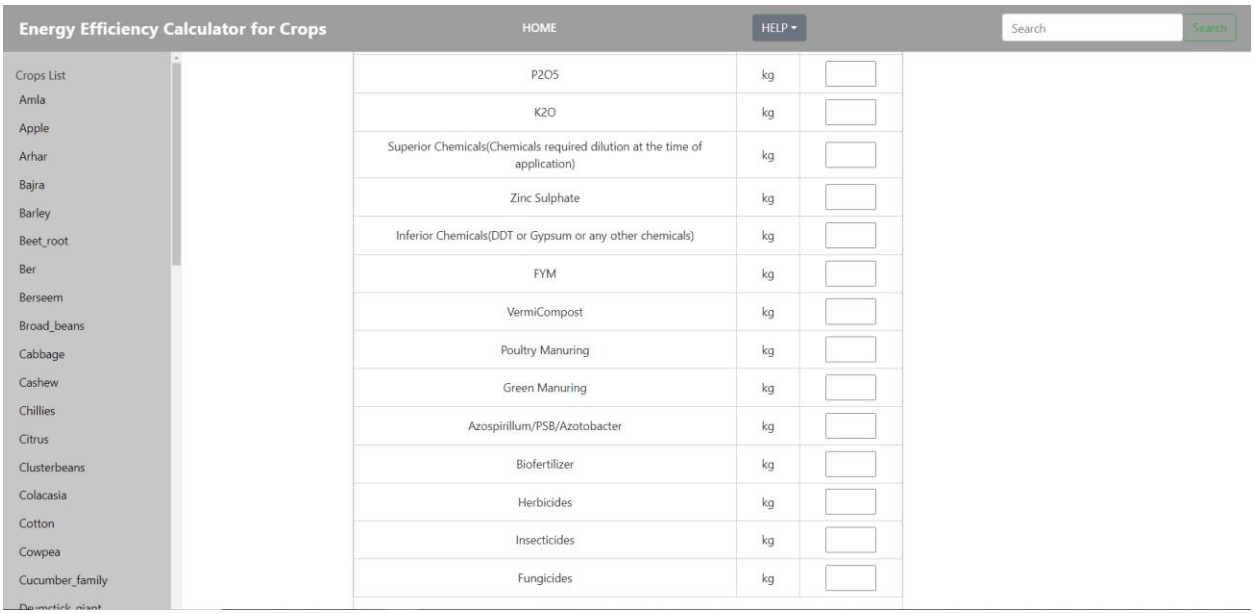
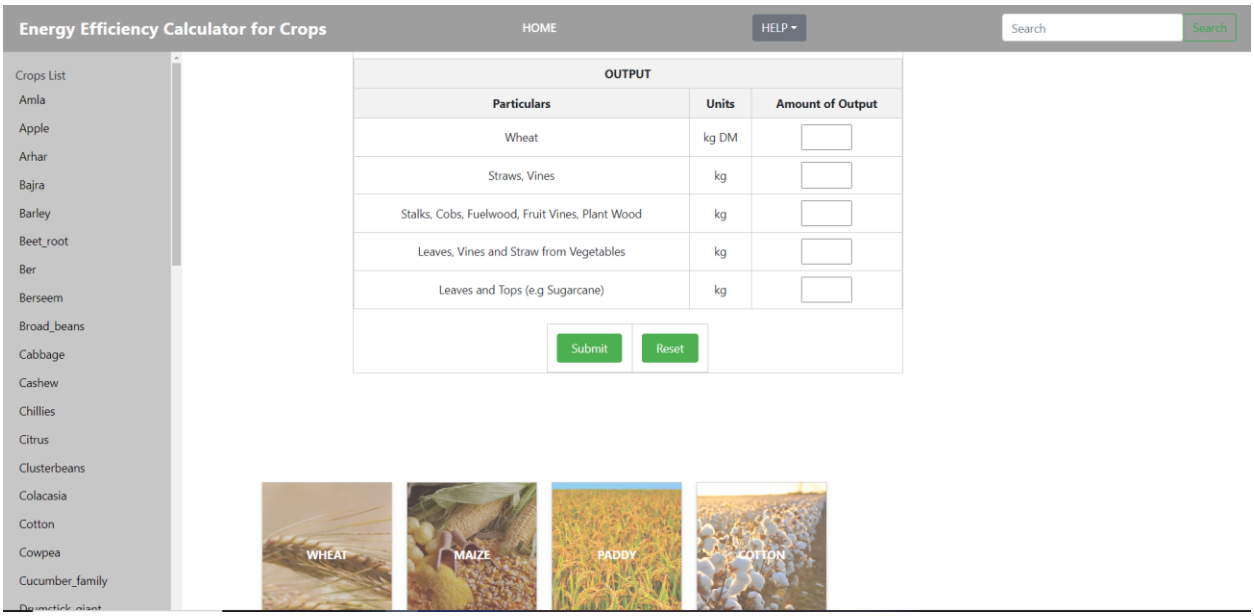
Area Cultivated	ha	
Cost of Cultivation	Rs	

