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Behavioral Lock-ins in Chemical Fertilizer Use: Implications for Agroecological Transitions to Sustainable Food Systems in Nepal

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Abstract

Agricultural policies continue to rationalize chemical fertilizer subsidy provisions for enhancing crop productivity and food security despite limited evidence of their positive outcomes. This study examines the factors that influence farmers' willingness to pay more for chemical fertilizers than the government-subsidized price. It also investigates how farmers' willingness to pay (WTP) for chemical fertilizers shapes agroecological transitions using the path dependence and lock-in concepts. The study used a convergent mixed-methods research design and surveyed a total of 800 farming households in Nepal. The descriptive analysis was carried out first, followed by the Chi-square tests and logistic regression models. Gender, education level, age, caste/ethnicity, landholding size, and migration status did not have a significant effect on farmers' WTP for chemical fertilizers. However, some behavioral elements' effects were revealed. Farmers using chemical fertilizers for over ten years were four times more likely to have WTP compared to those using them for less than five years (OR:3.92; $p<0.01$; CI:1.45-10.59). Likewise, farmers with perceived economic advantage of chemical fertilizer were three times more likely to have WTP than those who did not (OR: 3.26; $p<0.01$; CI: 1.86-5.73). These findings highlight that farmers' WTP for chemical fertilizers reflects behavioral lock-ins to conventional agriculture. These lock-ins reinforce the chemical path dependence and create barriers to adopting agroecological practices, thereby impeding progress toward sustainable food systems. The study argues that agroecology may not be adopted simply because of its long-term benefits. Multidimensional factors, including the fear of yield loss without

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chemical inputs influence farmers' decision making for shifting their current food production practices.

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Introduction

For over several decades, chemical fertilizers have been widely promoted across many countries as a reliable means of increasing crop yields and food security through extensive subsidy provisions (Gautam, 2015; Mdee et al., 2021). Consequently, it has increased the global food systems' addiction to chemical fertilizers, along with a huge fiscal burden (GRAIN, 2022). Initially, the Green Revolution, including through agrochemical-based farming systems, contributed to the enhancement of cereal productivity, food security, and poverty reduction (Dengerink et al., 2022; McKay et al., 2024). However, it resulted in several negative consequences over time, such as environmental degradation, climate change, and the failure of food systems in delivering sustainable diets (Dengerink et al., 2022; GRAIN, 2022; McKay et al., 2024). The global discourses have underscored the urgency of transforming food systems towards more sustainable, resilient, and equitable pathways to address these interconnected challenges (FAO, 2025; HLPE, 2017). Sustainable food systems are those that ensure food security, nutrition, and livelihoods for all while safeguarding the economic, social, and environmental foundations needed for future generations as well (HLPE, 2019). Agroecology, proposed in 1980 as one of the low-external input farming systems to address the negative consequences of the Green Revolution (Pimbert, 2018), has reemerged as a promising approach for achieving sustainable food systems (Gliessman, 2016).

Like many countries worldwide, Nepal's agricultural sector stands at a crossroads, with trade-offs between priorities of the commercialization of agriculture and transforming food systems towards sustainability (Suwal et al., 2025). Nepal also deliberately developed its national pathways in 2021 for transforming food systems aligned with the UN-led global action tracks (NPC, 2021). As one of six action tracks, the transformation pathways emphasize boosting nature-positive food production systems at scale, including through reforming agrochemical-intensive farming practices (Suwal et al., 2025). However, the national budgets for the fiscal year 2023/24 continued to allocate over half of the total agriculture sector budget to subsidies for chemical fertilizers (MoF, 2023), indicating a significant challenge to reorienting programs toward more sustainable goals (Suwal et al., 2025). Moreover, the recent studies conducted by Ward et al. (2020) and Thapa et al. (2024) highlight that many farmers are willing to pay above the government-subsidized price to ensure timely and adequate access to chemical fertilizers. Likewise, Ekanayake (2009) emphasizes that cost is not a single determinant of fertilizer use in Sri Lanka since changes in the fertilizer prices do not influence their use. Zheng et al. (2022)

