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Understanding the Influence of Socio-Economic Status and Digital Literacy in the Adoption of Smart Agriculture: A Study of Farmers in Surguja Division, Chhattisgarh

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Abstract

The farming scenario in India is witnessing different changes with Smart Agriculture, embeds AI, drones, AI, IoT, etc. While these technologies promise increased productivity, better resource management, and sustainable farming practices, their adoption across the country is uneven, especially in rural places. Earlier some existing studies have given evidence of the roles that digital literacy (DL) and social economic status (SES) have on the uptake of contemporary agricultural technologies.

The present study was conducted to assess the level of DL and SES among farmers in Surguja division of Chhattisgarh to analyse the potentiality and constraints available for the adoption of Smart Agriculture. By collecting and studying the data from the respondents (N=86) in this division, the study investigates the relationship between SES and Digital Literacy, whether and how increasingly socio-economic factors limit or enable farmers from adopting and using of smart farming technologies. The study indicates that low DL and SES severely limit farmers' utilization of agricultural innovations and widen the digital and economic gap in rural farming communities. This study matters because digital tools are reshaping agriculture, but inequality in access to and knowledge of digital technologies may prevent equitable adoption. Overall, this study indicates the necessity of specific interventions dealing with socio-economic and digital roadblocks to provide effective and fair access to Smart Agriculture in Surguja.

Keywords: Digital Literacy, Socio-Economic Status (SES), Smart Agriculture, Technology Adoption, Rural Farmers.

1. Introduction

Agriculture has been the mainstay of India's economy and in the past, it has provided a source of livelihood to millions of people. However, the traditional methods of farming are no longer sufficient to ensure the growing need for food and to maintain sustainable agricultural practices in this changing world. Many issues like climate change, soil degradation, water scarcity and rising population pressures demand farmers to adopt new, resource-saving technologies that could help them produce ever more output with ever less inputs. To address these challenges, the application of advanced technologies such as Artificial Intelligence (AI), drones, the Internet of Things (IoT), etc. lead to the emergence of Smart Agriculture. These technologies assist the farmers in monitoring their farming crops in real time, the efficient use of water, unnecessary nutrient loss due to overuse of fertilizers and pesticides, improving productivity, etc. Smart Agriculture Transforming Farming to be more Efficient, it is no longer just manual farming with Smart Agriculture, in many parts of world farmers have now become more micro-targeting and precision-driven through data analytics.

Despite the advantages of Smart Agriculture, not all farmers can benefit from these technologies. Farmers need two things, first the financial ability for technology adoption and second the knowledge to operate it well i.e. to adopt and use modern farming tools. Put differently, farmers need to have a good socio-economic status (SES) and adequate digital literacy (DL) level. SES includes factors such as income, Occupation and education levels, which influence whether a farmer can afford modern tools such as automated machinery, precision farming devices and digital advisory services. DL is critical because numerous smart farming systems rely on smartphones, applications, and online platforms to evaluate the status of a farm and assist in decision-making. So, if a farmer cannot understand or leverage these digital tools, just having access to technology is not enough, it stares at them unused or underused!

The role of SES and DL in the adoption of Smart Agriculture

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has already been recognized by various studies. Higher-income and more educated farmers are more likely to adopt modern farming because they have the financial means as well as the capacity to understand and use new technologies (Jadhav, 2024). Conversely, the farmers of lower SES often find it challenging to afford these tools, and if they do acquire them, there is a potential knowledge gap preventing them from utilizing them effectively (Verma & Mehta, 2023). Likewise, research on digital literacy reveal that users of digital tools and online platforms have better adoption of Smart Agriculture practices, while poor DL users struggle to incorporate technology into their farming methods (Gong et al., 2024) [4].