Particulars	Units	Amount of Input
Wheat	kg DM	
Human Labour		
Adult Man	hr	
Adult Woman	hr	
Adolescent	hr	
Animal Labour		
Bullocks Large(Greater than 450kg)	Pair-hr	
Bullocks Medium(350-450kg)	Pair-hr	
Bullocks Small(Less than 350kg)	Pair-hr	
He Buffalo	Pair-hr	
Camel or Horse	Animal-hr	



Others		
Ground Water for Irrigation	m3	
Diesel	L	
Petrol	L	
Electricity	KWh	
Electric Motor/Prime Movers(including Self Propelled Machine eg Tracktor, Pump)		
Weight in kg	kg	
Ecomomic Lifespan in hrs	hr	
Operation Conducted in hrs	hr	
Farm Machinary		
Weight in kg	kg	
Ecomomic Lifespan in hrs	hr	
Operation Conducted in hrs	hr	
Knapsack Sprayer	hr	
N	kg	





Step 5: Fill all the relevant information in specified unit. If any option is not relevant to you then put zero value instead of left blank.

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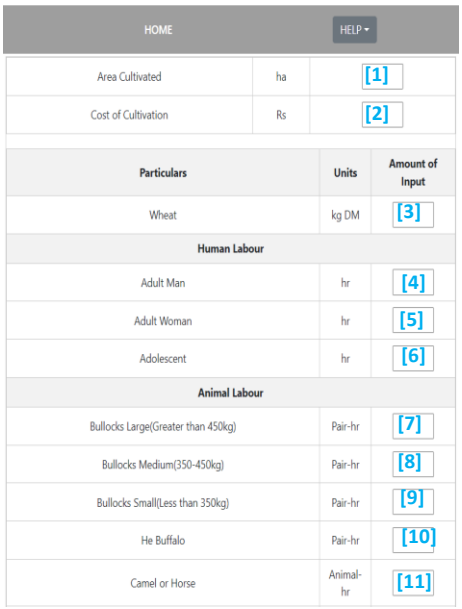

HOME	HELP

Area Cultivated	ha	[1]
Cost of Cultivation	Rs	[2]

Particulars	Units	Amount of Input
Wheat	kg DM	[3]
Human Labour		
Adult Man	hr	[4]
Adult Woman	hr	[5]
Adolescent	hr	[6]
Animal Labour		
Bullocks Large(Greater than 450kg)	Pair-hr	[7]
Bullocks Medium(350-450kg)	Pair-hr	[8]
Bullocks Small(Less than 350kg)	Pair-hr	[9]
He Buffalo	Pair-hr	[10]
Camel or Horse	Animal-hr	[11]

[1] Enter Area Cultivated (in ha): Enter the cultivated area in ha. The result of energy calculation will be displayed by per ha basis. If you measured your area in square foot, or square meter or acre, then convert it first to ha before enter by the following formulas:

- Area (in ha) = 0.000009290303997× Area (in square foot) (Eq 1)
- Area (in ha) = 0.0001× Area (in square meter) …(Eq 2)
- Area (in ha) = 0.404686× Area (in acre) …(Eq 3)

[2] Enter Cost of Cultivation (in Rs/₹): Enter overall cost incurred for the user defined cultivated area (in ha) to produce the crop including purchase of seed, fertilizers, hiring of tractor and other machinery for land preparation and harvesting, labour wages, etc.