have underscored the importance of understanding farmers' behavior and motivation factors that determine the control of chemical fertilizer application. However, in South Asia, farmers' behavior regarding the use of fertilizers and manure remains less explored (Aryal et al., 2021). Meijer et al. (2014) argue that shifting the current practice and uptake of agricultural technologies is a complex process influenced by both extrinsic factors and intrinsic factors of the adopter. Moreover, they highlight that intrinsic factors influencing farmers' decisions regarding the uptake of agricultural innovations remain underexplored. This study, therefore, aims to examine both types of factors (extrinsic and intrinsic) influencing farmers' willingness to pay for chemical fertilizers, and explore their policy and programmatic implications for the agroecological transition toward sustainable food systems amid the growing global and national calls for food systems transformation towards sustainability. Since a critical question remains: are farmers willing and ready to adopt more agroecological practices? Overall, significant research gaps remain regarding examining factors determining farmers' high perceived value of chemical fertilizers, along with the fertilizer-use behavior and their linkages with the adoption of agroecological practices.

Additionally, path dependence is an important concept while studying and analyzing processes of change, which explains how a particular pathway, after being dominant, creates a self-reinforcing mechanism and hinders switching to alternative options (Eitan & Hekkert, 2023; Arthur, 1989). According to Arthur (1989), path-dependent lock-in occurs when the accumulated return of the early-established technology is so high that new adopters find it irrational to switch, and the system becomes progressively more difficult and costly to switch to an alternative, even if that alternative might be superior in the long run. However, few studies have applied a path-dependence lens to explain how farmers' historical decisions to use chemical fertilizers and their behavioral responses over time underlie their reluctance to change. Hence, building on these path-dependence concepts, this study investigates behavioral lock-ins resulting in farmers' WTP for chemical fertilizers.

Overall, the conceptual framework (Figure 1) of this study presents the presumed relationship between farmers' WTP for chemical fertilizers and sustainable food systems through agroecology. It examines the factors influencing farmers' WTP and further analyzes intrinsic factors resulting in behavioral lock-ins. Lastly, it explores the implications of the presumed chemical path-dependence for adopting agroecological practices, as presented in Figure 1. To assess the implications of farmers' WTP for chemical fertilizers on the adoption of agroecological approaches, this study draws on Gliessman's (2016) agroecological transition framework for sustainable food systems. According to Gliessman's (2016) framework, there are five levels in agroecological transitions, which emphasize a linear transition pathway towards sustainable food systems. However, this study focuses on the first 3 levels of change (1. Farming practice efficiency, 2. Input substitution, and 3. Redesign the agroecosystems) driven by the farmers' level. The remaining two levels are broad, beyond the farm level, and driven by global food systems justice and equity, which is a key limitation of this study. In a nutshell, the study using path dependence and lock-in concepts offers unique behavioral economic insights into food systems transformation.

