UNIVERSITY OF GOTHENBURG

Labor-saving technologies in agriculture and jobs in Africa

THOMAS DAUM

Jobs matter but LST on the rise

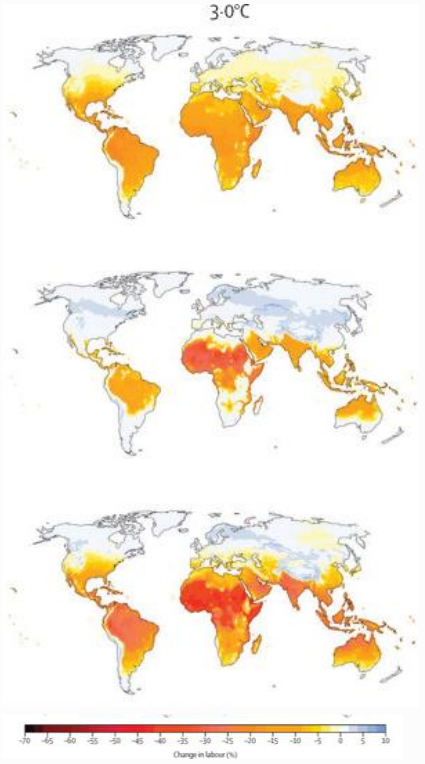
- **Agri-food system needs to contribute to job agenda but LST are on the rise**
- **Agricultural mechanization (umbrella term)**
  - Demand pull and supply push → 10% of farms use tractors, more in some parts (Daum, 2023; Diao et al., 2022)
- **Herbicides**
  - Pesticide revolution - driven by “flood” of generic products (Haggblade et al., 2017; Shattuck, 2021; Mansfield et al., 2023)
  - “Mothers little helpers” (Moseley & Pessereau, 2022)

Are LST a curse or a blessing?

- **Are LST a curse … ?**
  - La Via Campesina (2008): *“Intensive mechanization and agro-toxins (…) drive out manual labor, causing large contingents of the rural population to migrate”*
- ***… or are a blessing?***
  - Addressing toil of farming and seasonal labor bottlenecks
  - Freeing up labor for off-farm activities
  - Playing a role in rural, agricultural, structural transformation

Status of agricultural labor in Africa

- **Agriculture absorbs much labor**
- **Most labor by unpaid family members, incl. women and children** (Daum, 2023; Vos & Takeshima, 2021)
  - Drudgery can affect health / wellbeing - exaggerated with climate change (Daum & Birner , 2022)
  - Time-use can affect off-farm work, education, childcare, cooking (e.g., Daum et al., 2021; Johnston et al., 2018)
- **Hired labor is less prevalent but non-trivial**
  - Increasing wages in some contexts (e.g., Diao et al., 2014; Berhane et al., 2020)



