International Journal of Agriculture, Environment and Bioresearch

Vol. 08, No. 01; 2023

ISSN: 2456-8643

FACTORS INFLUENCING ADOPTION OF SELECTED PADDY INNOVATIONS AMONG SMALLHOLDER FARMERS IN MVOMERO DISTRICT, TANZANIA

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https://doi.org/10.35410/IJAEB.2023.5802

ABSTRACT

Adoption of paddy innovations is important for production and productivity but there has been low or non adoption at different places in Tanzania. Despite this adoption of innovations has not been convincing. This research was conducted in Mvomero District, Morogoro, Tanzania to determine the extent of adoption of innovations in paddy production and analyzed factors influencing this adoption. A cross-sectional research design was adopted and 299 respondents were sampled using simple random technique. Data were collected using questionnaire, in-depth interviews, field observation and Focus Group Discussions (FGDs). Qualitative data were analyzed using content analysis. Binary logistic regression analysis was used to estimate factors influencing adoption of innovations. The study concludes that, it is difficult for a smallholder paddy farmer to attain full adoption of an innovation package which composes several practices in it as it become complex to follow. Extension programmes including trainings on introduced innovations and regular visits are important for adoption of paddy innovations to rural farmers. Markets availability is an opportunity which motivates farmers to adopt paddy innovations. Therefore, farmers should be well-informed of the markets by the extension and marketing officers.

Keywords: SRI, adoption, innovation, paddy, smallholder farmer.

1. INTRODUCTION

Adoption of paddy innovations is important to rural farmers. It is the decision by the farmers to accept and make use of paddy innovation which is perceived beneficial towards achieving a sustainable increase in farm productivity and leading to improved well-being of respective farmers (Rogers, 2003). Adoption in this case occurs when there is a continued use of paddy innovations by farmers. The concept of innovation includes an application of advanced idea, method, farm practices and inputs which replace the conventional ones. Scholars define innovation as an idea, farming practice, and or a system that is perceived new by individuals (Leeuwis, 2004). In this paper, innovations refer to new paddy production practices, production tools, and threshing and processing tools. The paddy innovations in this study are Power Tillers (PTs), Wooden Thresher (WTs) and Combine Rice Mills (CRMs). These tools are considered innovations because they are new in paddy production and processing in the study area. Thus, this study refers to PTs, WTs and CRMs in paddy production as use of PTs in land preparation, threshing paddy using WTs and processing paddy using CRMs. Application of innovations in paddy production and processing has many advantages to rural farmers.

Adoption of innovations is an important aspect which is anticipated to deliver positive results to the rural paddy farming community. However, a few scholarly studies in Tanzania especially the study area have been conducted in this area. Literature show that, adoption of PT and WT is anticipated to save time, increase yield, profit, income and employment, expand the area under cultivation, reduce workload and labour required in paddy production and threshing (Sims and Kienzle, 2016; Miah and Haque, 2015; Quayum and Ali, 2012). Combine Rice Mills (CRMs) are the processing machines which perform a number of operations that produce higher quality and higher yields of white rice from paddy or rough rice. CRMs range from single to multiple pass rice milling machines depending on the scale of operation. In other hand, CRMs add value to the processed rice which leads to fetching lucrative market and earn higher income to respective farmers. However, multiple operations through milling help to reduce human drudgery attached in processing of paddy. Deliberate effort of communicating innovations to farmers is required so as to influence famers' decisions.

Effort has been undertaken by the government of Tanzania (GoT) to introduce and promote paddy innovations to rural farmers including Mvomero District aiming at improving production, productivity and farmers' wellbeing. Since 2005, GoT introduced paddy innovations to farmers including rice varieties – SARO 5 (TXD 306), IR05N 221 (named Komboka, be liberated) and IR03A 262 (named Tai, eagle); best agronomic practices, water-saving irrigation technologies, rice planting techniques, Integrated Pest Management (IPM), tools and implements-reapers, PTs, threshers, combine harvesters and processing machines (URT, 2009; URT, 2013). The PTs, WTs and CRM innovations have been in use in the study area between 1999 to 2006 years (Katambara et al., 2013). However, the practice shows that paddy farmers do not readily accept innovations immediately. Up to 2015, the GoT through Agricultural Sector Development Strategy (ASDP) phase one and two has been promoting better access and use of agricultural knowledge, technologies, and infrastructure to paddy farmers in 20 irrigation schemes including Mkindo and Dakawa. Similarly, extension agents have been advocating these innovations to ensure that smallholder paddy farmers take in full adoption. Despite the efforts done by the government and extension agents, the level of adoption of paddy innovations introduced in Mvomero District is not yet established. Therefore, this study intended to assess adoption of four selected paddy innovations among farmers. Specifically, it determined the extent of adoption of the selected innovations and analyzed the factors influencing adoptions of these innovations in the area of study.