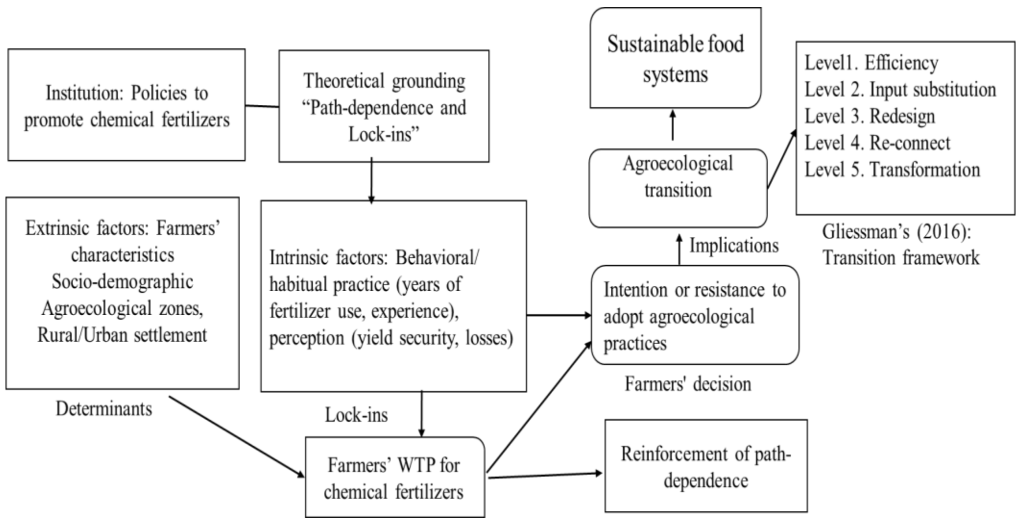

Fig. 1. Conceptual Framework of the Study

Materials and Methods

This study uses a convergent mixed-methods design that combines both quantitative and qualitative approaches following the pragmatist research paradigm. A total of 800 farming households were surveyed in Dhading (hill) and Rupandehi (Terai) districts of Nepal in 2023 through a multistage cluster sampling method. These two districts were purposively selected where the prevalence of chemical fertilizer use is quite high. Additionally, Rupandehi, near the Indian border, provides perspectives on alternative market sources and distribution networks of chemical fertilizers. Dhading, near Kathmandu, offers a perspective of potentials of developing an organic hub. The quantitative household survey employed a structured questionnaire via Open Data Kit. The data collection focused on farmers' WTP at a 50 % higher price than the government-subsidized rate, along with farmers' perspectives on conventional agriculture and switching to organic agriculture. Organic agriculture represents Gliessman's (2016) Level 2 agroecological transitions for sustainable food systems. The logistic regression model was used to analyze the key predictors of farmers' WTP (binary outcome, yes/no), consistent with prior WTP estimation studies in agricultural contexts. For example, Herath and Wijekoon (2020) used a binary logistic regression model to understand factors influencing coconut growers' WTP for the fertilizer. The logistic regression model adjusted for potentially confounding factors was estimated to explore determinants of farmers' WTP for chemical fertilizers. The dependent binary variable was defined as willing to pay more than the government-subsidized price for assured supply, categorized as "Yes" (willing) and "No" (not willing). Based on previous literature on technology adoption (Aryal et al., 2021), the explanatory variables, such as household characteristics (landholding size, livestock ownership, land tenure, migration), socio-demographic factors (age, gender, education, caste/ethnicity), and additional behavioral (intrinsic) and structural factors, were included. To assess the relative likelihood of WTP across categories, Odds Ratios (OR) with 95% confidence intervals (CI) were estimated. Additionally, this study employed a structured perception to assess farmers' views on various aspects of chemical and organic fertilizer use. Structured perception statements were developed based on a comprehensive review of prior empirical studies on drivers and barriers influencing the adoption of sustainable agricultural practices (Prokopy et al., 2008). Additionally, twenty-five in-depth interviews (IDIs) were conducted with diverse key stakeholders from all three tiers of governance, representing local, provincial, and federal. Findings were thematically analyzed to explore institutional perspectives on the challenges and drivers for accelerating agroecological transitions to sustainable food systems.

- **Demographic composition and household characteristics**

Out of the 800 respondents, 54% were female, and 46% were male, reflecting a modest predominance of female respondents in the study sample. However, male-headed households predominated, accounting for 75% of the total surveyed households. The education level of respondents was found significantly higher in urban areas and Terai compared to rural and hills ($p<0.001$). Overall, 15% of total households had a family member with migration status, and rural households reported a much higher incidence of migration (24.3%) compared to urban households (5.0%). Agriculture was found to be a dominant occupation across all groups, with over 90% of respondents. 32.6% of respondents were aware of the importance of soil testing, and only 18% of them reported practicing it in the field, reflecting a huge knowledge and practice gap. A majority of respondents (73.6%) reported that they often apply chemical fertilizers based on their own experience and judgments. Only 7.6% reported receiving training on effective management of fertilizer use.

Results and Discussions

Farmers' Perception of Fertilizer Use

A total of 762 respondents (92.25%) perceived higher crop yields from chemical fertilizers compared to 34.63% for organic fertilizers. Figure 2 shows a striking difference emphasizing farmers had a strong perception in favor of chemical inputs.