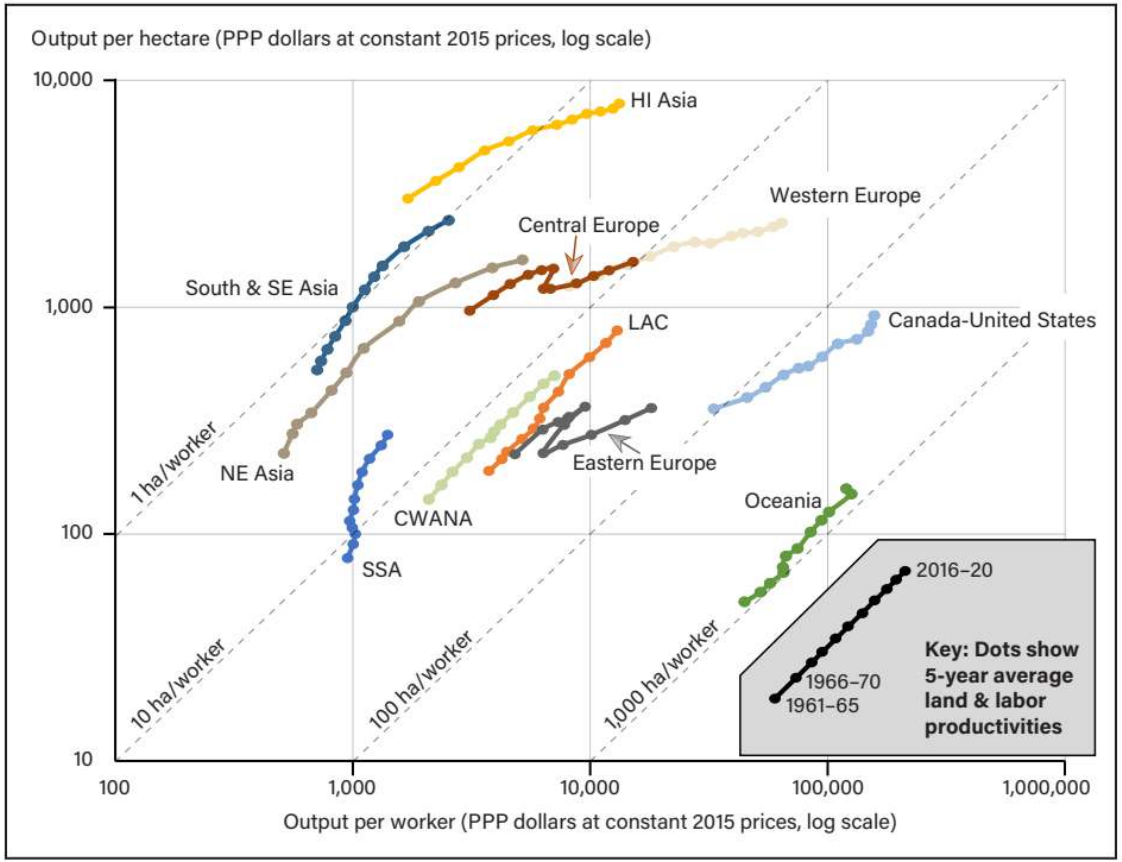
Dasgupta et al. (2021)

Status of agricultural labor in Africa

(Fuglie et al., 2024)

Figure 17

Trends in labor productivity, land productivity, and land-labor ratios by region, 1961–2020



How do LST impact the job agenda?

- **Disentangling job dimensions**
  - More (farm, off-farm)
  - Better (productivity, pay, stability, drudgery, safety)
  - Inclusive (smallholder, women, youth)
- **Possible trade-offs between dimensions** (e.g., Chiarella et al., 2023)

How do LST work?

- **LST affect labor per unit of output**
  - Manual tillage = 500 h/ha vs. tractors: 1-2 h/ha (Sims % Kienzle, 2016)
  - Herbicides reduce weeding labor by 80% (Haggblade et al., 2017)
- **But overall effects are complex**
  - Stepwise adoption (power-intensive first); substitution vs scale; hired vs unpaid family labor; induced / spillovers effects; short vs long-term

Non-farm labor in upstream AFS
(inputs, machinery, services)

Labor-saving technologies

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Farm labor
(family, hired)

-

Non-farm labor in downstream AFS
(logistics, processing, sales)

Non-farm labor in non AFS

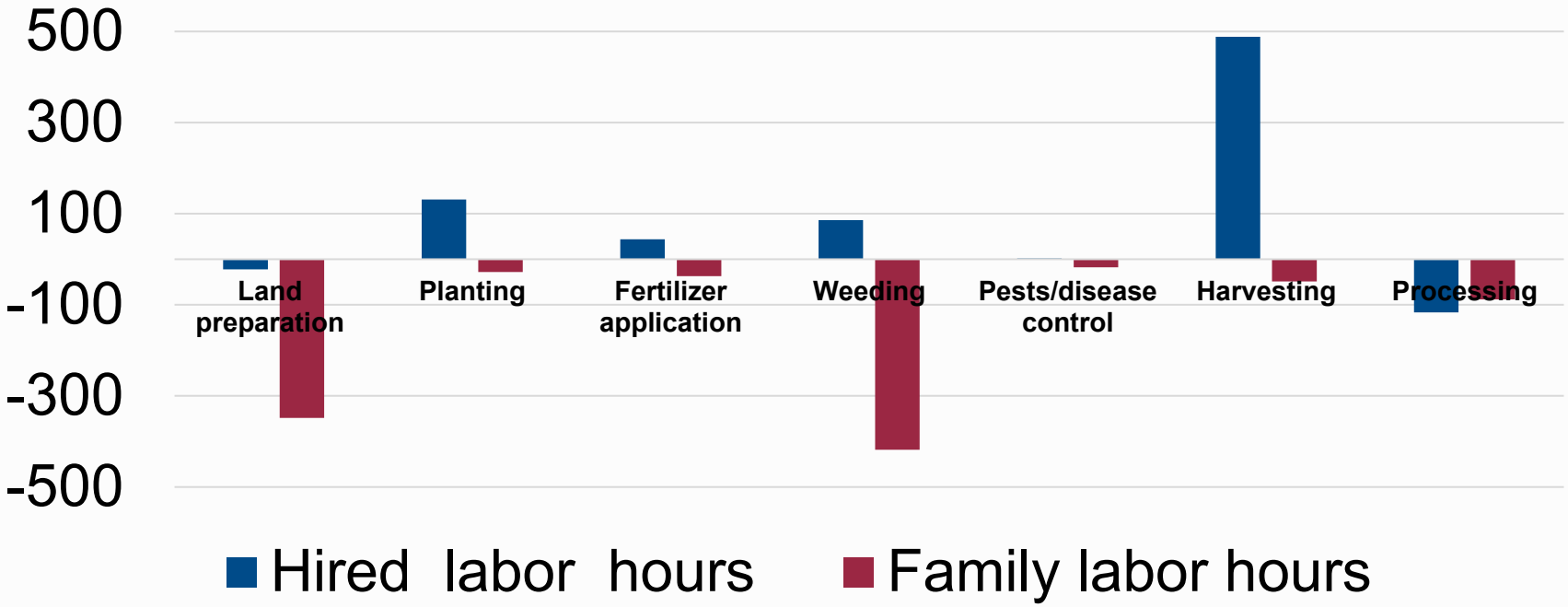
On-farm: Substitution vs scale / hired vs family

