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Investigating the impact of integrating land consolidation with agricultural mechanization on the technical, energy, and environmental dimensions of paddy production

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Key words: energy use; greenhouse gas emissions; life cycle assessment; sustainability, water usage.

Supplementary Table 1. Energy inputs and outputs vary across different paddy production systems.

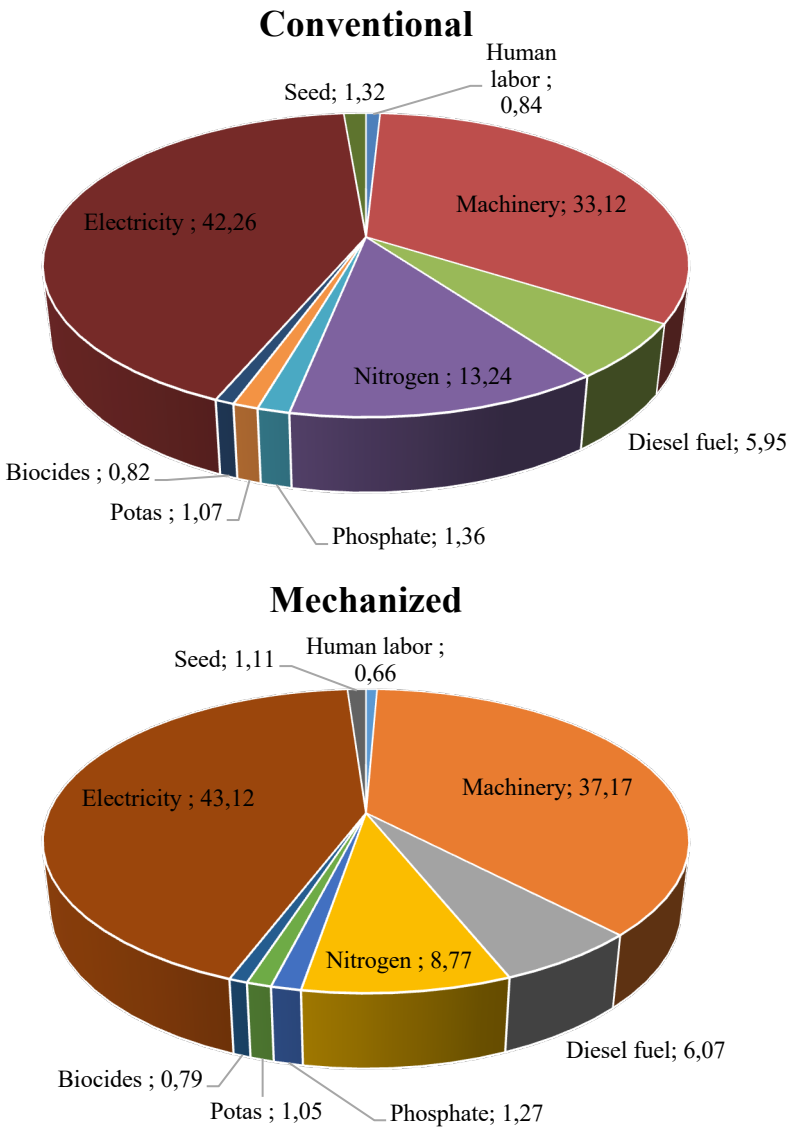
Items	Hashemi variety			
	Conventional		Mechanized	
	Unit per ha	Energy use (MJ ha^{-1})	Unit per ha	Energy use (MJ ha^{-1})
Human labor (h)	330.00	646.80	300.00	588.00
Machinery (kg)	405.00	25393.50	528.00	33105.60
Diesel fuel (L)	81.00	4561.11	96.00	5405.76
Chemical fertilizers (kg)				
Nitrogen	130.00	10153.00	100.00	7810.00
Phosphate (P_2O_5)	60.00	1044.00	65.00	1131.00
Potassium	60.00	822.00	68.00	931.60
Biocides (kg)	2.50	625.00	2.80	700.00
Electricity (kwh)	2700.00	32400.00	3200.00	38400.00
Seed (kg)	69.00	1014.30	67.00	984.90
Total energy use (MJ)		**76659.71**		**89056.86**
Output (kg)				
Paddy	3500	59500.00	3600.00	61200.00

Supplementary Table 2. Energy inputs and outputs vary across different paddy production systems.