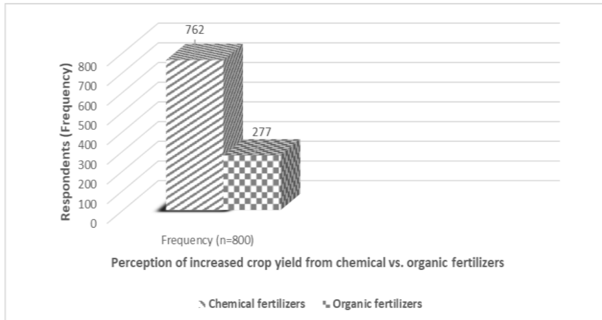

Fig. 2. Farmers' perception of crop yield

Table 1 presents that farmers predominantly perceived chemical fertilizers as more economically and agronomically beneficial, particularly in terms of high returns, lower cost, and fast growth. In contrast, organic fertilizers are considered for environmental and health benefits.

Table 1. Farmers' Perception of Advantages of Chemical and Organic Fertilizer Use

Advantages category	Perceived advantages	Frequency of respondents			
		Chemical fertilizers		Organic fertilizers	
		(n=800)	%	(n=800)	%
Economic	High return	311	38.88	132	16.5
	Low cost of production	433	54.13	197	24.63
	Improved Food Security	198	24.75	N/A	
	Self-reliance	N/A		119	14.88
Agronomic	Efficient and fast growth can contribute to a competing market	363	45.38	N/A	
Environmental	Quality and healthy food	N/A		305	38.13
	Environmental sustainability	N/A		456	57

Table 2. Farmers' Perception of the Disadvantages of Chemical and Organic Fertilizers

Category	Perceived disadvantages	Frequency of respondents			
		Chemical fertilizers		Organic fertilizers	
		(n=800)	%	(n=800)	%
Economic	Low return	135	16.88	303	37.88
	High cost of production	N/A		285	35.63

	High government budget	8	1	N/A	
	Relying on other countries	1	0.13		
Environment	Soil degradation	765	95.63	N/A	
	Water pollution	259	32.38		
Agronomic	Slow growth and low production	N/A		436	54.5
	Transportation difficulty due to high volume			293	36.63
Market	Less competitive	N/A		129	16.18
	Illegal trading of chemical fertilizers and low-quality production	34	4.25	N/A	
	Not easily available			345	43.13

Table 2 displays that a majority of respondents (95.63%) perceived soil degradation as the negative consequences of chemical fertilizer use. Regarding organic fertilizer use, farmers were largely concerned about their agronomic and economic issues. Table 1 and Table 2 illustrate that farmers are quite aware of the pros and cons of using chemical and organic fertilizers.

Farmers' WTP for Chemical Fertilizers and Determinants

WTP across Agroecological Zones and Locations

The Chi-square tests indicate significant differences in farmers' WTP for chemical fertilizers (91.2% rural vs. 42.6% urban; 89% hill vs. 44.8% Terai), $p<0.001$. These findings are similar to a previous study conducted by Ward et al. (2020) regarding variations in farmers' WTP according to the agroecological zone context. Their study reveals that farmers in the hills are more willing to pay compared to those in the Terai. Regarding the correlation between supply status and location/agroecological zones, the analysis indicates a significant difference in delays of subsidized chemical fertilizers across rural and urban areas (97% rural vs. 89.3% urban), $p<0.001$. Likewise, only 3.0% of hill respondents reported receiving fertilizers on time, compared to 10.8% in the Terai, a significant difference ($p<0.001$). These findings confirm that farmers from rural and hill areas have more problems in accessing subsidized fertilizers compared to urban and Terai. Therefore, to understand how the receipt status of chemical fertilizers influences farmers' WTP, a further correlation analysis was conducted. Table 3 shows a statistically significant negative correlation between timely fertilizer access and willingness to pay more ($r = -0.197$; $p<0.001$). This indicates that farmers who faced delays are more ready to pay an extra charge for assured timely access.