Therefore, this research describes the effect of SES and DL towards Smart Agriculture adoption in Surguja District, Chhattisgarh. Approximately 90% of this area's working populace is engaged in the agriculture sector, which is a pillar of its economy. Of them, 50.36% are cultivators who own land and cultivate it, and 12.77% are agricultural labourers who work daily in farms to earn a livelihood. Even though agriculture is one of the most essential sectors of this area, the use of smart farming technologies is limited. The study will assess the socio-economic constraints and digital illiteracy of farmers in Surguja, which may be preventing them from adopting and reaping the benefits of Smart Agriculture.

From this research, the author aims to highlight the barriers in the way of farmers and also offer some suggestions on how the government through policies, training programs and financial support can help farmers adopt positive impact on the technology in rural areas. The study's findings would assist in formulating strategies for equitable delivery of Smart Agriculture so that small and marginal farmers can overcome the technological gap and enhance their farming efficiency.

2. Review of Literature

Research on Smart Agriculture integration has been done globally and scholars highlight SES and DL as significant indicators of farmers' technology adoption capabilities. The integration of Artificial Intelligence (AI), Internet of Things (IoT), drones, and precision farming is recognized as Smart Agriculture and its possibilities to increase crop yield, resource utilization, and sustainability have been noted (Jadhav, 2024) There is, however, limited access to these technologies for many farmers because of the differences in financial resources, education, and digital marketing cognizance (Kumar & Singh, 2023) [2]. For both the developing and developed world, there are challengers that face the integration of technology and agriculture. The most common challenges for developing countries are issues related to the infrastructures and the availability of proper education to aid the exploitation of the available technology.

Farmers' SES determines whether they can afford to adopt new agricultural technologies or not and this SES differentiation shows that farmers of higher incomes group are more willing to spend money on advanced farming equipment as compared to lower income group farmers. It has been noted that wealthier farmers who earn higher incomes are more willing to purchase advanced farming equipment (Verma & Mehta, 2023). In contrast, small and marginal farmers with, low levels of income and savings, and poor institutional backing often struggle to buy out costly technologies like IoT based sensors, drones, and automated irrigation systems (Don, 2025).

Education also plays a vital role in SES, which greatly influences technology adoption. Studies show that educated farmers are technologically inclined and have higher rates of adopting modern technologies (Sharma & Gupta, 2024) [18]. Those who have poor literacy skills generally continue using old-fashioned farming techniques due to the uncertainty that combines with new technologies (Bai *et al*., 2024). Thus, other than financial limitations, a lack of digital literacy is a major obstacle of Smart Agriculture adoption. Several innovations in agriculture today require even the most basic understanding of smartphones, digital apps, and the internet for data harvesting and decision-making. Farmers who understand the concepts of digitization are able to make important decisions for their farms to ensure higher yields and profits because they can get weather updates, soil health information, and market prices in real-time (Singh *et al*., 2021).

Nevertheless, research points out that a significant number of farmers in remote areas, particularly in India, do not have the minimum required digital skills to use the basic farming applications (Chand & Sirohi, 2022). While the Digital India campaign has sought to address this challenge, there is still a strong relationship between SES and levels of digital literacy, whereby wealthier and more educated farmers tend to take greater advantage of digital technologies (Digital India, 2025).

Due to nearly universal and negative impacts of SES and DL with regards to technology adoption, some research recommends Direct Interventions like monetary payments, digital education, and local aid programs to help less advanced farmers adapt to Smart Agriculture (Singh & Kaur, 2024). Failing these actions could lead to stronger imbalances in farming practices between rich and poor regions.

The above literature review shows that SES and DL are two of the most important barriers to Smart Agriculture implementation. Barriers must be surmounted to foster holistic and balanced agricultural development especially in peripheral areas of Chhattisgarh state.

3. Research Gap

Even though previous researches have looked into the intersection of agriculture and digital literacy, there appears to be a gap in understanding how SES affects DL of farmers in rural India. As it is common in most works, either technology adoption is studied, or socio-economic disparity is studied, but their interplay in smart agriculture adoption is seldom researched. Moreover, there is insufficient area-based research for farmers from Surguja division. This study attempts to fill this void by presenting data concerning the SES-DL correlation and pointing out the impediments to digitalization in agriculture.