This study adapts a sociological model of adoption of innovation. The model considers adoption as a learning process and that every person goes through mental steps during that learning process about innovation (Semgalawe et al., 1998; Rogers and Shoemaker, 1971). The process involves four stages; awareness, evaluation, trial and adoption. In awareness stage, a farmer learns about the new idea; evaluation stage involves comparison of the expected benefits of the innovation with his/her conventional ones, while in trial stage a farmer decides to try an innovation in a small plot/quantity of paddy and then use it on a larger plot/ quantity of paddy. Adoption stage involves complete application (confirmation) or otherwise discards of the innovation.

2.METHODOLOGY

The study used cross-sectional data to measure the extent of adopt of each innovation and analyse factors influencing adoption of selected innovations among paddy farmers in Mvomero District in Morogoro Region. Two paddy irrigation schemes in the District namely Mkindo and Dakawa were selected. These schemes are the only smallholder schemes where SRI was introduced upon its arrival to Tanzania. Cross-sectional research design was adopted whereby simple random technique was used to obtain 299 respondents from two schemes and estimated by Yamane’s formula (Yamane, 1973). Proportionate sampling technique was used to obtain 96 and 203 respondents from Mkindo and Dakawa respectively. The study deployed a mixed methods approach which facilitated the deployment of both qualitative and quantitative methods in data collection. Primary data were gathered using questionnaire, in-depth key informant’s interviews (KIIs) and Focus Group Discussions (FGDs). Three FGDs and five KIIs were conducted using FGDs guide and checklist of questions respectively. In the field, observation was also used to watch PTs and CRMs under operations against conventional practices. Qualitative data were analyzed through content analysis, in which pieces of information from the FGDs and KIIs were condensed, coded and organized into different themes and compared based on study objectives. The extent of adoption of innovations was analyzed with fundamental statistics values, mainly, frequencies and percentages for adopters and non-adopters. This approach was also used by other scholars like Oman et al. (2010); Mackrell et al. (2009); Miller et al. (2008).

Factors influencing adoption of PTs, WTs and CRMs were analyzed using a binary logistic regression model in which dependent variables were dichotomous, that is, non-adoption (0) and adoption (1). So, three separate models were run for each innovation. Binary logistic regression, as explained by Challa and Tilahun (2014) and Agresti (2002) was used to test the hypothesis that the odds of the farmers adopting selected paddy innovations are the same among the paddy farmers with different socio-economic and socio-demographic characteristics ($p < 0.05$). The model was specified as follows:

$$\text{Logit}\left[p(x)\right] = Log\left[\frac{p(x)}{1-p(x)}\right] = \alpha + \beta_1\chi_1 + \beta_2\chi_2 + \beta_3\chi_3 + \beta_n X_n + \varepsilon \text{..............................(5)}$$

Where:

Logit (px) = ln (odds (event)), that is the natural log of the odds of adopting the innovations.

$p(x)$ = prob (event), that is the probability of adopting the innovations.

$1-p(x)$ = prob (nonevent), that is the probability of not adopting the innovations.

$Log\left[\frac{p(x)}{1-p(x)}\right]$ = is the logarithm of the ratio of probability of adopting the innovations p(x) to probability of not adopting them 1- p(x).

α = constant of the equation.

$\beta_1 - \beta_n$ = coefficients of the predictor variables.

$\chi_1 - \chi_n$ = predictor variables entered in the model, are described in Table 1.

ε = Error term.

n = number of independent variables.