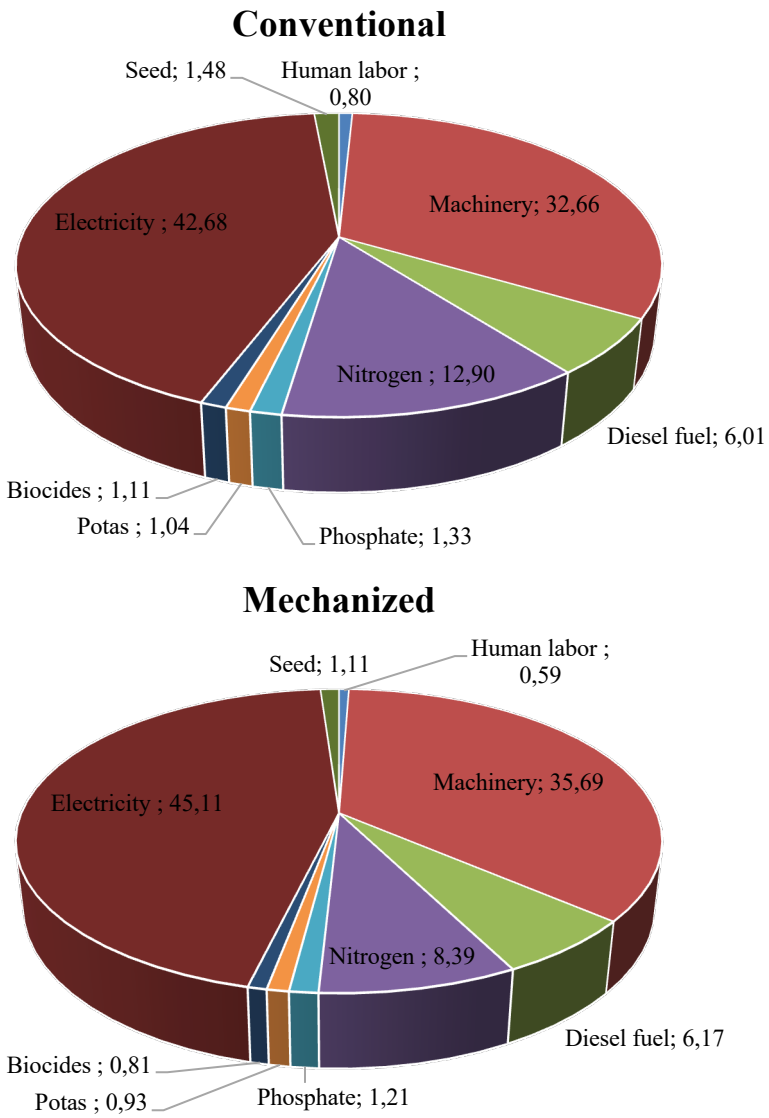
Items	Khazar variety			
	Conventional		Mechanized	
	Unit per ha	Energy use (MJ ha^{-1})	Unit per ha	Energy use (MJ ha^{-1})
Human labor (h)	320.00	627.20	280.00	548.80
Machinery (kg)	410.00	25707.00	530.00	33231.00
Diesel fuel (L)	84.00	4730.04	102.00	5743.62
Chemical fertilizers (kg)				
Nitrogen	130.00	10153.00	100.00	7810.00
Phosphate (P_2O_5)	60.00	1044.00	65.00	1131.00
Potassium	60.00	822.00	63.00	863.10
Biocides (kg)	3.50	875.00	3.00	750.00
Electricity (kwh)	2800.00	33600.00	3500.00	42000.00
Seed (kg)	79.00	1161.30	70.00	1029.00
Total energy use (MJ)		**78719.54**		**93106.52**
Output (kg)				
Paddy	5200.00	88400.00	5500.00	93500.00

Supplementary Table 3. On-farm emissions of different production of paddy in based on 1 hectare.