4. Research Objectives

i). To assess how socio-economic status (SES) influences digital literacy (DL) among farmers in Surguja Division, Chhattisgarh.

ii). To identify whether farmers from lower SES groups face greater challenges in adopting digital tools for smart agriculture.

5. Research Methodology

This research uses multistage sampling to measure the effect of socio-economic status (SES) and digital literacy (DL) on the adoption of Smart Agriculture in Surguja Division of Chhattisgarh.

i). Research Design
In this study the researcher adopted a quantitative research approach. In order to analyse the relationship between SES and DL of the respondents in targeted area, a descriptive and analytical approach was employed. For facilitating analysis, the data was collected using survey method. Researchers reached 86 respondents to get data and then finally statistical analysis was conducted to identify significant differences across SES groups.

ii). Study Area and Population
Six Districts viz., Balrampur, Jashpur, Koriya, Manendragarh-Chirmiri-Bharatpur (MCB), Surajpur, and Surguja, jointly make the Surguja Division which is located in the northern part of Chhattisgarh. Figure 1 shows the map of Chhattisgarh along with the map of the study area which is highlighted.
For the purpose of this study, out of six districts, Surguja and Surajpur districts were selected on convenience basis. These two districts hold agricultural significance in Surguja division. Villages within these districts were selected at random and farmers from these villages were selected using purposive sampling to ensure that only individuals practicing agriculture can be taken into sample to participated in the study.

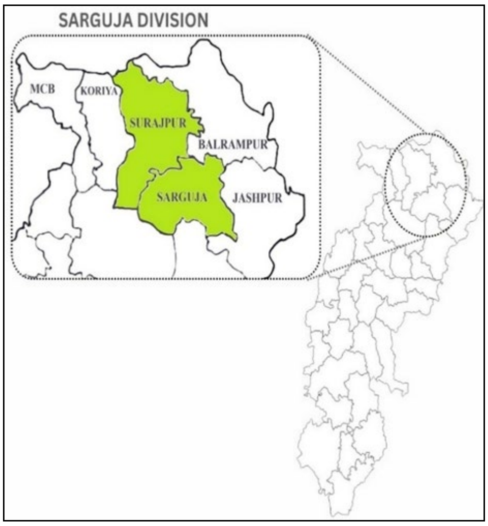

Fig 1: Map of Chhattisgarh

iii). Data Collection Methods
a) **Primary Data:** The researcher obtained data through structured questionnaires and personal interviews with farmers. The research survey targeted farmers' SES and their DL competencies. Researchers used the modified Kuppuswamy scale by Mandal & Hossain, 2024 to evaluate the SES of study participants. Researchers gathered income details alongside occupation and educational data to assign SES scores based on these three factors. Participants were sorted into various socio-economic groups based on their SES score calculations.
The researcher further employed a modified version of a previously validated measurement scale from Chandra, S. *et al*., 2024 to assess Digital Literacy among farmers. The study chose this scale to guarantee reliable and accurate assessments of digital proficiency in respondents during smart agriculture adoption.

b) **Secondary Data:** The researcher thoroughly reviewed secondary data from scholarly articles and official agricultural reports along with policy documents to establish a foundational background for their study. The study analyzed various sources to determine how SES and DL impact farmers' adoption of smart agricultural technologies. The researcher conducted an investigation to determine if there is a link between SES and DL which affects how farmers incorporate modern digital tools into their agricultural practices.

iv). Sample Size and Sampling Technique
This research has a total of 86 respondents. A Multistage sampling method was implemented in order to receive responses from person of different classes of farmers.

v). Data Analysis Methods
The relationship between SES, DL, was examined using statistical techniques. A quantitative approach was adopted, by using Welch's ANOVA and the Games-Howell Post Hoc Test to analyze the variations in DL scores across SES groups. In addition to this, thematic analysis was done on the interview answers to identify understood challenges and obstacles in Smart Agriculture.

vi). Limitations of the Study
The study was made in two districts of the division, the sample drawn from these two districts might not accurately reflect the whole population of Surguja Division. Other than this another limitation is that of sample size, the data pertaining to 86 respondents were studied this might limits its ability to fully represent the population across the entire division. The data were collected through standardized questionnaire where the findings are based on self-reported data which can be biased.