- **Some studies suggest substitution > scale** **(e.g., Charlton et al., 2022)**
- **Not a problem when …**
  - … response to transformation processes where labor finds more attractive jobs in non-farm AFS and beyond
  - … when replacing mainly unpaid family labor
- **Problem where mechanization is artificially pushed in areas with pronounced labor markets** (Binswanger, 1986; Pingali, 2007)
  - Example: South Africa pre-1980 (Thirtle et al., 1998)

On-farm: Substitution vs scale / hired vs family

- **Many studies suggest scale > substitution**
- **Farmland expansion** (Adu-Baffour et al., 2019; Houssou & Chapoto, 2014; Takeshima & Lawal, 2020)
- **Farmland intensification**
  - Labor bottlenecks, timeliness, yield penalties (Baudron et al., 2019; Silva et al., 2019)
  - Cropping frequencies (irrigation) (Diao et al, 2020)
  - Better practices (e.g., seedbed preparation) (Daum, 2023)
  - Reduce crop damages / losses (Berhane et al., 2020; Daum & Kirui 2021; Pingali, 2007)
  - Yield-increasing (partly, labor-increasing) inputs (Mano et al., 2020)
  - New crops and livestock

Example: Mechanized land preparation and labor hours in Zambia (Adu-Baffour et al., 2019)



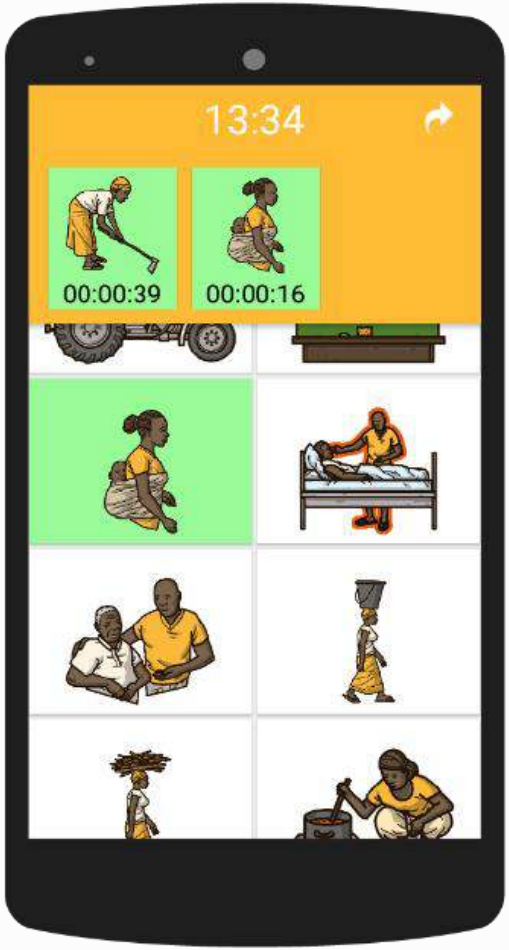
Example: Mechanized land preparation and labor in Cote d'Ivoire (Mano et al., 2020)