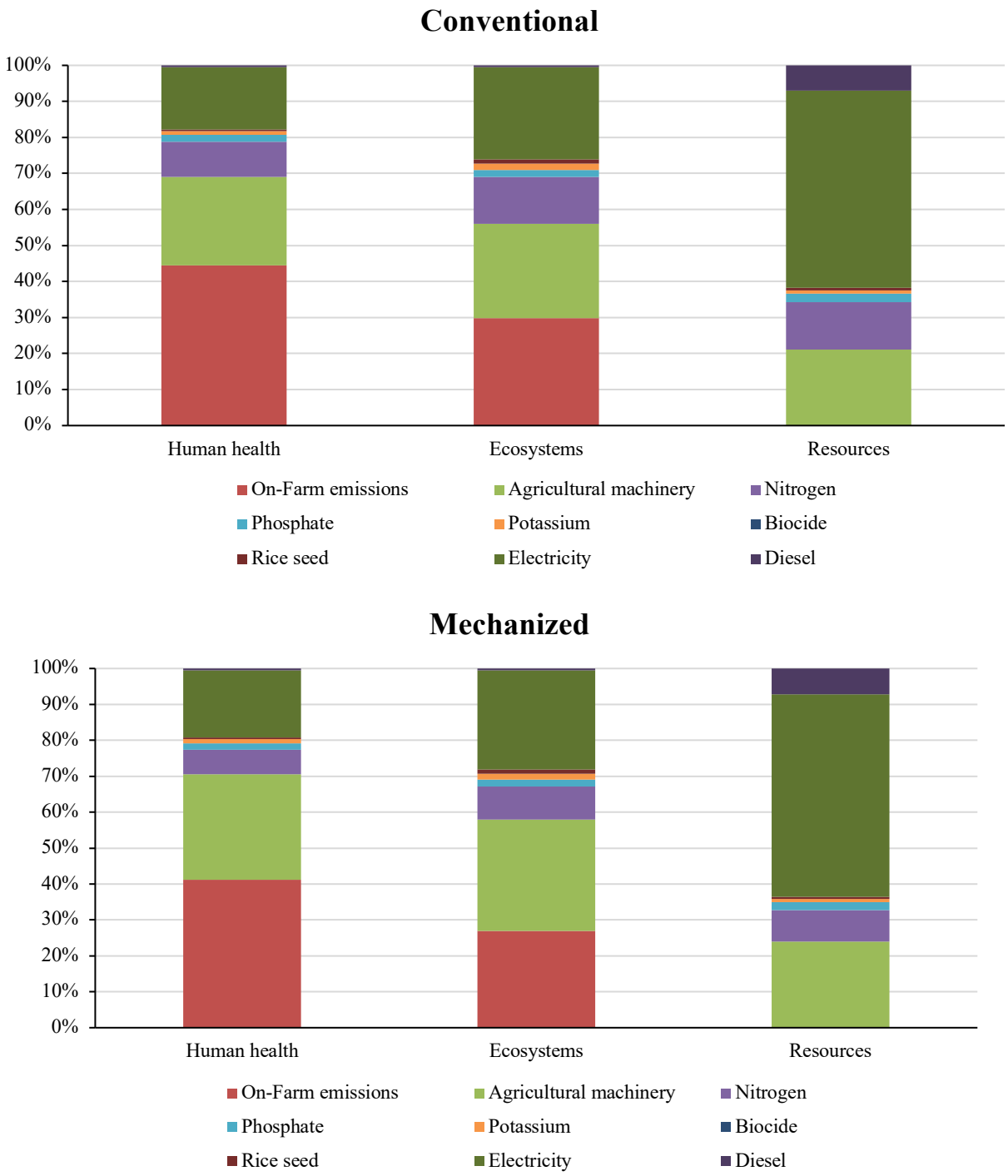
Item (unit)	Hashemi variety		Khazar variety	
1. Emissions by diesel fuel to air (kg)	Conventional	Mechanized	Conventional	Mechanized
(a). Carbon dioxide (CO2)	339.80	402.72	352.38	427.89
(b). Sulfur dioxide (SO2)	0.10	0.13	0.11	0.13
(c). Methane (CH4)	0.014	0.016	0.014	0.017
(d). Benzene	0.0007	0.0009	0.0008	0.0009
(e). Cadmium (Cd)	0.000001	0.000001	0.000001	0.000001
(f). Chromium (Cr)	0.000005	0.000006	0.000006	0.000007
(g). Copper (Cu)	0.000185	0.000219	0.00019	0.00023
(h). Dinitrogen monoxide (N2O)	0.013	0.015	0.013	0.016
(i). Nickel (Ni)	0.000008	0.000009	0.000008	0.00001
(j). Zink (Zn)	0.000109	0.000129	0.00011	0.00013
(k). Benzo (a) pyrene	0.000003	0.000004	0.000003	0.000004
(l). Ammonia (NH_3)	0.0021	0.0025	0.0022	0.0027
(m). Selenium (Se)	0.000001	0.000001	0.000001	0.000001
(n). PAH (polycyclic hydrocarbons)	0.00035	0.00042	0.00037	0.00045
(o). Hydro carbons (HC, as NMVOC)	0.31	0.36	0.32	0.39
(p). Nitrogen oxides (NOx)	4.83	5.73	5.013	6.08