Table 3. Relation between WTP and Timely Access

Variables	WTP to pay more		Total (n=800)	Correlation coefficient	p-value
Got on time	No	Yes			
Yes	62.3	32.7	55	-0.197	0.000
No	30.6	69.4	754		
Total	33.1	66.9	800		

Additionally, agrovets are more common in urban (92.8%) than rural areas (81.0%), $p<0.05$, and among Terai (93.0%) than hill (80.8%), $p<0.05$, as alternative sources of chemical fertilizers. These results highlight that supply chain issues and market constraints are the underlying causes of higher WTP for chemical fertilizers in hill and rural areas

WTP by Household Characteristics

Regarding the relationship between education level and farmers' WTP for chemical fertilizers, less-educated farmers, particularly illiterate farmers (90%), had a higher WTP for chemical fertilizers than educated farmers (60%), with a significantly negative association ($r=-0.217$; $p<0.001$). The previous literature (Ninh, 2020) highlights that farmers with limited education often do not prefer new technology until its benefits have been proven. Hence, this study emphasizes that lower education with limited exposure to sustainable alternatives may increase chemical dependence. Likewise, regarding the association between farmers' WTP for chemical fertilizers and farm size, households with farm size> 2 ha had higher WTP than those with < 0.5ha, with a significantly positive association ($p<0.001$). This finding supports the previous literature (Pingali, 2012), emphasizing that landholding size shapes farmers' investment behaviors and input use intensity. Often, larger farmers are more likely to prioritize yield-maximizing strategies, which may reinforce chemical dependency.

Factors Influencing WTP for Chemical Fertilizers

The logistic regression models, presented in Table 4, show that farmers from the hill (OR=0.83; $p<0.01$; CI: 0.79-0.87) and those residing in rural areas (OR=0.06; $p<0.01$; CI: 0.03-0.12) were significantly more likely to have WTP compared to those from the Terai and urban areas, respectively. These results indicate that agroecological zone and location contexts determine farmers' WTP for chemical fertilizers, which is more associated with supply chain and access gaps issues induced by subsidized fertilizers as discussed in Section 3.2.1.

Additionally, Table 4 shows that farmers who have been using chemical fertilizers for more than a decade were more than four times as likely to have WTP than those with less than five years of use (OR=3.92; p <0.01; CI: 1.45-10.59). This indicates that long use of chemical fertilizers has become a habitual practice of farmers, reinforcing farmers' WTP decision.

Likewise, the analysis also reveals that farmers who perceived chemical fertilizers as ensuring efficient and rapid crop growth were three times more likely to have WTP than those who did not perceive it (OR=3.26; p<0.01; CI: 1.86-5.73). These findings reflect that farmers perceived increasing returns from chemical fertilizers are quite high, reinforcing their positive attitude towards chemical inputs.

In contrast, variables such as gender, education level, caste/ethnicity, landholding size, ownership of livestock, migration status, information on subsidies, and training had no significant effects on farmers' WTP for chemical fertilizers. However, the Chi-square tests show significant association between some variables, such as education level and landholding size, and farmers' WTP for chemical fertilizers (section 3.2.2). Therefore, the study suggests considering these variables while analyzing policy and programmatic implications for agroecological transitions.

Table 4. Factors Influencing Farmers' WTP More for Chemical Fertilizers

Variables	Odds Ratio (OR)	Class Interval (CI)	P value
Ecological zone			
Hill	R	. - .	.
Terai	0.83	0.79 - 0.87	0.000
Urban-rural residence			
Rural	R		
Urban	0.06	0.03 - 0.12	0.000
Gender (respondent)			
Female	R		
Male	0.98	0.52 - 1.84	0.955
HH Head gender			
Female	R		
Male	1.00	0.52 - 1.94	0.998
Age group			
16-24	R		
25-40	0.40	0.11 - 1.46	0.164
41-59	0.35	0.09 - 1.39	0.137
60 and above	0.58	0.13 - 2.67	0.488
Education			

Variables	Odds Ratio (OR)	Class Interval (CI)	P value
Illiterate	R		
Non-formal education	0.40	0.07 - 2.19	0.290
Primary	0.83	0.38 - 1.83	0.643
Secondary	0.90	0.42 - 1.91	0.781
SLC and above	0.71	0.27 - 1.86	0.480
Land size			
Less than 0.5 hectare	R		
0.5-2 ha	0.94	0.51 - 1.75	0.854
> 2 ha	-	-	-
Ownership of large livestock			
No	R		
1-2 animals	0.76	0.44 - 1.31	0.320
3 or more animals	0.52	0.18 - 1.49	0.224
Experience with chemical fertilizers			
Less than 5 years	R		
5-10 years	2.24	0.65 - 7.70	0.200
More than 10 years	3.92	1.45 - 10.59	0.007
No idea/ Don't know	1.43	0.38 - 5.42	0.595
Caste/Ethnicity			
Brahmin/Chhetri	R		
Janajatis	0.95	0.55 - 1.64	0.862
Dalit	1.77	0.43 - 7.31	0.431
Family Migration			
No	R		
Yes	1.81	0.86 - 3.82	0.118
Own land			
No	R		
Yes	1.15	0.66 - 2.02	0.625
Information on chemical fertilizers subsidies			
No	R		