Table 1: Variable definition, unit of measurement and assumed influence

Variable	Variables definition and unit of measurement	Expected sign
X_1	Sex of the paddy farmer (1 if Male, 0 if Female)	+
X_2	Age of the paddy farmer in years	+/-
X_3	Marital status of the paddy farmer (1 if married , 0 if otherwise)	+
X_4	Education of the paddy farmer in terms of years spent schooling	+/-
X_5	Household size in terms of number of people in the household	+
X_6	Labour availability (1 if available, 0 if Not)	+
X_7	Land ownership (1 if owned, 0 if otherwise)	+
X_8	Farm size for paddy production in hectares	+
X_9	Access to extension advisory (1 if yes received, 0 if not)	+
X_{10}	Access to credit facilities (1 if yes, 0 If Not)	+
X_{11}	Market availability (1 if yes, 0 if Not)	+
$X^{\star}_{12}$	Relative advantage (1 if yes, 0 if otherwise)	+
X_{13}	Total revenue per hectare per production season in 2015 in TZS	+
X_{14}	Decision making (index score in continuous from 0 to 1).	+
$X^{\star}_{15}$	Knowledge of a respective innovation (in scores; ranging from 0-13 scores for SRI; 0-7 scores for PT; 0-2 scores for WT; 0-4 scores for CRM).	+

Note: Innovation attribute ($\chi_{12}{}^{*}$) and Knowledge ($\chi_{15}{}^{*}$) apply to four separate innovations

i.e PT, WT and CRM.

Decision-making (DM) and Knowledge were the composite variables that involved procedure in measurement. DM fitted in binary logistic regression model was determined using scores whereby 3 statements representing DM were assigned scores i.e. 1 =yes and 0=otherwise and decision-making index (DMI) was developed in a range of 0 to 1 for each innovation. The formula was adapted from Meena *et al.* (2012);

$$DMIndex = \frac{TscoreObt}{Maxscore} \quad \ldots\ldots(6)$$

Where:

ISSN: 2456-8643

$TscoreObt =$ Total scores obtained

$Maxscore =$ Maximum expected score

Knowledge as a variable in this research involved farmers' awareness and technical know-how to utilize each innovation (i.e PT, WT or CRM separately). It was determined using scores whereby statements were made to represent knowledge for each innovation and assigned scores i.e. 1 =yes and 0=otherwise. There were 7 statements for PT, while 2 statements for WT and 4 statements represented knowledge for CRM.

3. RESULTS AND DISCUSSION

3.1 Factors Influencing Adoption of PT, WT and CRM

Each innovation has different factors that determine its adoption. Factors influencing adoption of PTs were: knowledge, relative advantage of using PTs ($p < 0.01$), labour availability, land size, access to extension advisory, market availability, access to credit facilities, and decision making power ($p < 0.05$) (Table 2). While, marital status, access to credit facilities ($p < 0.05$) and knowledge ($p < 0.01$) influenced adoption of WT and land ownership and knowledge on CRM were found to influence adoption of CRM ($p < 0.01$) (Table 2).

A relationship existed between adoption of power tillers and availability of labour in the area of study. The results indicate that labour availability was statistically significant (ß=0.668; p=0.065) related with adoption of PTs (Table 2). This means that farmers who had available labour (hired and not hired) had higher chance to adopt PTs than farmers who had no labour. The odds ratio for labour availability is 1.950; meaning that farmers who had access to labour 1.950 more likely to adopt power tillers compared to farmers with no access to labour. Thus, it can be inferred that those farmers who had access to labour (that means labour who were sourced from households or hired) for rice production operations were motivated to adopt PTs. Power tillers are applied for land preparation, so labour is highly important to fulfill immediate post-land preparation activities such as perfect leveling and irrigation which are followed by timely transplanting. Scholars hold that availability of labours encourages farmers' adoption of technology (Nirmala and Vasantha, 2013).

Availability of markets was significantly associated with adoption of PTs (ß=0.986; P=0.011). This result indicates that farmers who were informed on availability of markets had higher chance to adopt PTs compared to farmers who were not informed on availability of markets. Paddy was sold in farm gate to middlemen, warehouses owners and rice millers. During the interview it was revealed that farmers get information about paddy markets from extension officers and fellow farmers. The results from binary logistic regression analysis also show that, the odds of adoption is estimated to increase by a factor of 2.680, meaning that farmers who were accessible to information on paddy markets had 2.7 times more likely to adopt PTs than those who had no accessibility. This implies that the rational decision made by farmers to adopt PT resulted from the availability of market that assures the farmer to sell his/her paddy/and rice.