[3] Enter amount of dried crop seed used in Kg (DM means dry matter)

[4-6] Enter human labour used in hours for land preparation to harvesting of crops including labour required for operation of machinery. For example, tractor driving by hours, Sparaying using Knapsack sprayer etc. Three input option for human labour, Adult man, Adult woman and Adolescent (<18-year age).

[7-11] Enter Animals labour is sum of pair-hour/ animal hour used during entire period of the crop cultivation similar to man power. Bullocks and he buffalo inputs are taken as pair-hour (Two animals working for number of hours) whereas input for camel or horse, mules and other small animals was animal-hour (single animal working for number of hours). Bullocks have three input categories: Large (pair body weight>450 kg), Medium (pair body weight 350-450 kg) and Small (pair body weight <350 kg).

Others		
Ground Water for Irrigation	m3	[12]
Diesel	L	[13]
Petrol	L	[14]
Electricity	KWh	[15]
Electric Motor/Prime Movers(including Self Propelled Machine eg Tracktor, Pump)		
Weight in kg	kg	[16]
Ecomomic Lifespan in hrs	hr	[17]
Operation Conducted in hrs	hr	[18]
Farm Machinary		
Weight in kg	kg	[19]
Ecomomic Lifespan in hrs	hr	[20]
Operation Conducted in hrs	hr	[21]
Knapsack Sprayer	hr	[22]
N	kg	[23]

[12] Enter irrigation in m^3. If you measured your irrigation in liter, then convert it first to m^3 before enter by the following formulae:

- Ground water for irrigation (in m^3) = 0.001× Ground water for irrigation (in liter)
- Ground water is considered a non-renewable resource if the use rate stays above its recharge rate of 240 mm per year (Chen et al. 2006)

[13-15] Enter Petrol, Diesel and electricity are non-renewable and direct source of energy. It is directly burnt or consumed by motors, different machineries during operations year (Chen et al. 2006)

[16-18] If more than one electric motors/prime movers (Tractor, pump) (let say p>1) were used in field work, then
Weight=sum of weight of p electric motors/ and prime movers
Economic life span (in hours) = sum of Economic life span of the p electric motors/ and prime movers
Operation conducted (in hours) = sum of hours operation conducted with the p electric motors/ and prime movers (Devasenapathy *et al.* 2009)

[19-21] Farm machinery (e.g., seed showing machine, Rotary tiller, Cultivator, Harrow, Rotavator, Power thresher farm land preparation, Digger machine, etc.) are different type of machinery used for field preparation, seed showing, fertilizer application and other used
If more than one type (let say q>1) were used in field work, then Weight=sum of weight of q machineries
Economic life span (in hours) = sum of Economic life span of the q machineries (default value 12 years i.e., 105,120 hours)
Operation conducted (in hours) = sum of hours operation conducted with the q machineries (Devasenapathy *et al.* 2009)

[22] Knapsack sprayer: Enter hours operated by Knapsack spryer (West and Marland 2002)

[22] Knapsack sprayer: Enter hours operated by Knapsack spryer (West and Marland 2002)

P2O5	kg	[24]
K2O	kg	[25]
Superior Chemicals(Chemicals required dilution at the time of application)	kg	[26]
Zinc Sulphate	kg	[27]
Inferior Chemicals(DDT or Gypsum or any other chemicals)	kg	[28]
FYM	kg	[29]
VermiCompost	kg	[30]
Poultry Manuring	kg	[31]
Green Manuring	kg	[32]
Azospirillum/PSB/Azotobacter	kg	[33]
Biofertilizer	kg	[34]
Herbicides	kg	[35]
Insecticides	kg	[36]
Fungicides	kg	[37]