Variables	Odds Ratio (OR)	Class Interval (CI)	P value
Yes	3.49	0.64 - 19.12	0.150
Received any training on chemicals			
No	R		
Yes	0.98	0.34 - 2.83	0.969
Decision Making			
Male member	R		
Female member	0.69	0.33 - 1.45	0.326
Both	1.72	0.89 - 3.33	0.108
Perceived chemical fertilizers as efficient and fast growth			
No	R		
Yes	3.26	1.86 - 5.73	0.000

WTP for Chemical Fertilizers and Adoption of Agroecological Practices

The study further explored the association between farmers' adoption intent of organic agriculture and farmers' WTP with "yes" and "no" responses, and Table 5 shows a significantly negative relationship between these two variables. ($r = -0.382$; $p<0.001$). This finding suggests that respondents with higher willingness to pay for chemical fertilizer are associated with a lower likelihood of adopting organic agriculture, compared to those unwilling to pay more for chemical fertilizers.

Table 5. Relation between WTP and Intention to Adopt Organic Agriculture

Variables	Interest in adopting organic agriculture with subsidies		Total	correlation coefficient	p-value
WTP more	No	Yes			
No	7.2	92.8	265	-0.382	0.000
Yes	45.2	54.8	535		
Total	32.6	67.4	800		

Additionally, the barrier analysis as presented in Table 6 shows that farmers perceived low crop yield was negatively associated with the intent to adopt organic agriculture ($r = -0.276$; $p<0.001$). The remaining two barriers (slow growth and less competitive) had no significant associations. These results emphasize that farmers' fear of yield loss is the key barrier to adopting organic agriculture. According to

Kahneman and Tversky's prospect theory (1979), people make decisions based on perceived gains and losses. The study, therefore, argues that farmers with high WTP are loss-averse and unwilling to take the risk of switching to organic options, even though they were quite aware of the long-term benefits of organic fertilizers (see Table 1-2). The previous literature also indicates that yield concerns are a major cause of slow adoption of organic agriculture (Reganold & Watcher, 2016).

Table 6. Relation between Perceived Barriers and Intention to Adopt Organic Agriculture

	Interest in adopting organic agriculture with subsidies		Total	Correlation coefficient	p-value
Variables	No	Yes			
Low crop yield				-0.276	0.000
No	22.5	77.5	497		
Yes	49.2	50.8	303		
Total	32.6	67.4	800		
Slow growth					
No	30.2	69.8	364	-0.047	0.185
Yes	34.6	65.4	436		
Total	32.6	67.4	800		
Less competitive					
No	68.0	30.0	671	-0.028	0.423
Yes	64.3	35.7	129		

This study also explored farmers perceived drivers for adopting organic agriculture to inform the discussion on the policy and programmatic implications for agroecological transitions toward sustainable food systems. As shown in Figure 3, the descriptive analysis shows that a majority (72.75%) of respondents preferred compensation for low economic returns as the strongest motivation to adopt organic agriculture. This indicates that farmers' motivation is associated with economic incentives, followed by accessibility of inputs and support systems.