TABLE 5 Association between tractor use in land preparation and the application of production factors

Outcomes	Village FE	DR
Family labor (000FCFA/ha)	99.35**	101.79***
	(40.11)	(34.58)
Hired labor (000FCFA/ha)	45.38**	44.39***
	(19.00)	(16.60)
Machine (000FCFA/ha)	55.50***	53.40***
	(11.03)	(7.01)
Chemical fertilizer (kg/ha)	86.73*	127.37***
	(44.86)	(41.50)

Note: Robust standard errors are in parentheses. We also controlled for the other characteristics. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Important gender aspects – not covered today, but we can discuss



Mechanism: Scale effects from extensification and/or intensification (labor bottlenecks, cropping frequency, improved practices, damages/losses, complementary inputs, new crops/livestock)

+

Non-farm labor in upstream AFS (inputs, machinery, services)

Labor-saving technologies

Farm labor (family, hired)

Non-farm labor in downstream AFS (logistics, processing, sales)

Labor in non AFS

-

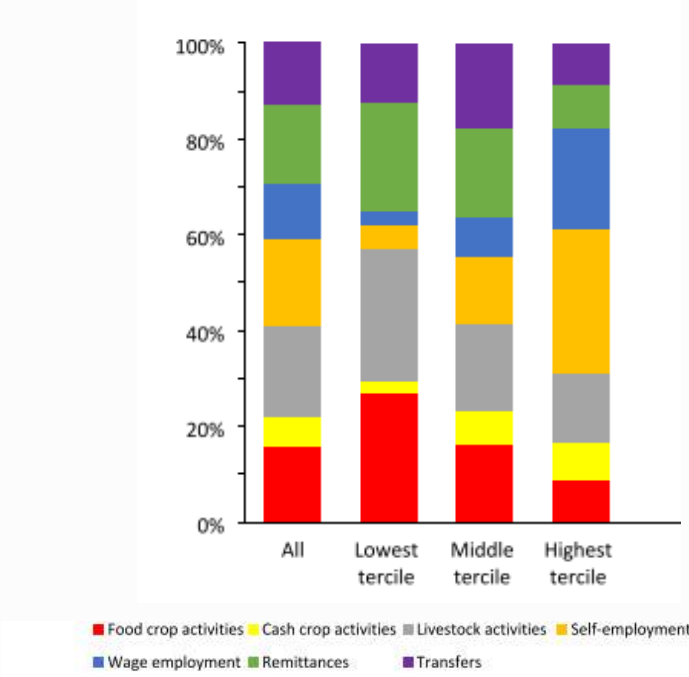
Question to be asked: Family or hired? Response to transformation?

LST and labor effects beyond the farm

- **When LST reduces farm labor, this may not lead to less jobs overall**
  - Charlton et al. (2022): Losses offset by new, more productive jobs downstream and upstream
  - Link to rural, agricultural, and structural transformation (Berdegue et al., 2025; Christiaensen et al., 2021; Pingali, 2007)

LST and rural transformation

- **LST can affect household incomes** (e.g., Adu-Baffour et al. 2019, Takeshima and Lawal 2020)
  - On-farm: Scale effects, value addition, labor costs
  - Off-farm business or wage work (Kansanga et al. 2020; Ma et al. 2018; Theis et al. 2019)
- **Spill-overs to wider (rural) economy** (Christiaensen t al. 2021; Haggblade et al. 2010)



Mutsami et al. (2024)

Intensification in Cote d'Ivoire (Aihounton & Christiaensen, 2022)

Table 7
Effects of rice intensification on labor allocation in rice production by age and type.

VARIABLES	Total labor use	Household labor	Adult male labor	Adult female labor	Child labor	Hired labor
Semi-traditional package	−22.72	−21.79*	−13.09*	−11.89**	3.92	6.63
	(14.44)	(11.80)	(7.67)	(5.58)	(2.64)	(6.40)
Semi-modern package	−95.51***	−67.24***	−42.16***	−25.69***	6.16***	−40.00***
	(14.67)	(13.87)	(7.99)	(6.35)	(2.03)	(5.67)
Modern package	−58.84***	−58.86***	−37.29***	−21.85***	2.62	−13.06*
	(16.24)	(12.66)	(8.22)	(5.42)	(2.37)	(7.42)
Control variables	YES	YES	YES	YES	YES	YES

Table 6
Effects of rice intensification on farm performance.