[23-25] If you have used commercial fertilizer then first convert amount of commercial fertilizer (in Kg) in term of N (in Kg), P2O5 (in Kg) and K2O
N (in kg) = Fertilizer (in Kg) × N content in fertilizer (in %) (Eq 8)
P2O5 (in kg) = Fertilizer (in Kg) × P2O5 content in fertilizer (in %) (Eq 9)
K2O (in kg) = Fertilizer (in Kg) × K2O content in fertilizer (in %) (Eq 10)

OUTPUT		
Particulars	**Units**	**Amount of Output**
Wheat	kg DM	[38]
Straws, Vines	kg	[39]
Stalks, Cobs, Fuelwood, Fruit Vines, Plant Wood	kg	[40]
Leaves, Vines and Straw from Vegetables	kg	[41]
Leaves and Tops (e.g Sugarcane)	kg	[42]

Submit Reset

[38-42] Yield & byproducts harvested

Click button
Submit: Click on submit button to get result and generate report
Reset: Click to clean all entered value from the input screen

Step 6: After filling up all information click on submit button (bottom of the data entry form) to get result output and a report will generate. After downloading report file (pdf) user can see input data and output results in pdf format.

Output Result and Interpretation

Table 01: Energy efficiency indices for crop production

	Indices	Formula	Unit	Interpretations of index value	Desired reference value	Reference
1	Net Energy Return	Total energy output (MJ ha^{-1})- Total energy input (MJ ha^{-1})	MJ ha^{-1}	a. >0, energy conserved b. <0, energy emitted c. 0, no energy conserved or emitted	>0 (indicates that more energy is produced or gained than is consumed or invested)	Mandal et al. 2002, Mohammadi et al. 2008, Rafiee et al., 2010, Lal et al. 2016 and Semerci et al 2019
2	Energy Use Efficiency	Total energy output (MJ ha^{-1})/ Total energy input (MJ ha^{-1})	Ratio (unit free)	Ratio indicates how effectively input energy is converted into useful output energy a. >1, energy conserved b. <1, energy emitted c. 1, no energy conserved or emitted	higher value (at least **>1)**	Mandal et al. 2002, Mohammadi et al. 2008, Rafiee et al., 2010, Lal et al. 2016 and Semerci et al 2019
3	Energy Productivity	Yield output (kg ha^{-1})/ Total energy input (MJ ha^{-1})	Kg MJ^{-1}	Amount of economic output that is derived from each unit of energy consumed	**High value (**meaning more yield is obtained per unit of energy input.**)**	Mandal et al. 2002, Mohammadi et al. 2008, Rafiee et al., 2010, Lal et al. 2016 and Semerci et al 2019
4	Energy Profitability	Net energy return (MJ ha^{-1}) / Total energy input (MJ ha^{-1})	Ratio (unit free)	Energy profitability is a measure of energy profit (or conserve) relative to its energy	**High value(**meaning more net energy is gained relative to the energy invested)	Lal et al. 2016

				expenses		
5	Specific Energy	Total energy input (MJ ha^{-1})/ Economic yield output (kg ha^{-1})	MJ Kg^{-1}	Energy per unit mass (or economic yield output).	**Low value**	Mandal et al. 2002, Mohammadi et al. 2008, Rafiee et al., 2010, Lal et al. 2016 and Semerci et al 2019
6	Energy Intensiveness (or efficiency)	Total input energy (MJ ha^{-1})/ Cost of cultivation (₹ ha^{-1})	MJ ₹$^{-1}$	Per unit input energy cost.	**High value**, (it means less energy is required per unit cost)	Lal et al. 2016
7	Human Energy Profitability	Total output energy (MJ ha^{-1}) / Labour energy (MJ ha^{-1})	Ratio (unit free)	Measure of energy profit (or conserve) relative to its labour energy expenses	A higher value would indicate higher profitability or efficiency in utilizing human labor (or low labour intensive production).	Lal et al. 2016
8.	Renewable Energy	the Amount of energy consumption that comes from renewable sources	MJ ha^{-1}	A higher value indicates a greater reliance on renewable energy sources	High value	Devasenapathy et al (2009)
9.	Non-Renewable Energy	the Amount of energy consumption that comes from non-renewable sources	MJ ha^{-1}	A higher value indicates a greater reliance on non-renewable energy sources	Low value	Devasenapathy et al (2009)

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