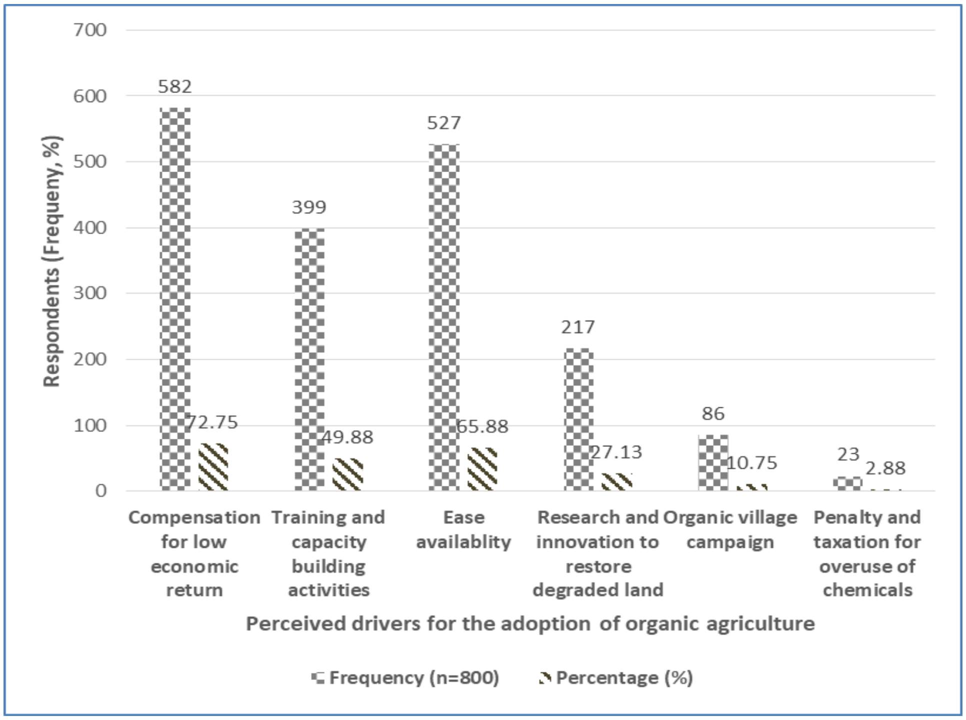

Fig. 3. Farmers perceived drivers for adopting organic agriculture

Stakeholders' Perspectives on Chemical Fertilizers and Agroecology

In-depth interviews (IDIs) with public sector stakeholders across all three tiers of government (federal, provincial and local) show a shared view that farmers' high WTP for chemical fertilizers is due to the inefficient supply mechanisms of the subsidized fertilizer. During the IDIs, representatives of agriculture cooperatives reported that a limited supply of government-subsidized fertilizers compared to actual demand forced farmers to seek alternative sources, including higher-priced commercial markets and illegal channels. In addition to supply chain issues, one local-level extension worker said, "*Fertilizer application has become a habitual practice of farmers like addiction to tobacco or alcohol, and they just ignore other soil nutrient management practices*".

Regarding challenges of agroecology, municipal agriculture units asserted that, although they allocate budgets for subsidies on organic fertilizers, these have been ineffective due to low demand from farmers. The government officials from municipal agriculture units acknowledged that the demand for chemical fertilizers is quite high because farmers prefer short-term returns.

IDIs identified two critical leverage points for advancing agroecological transitions toward sustainable food systems: 1. generating and demonstrating evidence on the productivity and economic viability of agroecological farming practices to enhance farmers' confidence and encourage wider adoption; 2. strengthening the technical capacity of local agricultural extension workers to provide effective advisory, training and support services that facilitate agroecological transitions.

Implications of WTP for Chemical Fertilizers for Sustainable Food Systems

Behavioral Lock-ins and Chemical Path dependence

Overall, the study reveals that factors such as habitual practice, perceived increasing returns, a yield security mindset, location-based supply chain constraints, and access gaps for subsidized fertilizers significantly influence farmers' WTP for chemical fertilizers (Table 4). According to path dependence concepts, the accumulated return of the early-established technology creates lock-in into the dominant path, and attitudes, subjective norms, and perceived behavioral control determine intention of behavior, including resistance to change (Ajzen, 1991; Arthur, 1989; Kahneman &Tversky, 1979). Building on these concepts, this study emphasizes that farmers' high WTP for chemical fertilizers not only reflects economic choice due to supply chain and access gaps but also farmers' behavioral lock-in to chemical fertilizers, creating barriers to shifting towards agroecological practices. The study argues that farmers with more than a decade of experience using chemical fertilizers has become a habitual practice. Over time, they perceive chemical inputs as a necessity for yield security and increased returns. Additionally, farmers' limited exposure to training and information on alternative solutions (see Section 2) results in status quo bias and fear of yield loss in agroecological practices. Therefore, both farmers' behaviors and structural factors such as a regulated supply chain of subsidized chemical fertilizer and limited local government extension capacity are locked into chemical-intensive models. This chemical path dependence consequently slows down the adoption of agroecological practices and hinders progress toward sustainable food systems. These findings support the previous literature (Conti et al., 2021; Spangler et al., 2022), which highlights the resistance of agri-food systems changes due to a combination of technological, behavioral, and structural lock-ins.