(q). Carbon monoxide (CO)	0.684167	0.81	0.70	0.8615
(r). Particulates (b2.5 µm)	0.48	0.57	0.50	0.614
2. Emissions by fertilizers to air (kg)				
(a). NH_3 by chemical fertilizers	15.78	12.14	15.78	12.142
3. Emissions by fertilizers to water (kg)				
(a). Nitrate	17.27	13.28	17.27142857	13.28
(b). Phosphate	1.31	1.41	1.309859155	1.419
4. Emission by N_2O of fertilizers and soil to air (kg)				
(a). Nitrogen oxides (NO_x)	27.3	21.00	27.3	21
5. Emission by human labor to air (kg)				
(a). Carbon dioxide (CO_2)	231.00	210.00	224	196
6. Emission by heavy metals of fertilizers to soil (mg)				
(a). Cadmium (Cd)	6222.00	6496.10	6222.00	6495.10
(b). Copper (Cu)	16322.00	16646.60	16322.00	16603.10
(c). Zink (Zn)	142448.00	146063.40	142448.00	146006.90
(d). Lead (Pb)	712500.00	551012.00	712500.00	551004.50
(e). Nickel (Ni)	15107.00	15526.00	15107.00	15503.50
(f). Chromium (Cr)	85457.00	89429.00	85457.00	89376.50
(g). Mercury (Hg)	61.00	62.30	61.00	61.80