VARIABLES	Yield (kg/ha)	Profit per ha (1000 FCFA/ha)	Economic Profit per ha (1000 FCFA/ha)	Labor Productivity (kg/ person-day)	Return to family labor (1000 FCFA/ person-day)	Return to total labor (1000 FCFA/ person-day)
Semi-traditional package	719.79***	−8.12	6.02	5.08*	0.13	0.20
	(192.69)	(47.74)	(41.01)	(2.83)	(1.89)	(0.35)
Semi-modern package	849.72***	74.40**	132.95***	22.79***	3.90*	2.20***
	(206.35)	(37.27)	(30.01)	(3.45)	(1.99)	(0.43)
Modern package	1,378.28***	51.81	88.82*	32.56***	7.20**	3.25***
	(253.55)	(67.91)	(47.64)	(6.69)	(3.09)	(0.97)
Control variables	YES	YES	YES	YES	YES	YES

Table 9
Effect of production packages on rice specialization, commercialization and food security.

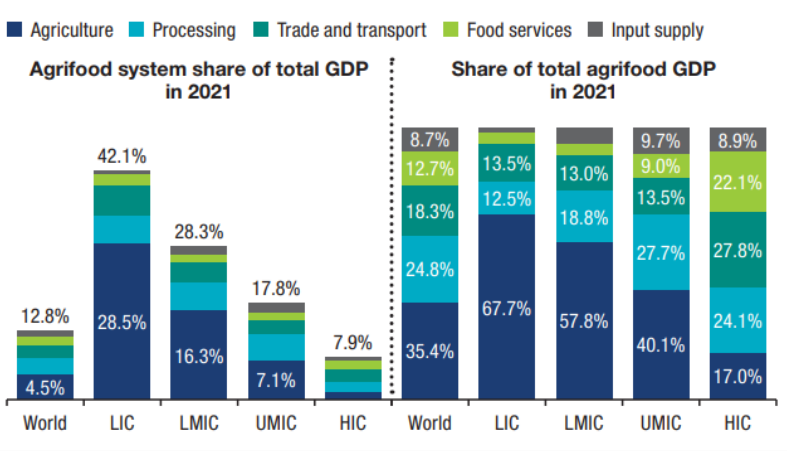
	Rice land area cultivated (ha)	Rice share of cultivated land (%)	Rice sold (1 = Yes)	Share of rice sold (%)	Rice sold per capita (kg)	Food insecurity	Dietary diversity (24hr recall)	Dietary diversity (7-day recall)
Semi-traditional package	0.00	3.06	0.48***	29.81***	73.90***	−0.07	0.39***	−0.18
	(0.09)	(3.54)	(0.02)	(5.03)	(27.05)	(0.13)	(0.15)	(0.42)
Semi-modern package	0.37***	−3.27	0.31***	12.17***	91.09***	−2.94***	0.41**	0.51
	(0.11)	(2.96)	(0.05)	(3.89)	(30.23)	(0.17)	(0.16)	(0.50)
Modern package	0.45***	−2.81	0.71***	42.14***	358.73***	−2.18***	−0.75***	−0.17
	(0.17)	(5.11)	(0.05)	(4.80)	(79.76)	(0.26)	(0.23)	(0.53)

LST and land size distribution

- **Adoption of tractors (non-divisible, economics of scale) happens first on large farms** (e.g., Berhane et al. 2020; Daum, 2023; Takeshima 2017)
  - Herbicides more scale-neutral
- **Can give large farms comparative advantage over small farms → unequal distribution of land** (Binswanger 1986)
- **Small, medium, and large farms have markedly different demand for labor and economic spillovers** (Chamberlain & Jayne, 2020; Chiarella et al., 2023)
  - What is optimal level in terms of jobs? How to make mechanization inclusive to smallholder farmers?