Policy and Programmatic Implications for Agroecological Transitions

This study highlights that farmers' WTP for chemical fertilizers has significant policy and programmatic implications for the agroecological transitions to sustainable food systems. The intensity of these implications is likely to vary across Gliessman's (2016) Levels 1-3 of agroecological transition. In the case of the persistence of high WTP for chemical fertilizers, it may slow down Level 1, which focuses on improving resource-use efficiency through practices such as sustainable agriculture intensification, precision agriculture, and balanced soil nutrients management. It may also constrain advancement to Level 2, which emphasizes the substitution of synthetic inputs with more sustainable alternatives, including organic agriculture. More importantly, it may impede Level 3, which involves the fundamental redesign of agroecosystems through approaches such as agroforestry, permaculture, and multiple cropping. Building on these findings, the study proposes the following five measures to help break path-dependent lock-ins and advance agroecological transitions toward sustainable food systems in Nepal. These recommendations are informed by global and national experiences, stakeholder perspectives, and farmers' insights generated through this study.

- Reform the chemical fertilizer subsidy structure

The study suggests reducing the chemical fertilizer subsidy rate since farmers are ready to pay a higher price than the current subsidized one. This helps redirect the subsidy savings for reducing chemical dependency by prioritizing Level 1 of food systems change as the entry point, particularly sustainable and balanced soil nutrients management, and generating evidence on the effectiveness of agroecological practices.

- Establish transition support mechanisms

The study suggests designing and establishing explicit transition support mechanisms such as yield loss compensation, minimum price support for agroecological products, and targeted transition input subsidies for the Level 2 and Level 3 food systems change process. Simply capacity-building activities such as training and basic input support may not be sufficient to motivate adopters and behavioral change (Meijer et al., 2014). Moreover, the majority of respondents voted on compensation for low economic returns as the strongest motivation to adopt organic agriculture (see Figure3).

- Design context-specific agroecology roadmaps

Instead of one-size-fits-all solutions, the roadmap of agroecology needs to guide the implementation of targeted and context-specific interventions. Tailored approaches, such as those for farmers unwilling to pay for chemical fertilizers, can be developed as champions of scaling agroecological approaches. Less-educated farmers are deeply rooted in fertilizer dependency (see Section 3.2.2), and interventions targeting this group may need to emphasize exposures and capacity building of sustainable alternatives. The study emphasizes prioritizing building empirical evidence on the yield security and profitability of agroecology through farmer extension programs, demonstration plots, and farmer field schools (Polonio Punzano et al., 2021).

- Redirect extension services towards agroecological practices

One-time training and orientation support are unlikely to be adequate to address the technical challenges and agronomic performance issues that farmers encounter when transitioning to agroecological practices. Sustained adoption requires reliable, regular follow-up, and context-specific extension support services that provide continuous technical guidance throughout the transition process. Therefore, based on stakeholder-informed discussions, the study also recommends enhancing the capacity of local extension workers on food systems, agroecological principles, and agronomic issue-based extension services.

- Integrate behavioral perspectives into policy and program design

This study suggests integrating behavioral perspectives into agricultural policies and programs to address entrenched farming practices, perceptions of yield security, and institutional incentives that reinforce chemical path dependence, building on findings of Dessart et al. (2019).

Conclusion

The study concludes that agroecological approaches may not be adopted simply because of their long-term benefits. Multidimensional factors, including the fear of economic loss without chemical inputs, influence farmers' decision-making for shifting their current food production practices. Farmers' WTP for chemical fertilizers has significant policy and programmatic implications for the agroecological transitions toward sustainable food systems. A blanket approach, such as simply removing chemical subsidies and capacity-building activities, may not be effective to break chemical path dependence. The study emphasizes the need to mainstream behavioral perspectives into policy and programs to facilitate agroecological transitions toward sustainable food systems.

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