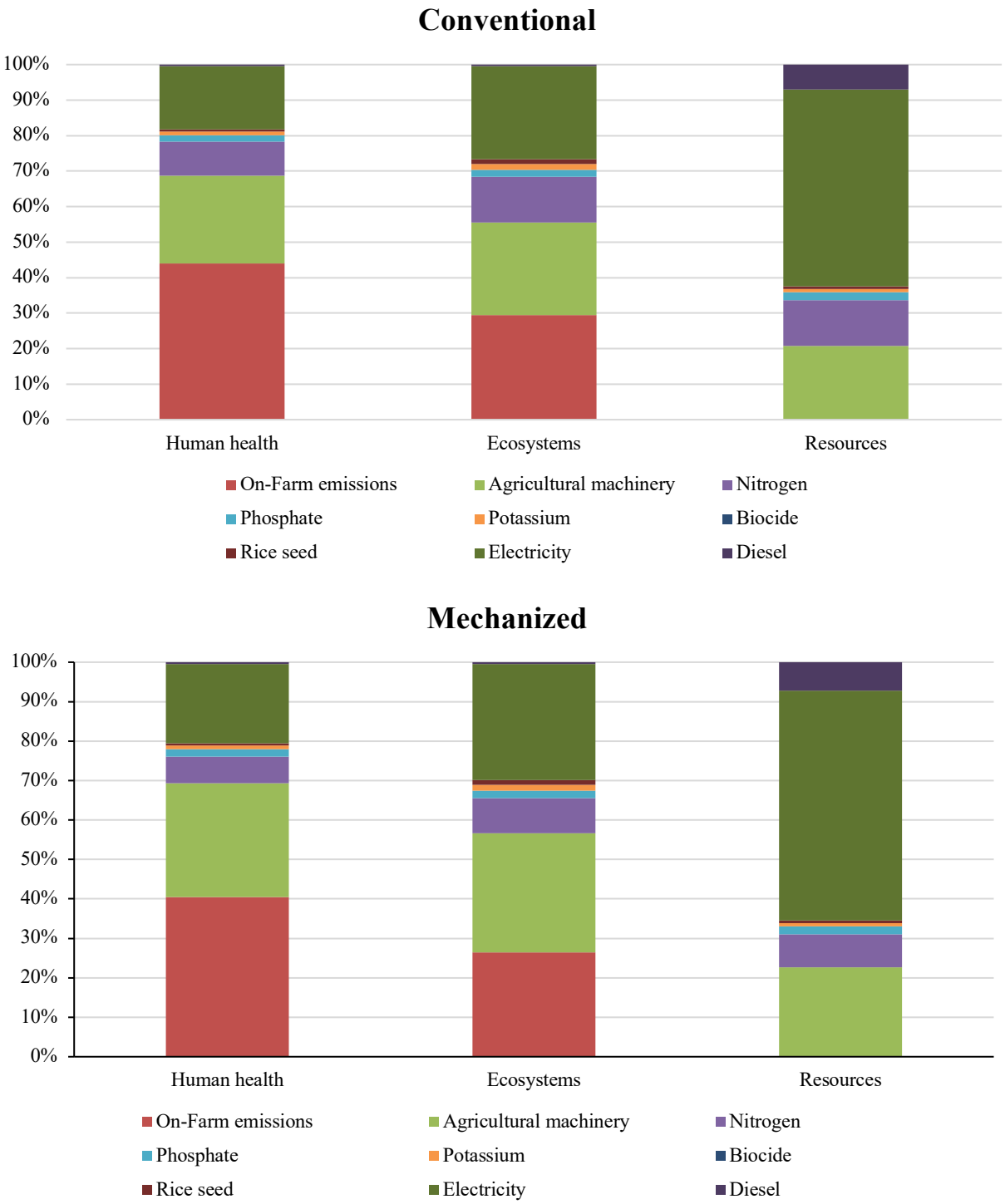
Supplementary Figure 1a. Distribution of energy sources in the production of Hashemi variety paddy.