LST and agricultural transformation

- **Agri-food system transformation**
  (e.g., Reardon et al. 2025)
  - Growing/changing food demand
  - Competition with imports
- **LST can help raise local production, keep prices at bay, and facilitate market integration**
  - Tractors *and* trailers (e.g., Daum et al., 2023)
  - Agri-food processing (Daum & Kirui 2021)



Reardon et al. (2025)

LST and upstream value chains

- **Creation of new jobs related to provision of LST**
  - Examples: tractors operators, technicians (servicing, repairs), spare part dealers…
- **Opportunities for local manufacturing sector**
  - Potential comparative advantage for domestic industries (Daum et al., 2023)

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RESEARCH ARTICLE

INTERNATIONAL DEVELOPMENT WILEY

Made in Africa – How to make local agricultural machinery manufacturing thrive

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LST and structural transformation

- **Historical pattern of economic development**
  - Shift of surplus labor from low-productivity, (semi)subsistence agriculture to higher productivity manufacturing and services
- **What about Africa?**
  - Productivity difference between sectors less pronounced then previously assumed (e.g., Headey, 2010; Gollin et al., 2014)
  - Is non AFS absorptive enough? (Berdegue et al., 2025)

Mechanism: Scale effects from extensification and/or intensification (labor bottlenecks, cropping frequency, improved practices, damages/losses, complementary inputs, new crops/livestock)

Mechanisms: Economic spillovers, integration into agri-food chains; competitiveness of agri-food chain, food prices…

Non-farm labor in upstream AFS (inputs, machinery, services)

+

Labor-saving technologies

+

Farm labor (family, hired)

+

Non-farm labor in downstream AFS (logistics, processing, sales)

+

Non-farm labor in non AFS

-

Question to be asked:
Family or hired? Response to transformation?

Short-term

Medium-term

Some knowledge gap

- **Need for better data on adoption of LST and labor in agriculture**
- **Need to better study interplay between different effects**
  - Substitution vs scale; hired vs unpaid family labor; induced / spillovers effects; farm-size link; short vs long-term
  - Long-run modelling projections; microeconomic case studies
    - Role of agro-ecological and wider socio-economic factors
    - Role of new aspects such as climate change and demand for agro-ecological production (Daum et al., 2023)

Policy implications

- **Do not push LST artificially but focus on addressing supply side constraints (create level playing field)**
  - Enabling business environment, knowledge and skills development, research and development … (Daum & Birner, 2017)
- **Holistic look at LST (complementary inputs, chain integration, farm sizes)**
  - In some contexts: LST that increase labor-productivity and harness scale effects - fill farm labor calendars (irrigation, vegetables/fruits, livestock, off-farm)
- **Ensure inclusiveness (smallholder, women, youth)**

Ensuring inclusive LST

- **Asset sharing arrangements**
  - Cooperative solutions for less-time bound, stationary operations (Daum, 2023)
  - Facilitate service markets – potentially with the help of Uber-type solutions (Daum et al. 2021)
- **Scale-appropriate mechanization**

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Uber for tractors? Opportunities and challenges of digital tools for tractor hire in India and Nigeria

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RESEARCH ARTICLE

Animal traction, two-wheel tractors, or four-wheel tractors? A best-fit approach to guide farm mechanization in Africa

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Thank you

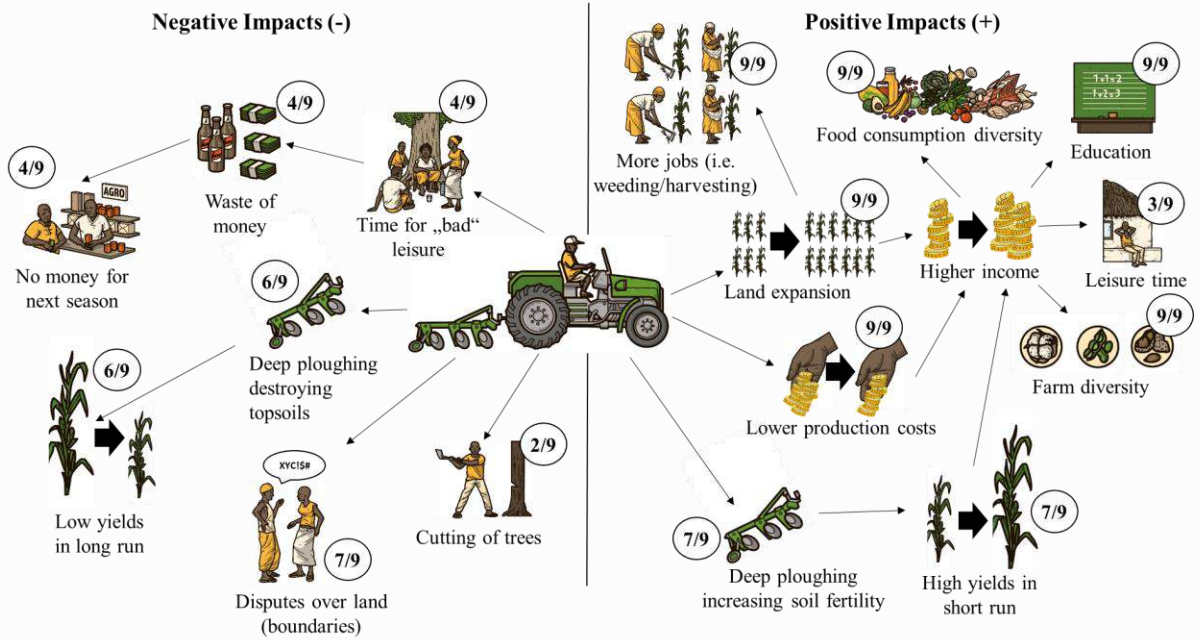
Example: Mechanized land preparation and labor in Cote d'Ivoire (Mano et al., 2020)