Adoption of PTs was also influenced by perceived relative advantage of using PTs. The results revealed the significance relationship between perceived relative advantage of using PTs and adoption of PTs (ß=1.755; p=0.000) (Table 2). The odds ratio for relative advantages of using PTs was 5.786; this shows that farmers who perceived power tillers being relatively advantageous to conventional ones had around 5.8 times likely to adopt PTs than farmers who felt the use of PTs had no benefits. The result confirms that farmers who perceived PTs being advantageous in land preparation over conventional tools had greater chance of adoption than farmers who perceived PTs otherwise. Similar to this result, Howley et al. (2012); Akudugu et al. (2012) noted that farmers who are more likely to receive benefits from the use of an innovation are more likely to adopt such innovation.

Decision making power makes contribution to farmers' choices in adopting PTs. The decision making power attributes; use of farm resources, use of innovations and choice of market were statistically significant related with adoption of PTs (ß=1.292; p=0.084) (Table 2). The odds ratio confirms that an increase in decision making power by 0.1 index score increases the adoption of PTs by a factor of 3.642 (Table 2). This implies that adoption of PTs is subject to the farmers' decision on utilization of land, water, harvests and relative ability to decide market to sell produce. Thus, farmers with higher decision making power increased adoption of PTs than those with low decision making power. Water saturation on paddy fields is a necessary condition for a farmer to operate a PT, therefore a farmer who is denied access to irrigated water will probably not use a PT. Baird et al. (2004) found the similar result that decision usefulness was statistically significant related with adoption of innovations.

Knowledge about innovation is a pre-disposing factor for adoption. The results indicate that farmers' knowledge was common across innovations. It was found that knowledge of farmers on PTs, WTs and CRMs was significantly related to adoption of each innovation ($p < 0.01$) (Table 2). The odds ratios for knowledge of respective innovation were 1.807, 23.00 and 3.97 for adoption of PTs, WTs and CRMs respectively. This suggests that farmers who were knowledgeable on the three separate innovations are around 2.0, 23.0 and around 4.0 times more likely to adopt PTs, WTs and CRMs respectively, compared those who not knowledgeable. Farmers who have appropriate knowledge on an innovation can assess the advantages and the opportunities of using innovation. So, the possibilities of making profit via such innovation made the farmers to take positive decisions to adopt SRI practices, PTs, WTs and CRMs. This finding is in line with other researchers who reported significance and positive influence between farmers' knowledge and adoption of innovations (Ngwira et al., 2014; Sarada and Kumar, 2013; Fita et al., 2012).

Table 2: Binary logistic regression model estimates of factors influencing adoption of PT, WT and CRM separately