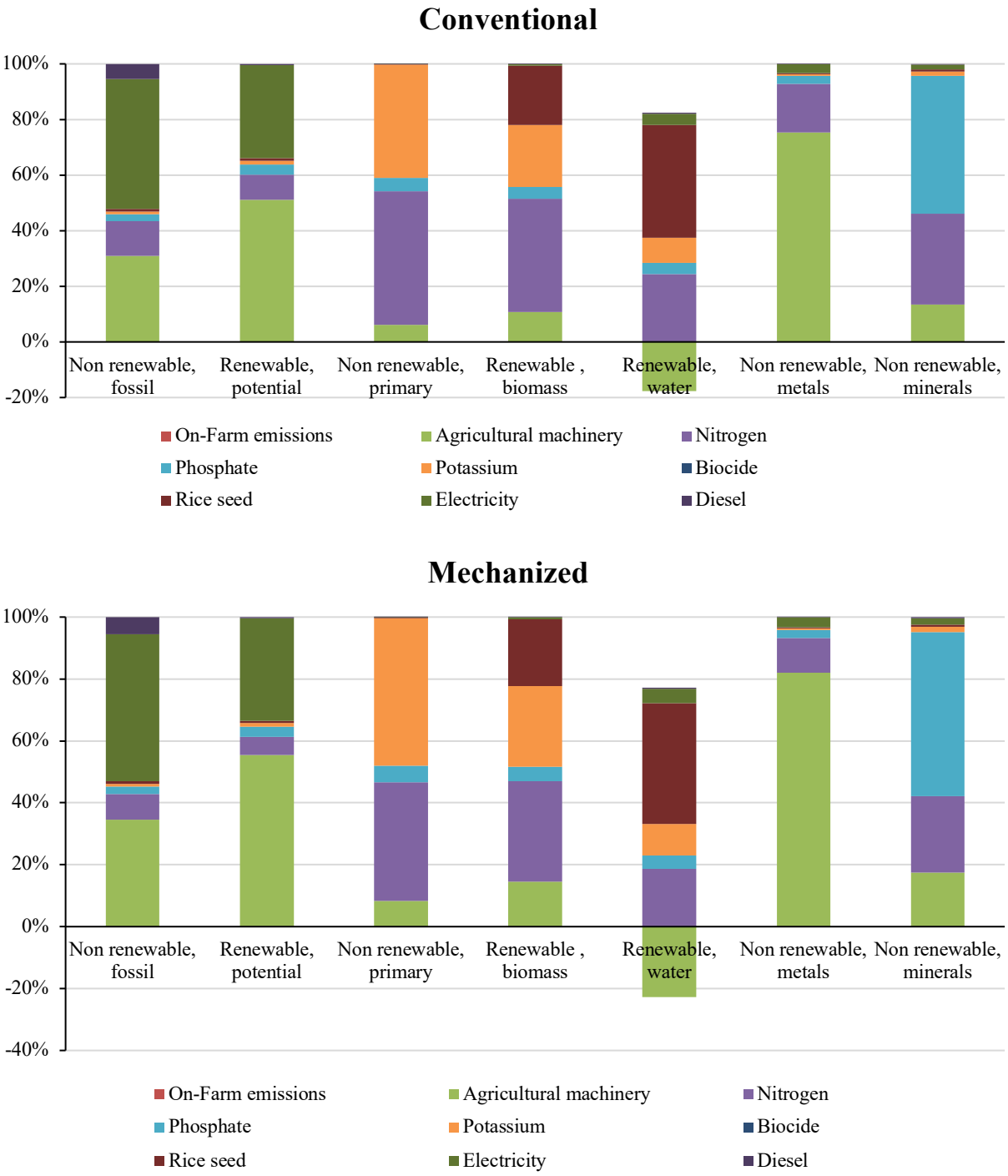
Supplementary Figure 1b. Distribution of energy sources varies in the production of Khazar variety paddy.