TABLE 2 The application of production factors by method of land preparation

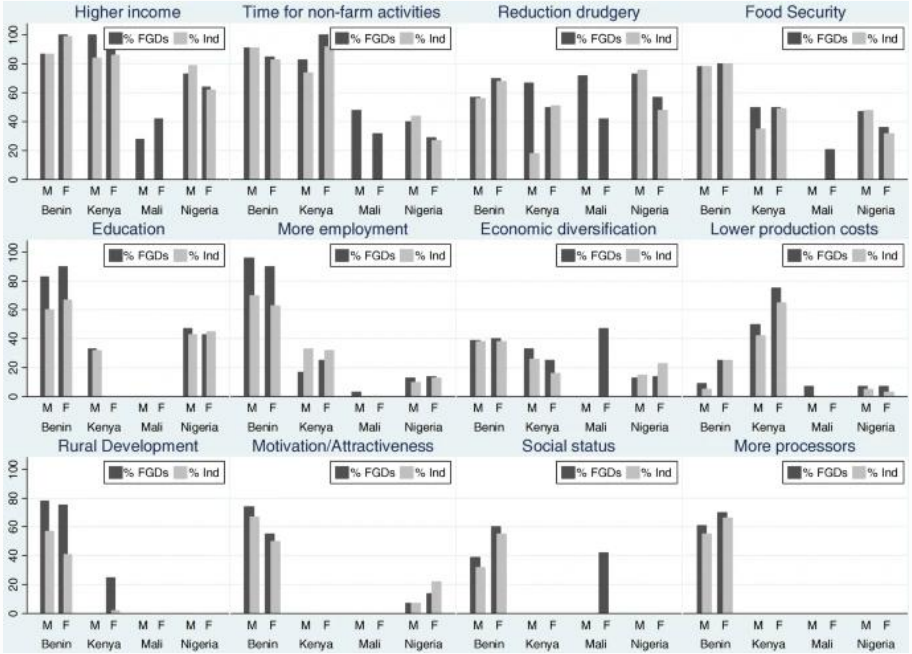
Outcomes	Tractor	Manual	Diff.
Family labor (000FCFA/ha)	153.7	76.71	77.03**
	(236.6)	(99.40)	
Hired labor (000FCFA/ha)	92.22	24.86	67.36***
	(93.35)	(55.92)	
Machine (000FCFA/ha)	59.41	5.36	54.04***
	(44.94)	(30.00)	
Chemical fertilizer (kg/ha)	298.3	181.6	133.2***
	(196.9)	(154.7)	
Obs.	56	80	