Variable	Power Tillers					Wooden Threshers					Combine Rice Mills				
	ß	SE	Wald	Sig.	Exp(B)	ß	SE	Wald	Sig.	Exp(B)	β	SE	Wald	Sig.	Exp(B)
Sex (X_1)	.293	.370	.628	.428	1.341	.562	.829	.459	.498	1.754	.229	.543	.177	.674	1.257
age (X_2)	-.019	.015	1.601	.206	.981	-.022	.033	.460	.498	.978	-.025	.027	.898	.343	.975
Marital status (X_3)	.379	.442	.737	.391	1.461	-1.934**	.918	4.434	.035	.145	.243	.654	.138	.711	1.275
Education level (X_4)	-.031	.068	.203	.652	.970	.011	.128	.008	.929	1.012	-.031	.098	.098	.754	.970
Household size (X_5)	-.012	.091	.018	.894	.988	.223	.176	1.610	.204	1.250	-.018	.115	.023	.879	.983
Labour availability (X_6)	.668*	.362	3.405	.065	1.950	.234	.695	.114	.736	1.264	.514	.585	.773	.379	1.672
Land ownership (X_7)	.469	.400	1.377	.241	1.598	.601	.823	.533	.465	1.823	1.904***	.585	10.571	.001	6.710
Land size (X_8)	-.337**	.140	5.827	.016	.714	.167	.240	.484	.486	1.182	-.004	.183	.000	.984	.996
Access to extension advisory (X_9)	-.924**	.409	5.110	.024	.397	-.606	.912	.442	.506	.545	-.682	.617	1.225	.268	.505
Access to credit facilities (X_{10})	-.583*	.352	2.746	.098	.558	1.453**	.693	4.394	.036	4.274	.389	.500	.605	.437	1.476
Rice markets availability (X_{11})	.986**	.390	6.404	.011	2.680	$2.0x10^{1}$	$3.8x10^{3}$	.000	.996	$4.8x10^{8}$	.736	.556	1.751	.186	2.087
Perceived relative advantage (X^*_{12})	1.755***	.371	$2.2x10^{1}$	.000	5.786	.558	.842	.439	.508	1.747	.936	.672	1.938	.164	2.550
Total revenue per hectare per production season in 2015 (X_{13})	.000	.000	.036	.849	1.000	.000	.000	.189	.664	1.000	.000	.000	1.377	.241	1.000
Decision making power index (X_{14})	1.292*	.748	2.985	.084	3.642	1.816	2.895	.393	.530	6.147	.175	1.193	.022	.883	1.191
Knowledge of innovations (X^*_{15})	.592***	.103	$3.3x10^{1}$	.000	1.807	3.117***	.929	$1.1x10^{1}$	.001	$2.3x10^{1}$	1.379***	.187	$5.4x10^{1}$	.000	3.972
_cons	-3.391	1.279	7.029	.008	.034	$-2.6x10^{1}$	$3.8x10^{3}$	.000	.994	.000	-6.120	2.051	8.900	.003	.002
Nagelkerke's R^2	0.549					0.445					0.631				
Cox and Snell R^2	0.404					0.152					0.383				
Hosmer and Lemeshow Test	(chi^2 = 11.976; Sig. = 0.152)					(chi^2 = 3.823; Sig. = 0.873)					(chi^2 = 4.525; Sig. = 0.807)				
Omnibus Tests of Model Coef	(chi^2= 154.698; Sig. = 0.000)					(chi^2= 49.202; Sig. = .000)					(chi^2=144.438; Sig.= 0.000)				
- 2 Log likelihood	258.596					75.618					134.953				

Note: β = Coefficient; SE = Standard error; Exp (B) = Odds ratio; *, ** and *** indicates statistical significance at 10, 5% and 1% significance levels respectively; χ_{12}^{*} = Relative advantage of PT, WT and CRM separately; χ_{15}^{*} = knowledge on PT, WT and CRM separately.

Farm size influenced the adoption decision of the farm households significantly. Farm size was correlated with the adoption of PTs at 0.05 level of significance (ß= -0.337; p-value = 0.016) (Table 2). The negative sign of the coefficient reflects that as land size increases, the adoption of PTs decreases. This is due to the fact that as the farm size increases, the applicability of the PTs for land preparation and transplanting decreases. PTs become more usable and desirable where a farm is small. In other hand, PTs are ineffective where farm size is large. The odds ratio depicts that an increase in farm size by one hectare decreases the adoption of PTs by a factor of 0.714. Similar to the finding of this study, Ngwira et al. (2014); Umeh and Chukwu, (2013); Howley et al. (2012) reported that farm size was statistically significant and negatively correlated with adoption of innovations.

Farmers' access to extension services is an important component in the adoption of innovations. The finding in Table 2 revealed that an access to extension advisory significantly (ß= -0.924; p=0.024) associated with adoption of PTs. This result connotes that farmers who received extension advices had less likelihoods to adopt PTs compared to those who received no advices. The results also indicate the odds ratio of 0.397; that means farmers with access to extension services were 0.4 times less likely to adopt power tillers compared to those with no access to extension services. In this regard, it is clear extension service packages were not context specific. For instance, the introduction of PTs in the study area did not take into consideration the paddy farming situation such as appropriate soil. This study result is consistent with other findings like Akinbode and Bamire's (2015); Fita et al. (2012) who found negative relationship between extension services with the adoption of innovations.

There is an association between farmers' access to credit facilities and adoption of PTs. It was found that access to credit facilities significantly associated with adoption of PTs (ß= -0.583; p=0.098) (Table 2). This suggests that farmers who had access to credit had low chance to adopt PTs than those with no access to credits. The odds of adopting PTs are estimated to decrease by a factor of 0.558, meaning that farmers who had access to credit facilities were around 0.6 times less likely to adopt power tillers compared to those with no access credit facilities. Therefore, access to credit facilities was not applicable in the adoption of PTs. In other words, application of power tillers was not a preference to farmers who had access to credit but it was mentioned during the interview that the beneficiaries of loan tend to purchase fertilizers and pesticides.