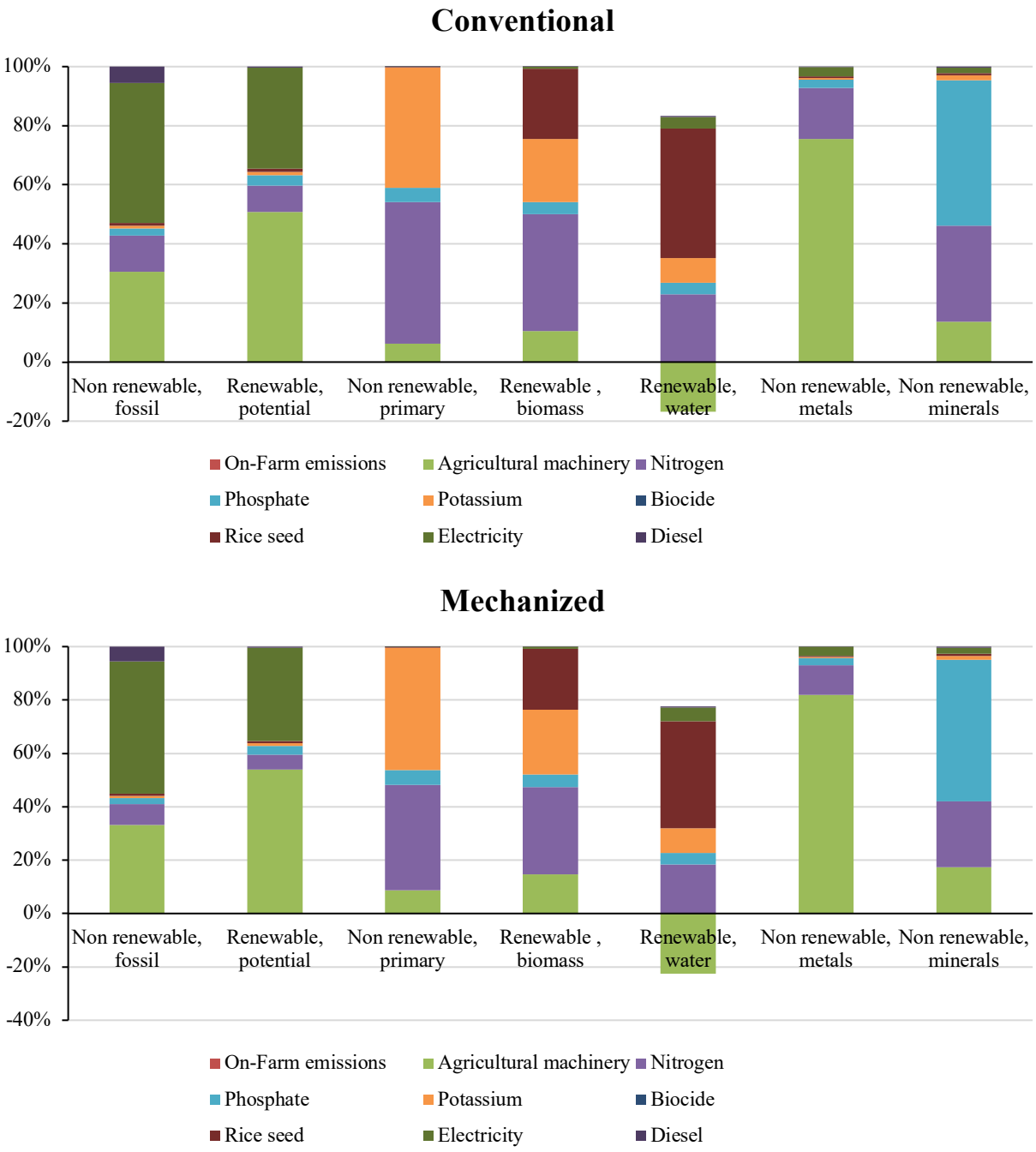
Supplementary Figure 2a. The Hashemi variety of paddy production contributes to the emission of environmental impact categories through its input usage in various production processes.



Supplementary Figure 2b. The Khazar variety of paddy production contributes to the emission of environmental impact categories through its input usage in various production processes.



Supplementary Figure 3a. The Hashemi variety of paddy production relies on various inputs to consume energy forms for different stages of production.



Supplementary Figure 3b. The Khazar variety of paddy production relies on various inputs to consume energy forms for different stages of production.