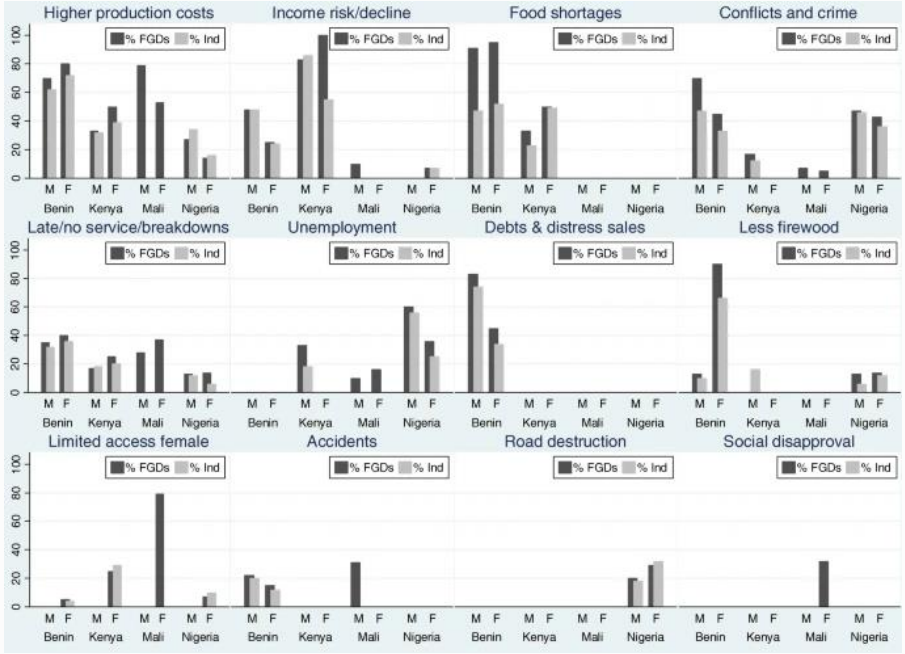
Note: Standard deviations are in parentheses. The *t*-test is between "Tractor" and "Manual." *** and ** indicate statistical significance at the 1% and 5% levels, respectively.

129 participatory impact diagrams in four African countries (Daum et al., 2020)



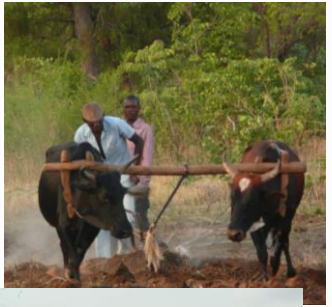
129 participatory impact diagrams in four African countries (Daum et al., 2020)

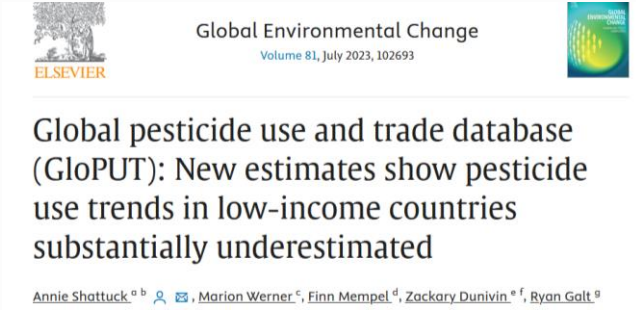
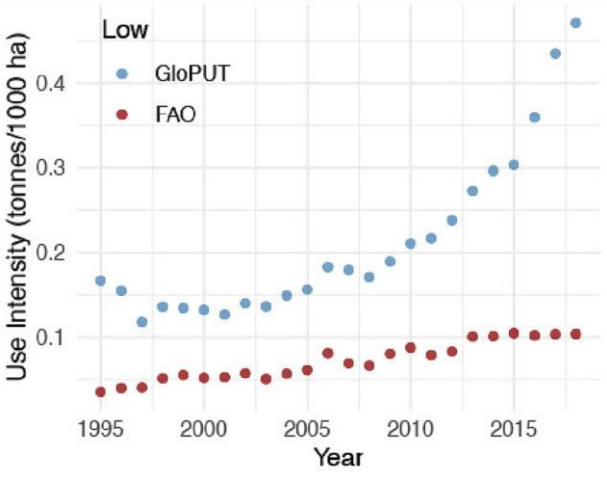




LST 1 - agricultural mechanization

- **Umbrella term – more than tractors**
  - Power-intensive activities mechanized first
- **Demand pull and supply push**
  - Raising labor costs in some areas (e.g., Berhane et al., 2020)
  - Cheap machinery imports, strong policy focus (“hoe & cutlass”) (Daum & Birner, 2020; Mockshell & Birner, 2016)
- **Status**
  - 10% of farmers use tractors – much more in some areas (Daum, 2023)



LST 2 - Herbicides

- **Demand pull and supply push**
  - “Mothers little helpers” (Moseley & Pessereau, 2022)
  - “Flood” of generic products from China and India (Shattuck, 2021; Mansfield et al., 2023)
- **Status**
  - Pesticide revolution (Haggblade et al., 2017)
  - 153% growth in LIC (Shattuck et al., 2023)