Marital status of the respondents influenced adoption of WTs. The results show that marital status was statistically significant associated with adoption of wooden threshers (ß= -1.934; p=0.035) (Table 2). The result shows that unmarried respondents had higher likelihood to adopt WTs than married couple. Also model results indicate that, the odds ratio for marital status was 0.145; so, married farmers were 0.145 times less likely to adopt WTs compared to unmarried ones. This might be due to the fact that married farmers, unlike unmarried, have family responsibilities and thus, the costs related to taking care of a large family diminish commitment to adopt WTs in expense of traditional method of paddy threshing. In the same line, FGDs revealed that adoption of WTs had cost implication compared to conventional way of paddy threshing. A quotation below was aired by one of participant in a FGD at Mkindo village:

"…adoption of a WT requires to incur costs of purchasing large canvases and a wooden stand…..married farmers find it difficult to adopt in line to costs required to take care of their families " (FGD at Mkindo village, 04thMay, 2016).

Therefore, it can be concluded that cost related to family obligations among married farmers hinder farmers' adoption of a WT which also requires substantial investment.

Farmers' access to credit facilities is related to adoption of WTs. The results show that there is a significant relationship between farmers' access to credit facilities with adoption of WTs (ß=1.453; p=0.036) (Table 2). This means that farmers with access to credit facilities had higher likelihood to adopt WTs than farmers who lack access to credit facilities. This is also revealed in regression analysis results where the odds of adopting WTs are predicted to increase by a factor of 4.274, meaning that farmers who had access to credit facilities were 4.3 times more likely to adopt WT compared to those with no access to credit facilities. This implies that accessibility to credit facilities is a capital that facilitates farmers to secure loans which in turn will enable them to meet the expenses of applying WTs. Adoption of WTs require purchase of materials like canvases and wooden stand and transportation to and from the fields. This research revealed similar finding to Mmbando and Baiyegunhi (2016) who reported positive relationship between access to credit and adoption of innovations.

Land ownership showed a highly significant relationship with adoption of CRMs. A binary regression analysis indicate that there was significant (ß =1.904; p=0.001) relationship between land ownership and adoption of CRMs (Table 2). Also, model analysis found that the odds ratio for land ownership status was 6.710; meaning that farmers with ownership to land were 6.7 times more likely to process paddy using CRMs compared to those with no ownership. This indicates that farmers with land ownership have higher chance to adopt CRMs than those with no land ownership. As it was observed by Ogutu et al. (2015) that land ownership security increases farmers' incentives to adopt agricultural innovations, this result implies that land ownership as a security encourages farmers to engage into paddy production and thus accumulate enough harvests which enable them to process using CRMs instead of simple mills.

4. CONCLUSION AND RECOMMENDATIONS

This study indicates that only farmers' knowledge is an important variable in adoption of each innovation. Therefore, it is not necessary for the variables which influence adoption of one innovation to have an influence on other innovations. The land ownership gives a farmer the right and security which is a motivation to adopt innovations. It further revealed that although extension services are crucial in promoting paddy farming, if not well programmed to promote innovations, there is a possibility to constrain adoption of such innovations. Available paddy markets at farm level are an opportunity that motivates farmers to adopt innovations and eventually raise their production and productivity.

Since knowledge was an important aspect in the adoption of innovations, therefore extension officers are advised to educate and train farmers to clearly understand and eventually practice the innovations. The knowledgeable farmers in turn are anticipated to practice innovations thereby advance their rate of adoption. Paddy farmers should be assisted to secure land titles by the village government in collaboration with District land planners. In order to avoid negative influence of extension services, extension officers and agricultural interventionists should design farm-level innovations that reflect the paddy production and processing attributes of the potential recipients in the rural farmers' communities. Such innovations should be simplified to fit into the existing paddy farming of the potential users. Active participation of paddy farmers in agricultural empowerment interventions is needed because their willingness is important in adoption of innovations. Extension officers are advised to raise awareness to paddy farmers on available markets at their setting as an opportunity for their economic growth.

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