6. Data and Measures
6.1. Descriptive Statistics of Demographic Variables (Gender, Age, Education, Occupation, and Income)

Table 1: Demographic variables

	Mean	SD
Gender	1.19	0.391
Age	2.59	0.845
Edu	5.70	1.237
Occupation	8.42	1.662
Income	5.63	0.882

Table 1 presents the mean and standard deviation (SD) for key demographic variables viz., Gender, Age, Education (Edu), Occupation, and Income. The respondents' gender mean value near 1 indicates male predominance in the sample. The dataset's mean age value of 2.59 shows that most respondents belong to the age groups 31 to 40 or 41 to 50. Most respondents possess educational attainment between Middle School and Primary School levels based on an education mean of 5.70. The standard deviation value of 1.237 demonstrates that education levels among respondents show some degree of variation. The average occupational score of 8.42 indicates that most survey participants either work in Elementary Occupations or remain Unemployed. The average Income level of 5.63 indicates that most survey participants belong to the lower income brackets which are ₹10,703 to ₹31,977 or under ₹10,702.
Demographic characteristics such as gender, age, education level, occupation type, and income range. The bar charts display how often each category appears and reveal insights about the SES of the surveyed farmers. Most survey participants are males aged between 31 and 50 years who

have middle to primary school education levels and work in elementary jobs while earning low incomes. The observed patterns suggest obstacles that impede digital literacy and smart agriculture technology integration.

The limited educational achievement of survey participants leads to minimal experience with digital technologies which creates barriers for farmers to adopt modern agricultural methods. Occupational status along with low-income levels prevent farmers from obtaining smart farming technologies including smartphones and IoT sensors. The powerful connection between Socio-Economic Status and Digital Literacy creates a digital divide within agricultural communities. Targeted digital literacy programs alongside financial assistance and policy interventions are essential to boost smart agriculture adoption and address technology usage disparities caused by SES differences.

6.2. Statistical Analysis

Table 2: Descriptive Statistics of DL Scores across SES Groups

	SES	Mean	SD
Digital Literacy	Lower	2.26	0.0882
	Upper Lower	3.04	0.2614
	Lower Middle	3.76	0.2066

Table 2 presents the descriptive statistics for Digital Literacy (DL) scores across three Socio-Economic Status (SES) groups viz., Lower, Upper Lower, and Lower Middle. DL scores reach their lowest mean in the Lower SES group ($M = 2.26$, $SD = 0.0882$) while achieving their highest mean in the Lower Middle SES group ($M = 3.76$, $SD = 0.2066$). The score for the Upper Lower SES group ($M = 3.04$, $SD = 0.2614$) positions itself between the Lower and Lower Middle SES groups. The DL scores' median values match the mean values which indicates a symmetrical distribution inside each group. The score range expands when SES level increases which shows that digital literacy becomes more variable alongside SES advancement. The descriptive statistics show that higher SES backgrounds correlate to increased levels of DL. Statistical tests like ANOVA must be performed to establish whether the observed differences reach statistical significance or not.

Statistical tests will be performed to further confirm these observations. The Shapiro-Wilk test examines whether Digital Literacy scores demonstrate normal distribution patterns across each SES level. The Levene's test will examine if DL score variability remains consistent throughout different SES groups by verifying homogeneity of variances. Statistical assumption checks serve as a basis for choosing the proper analysis method like One-Way ANOVA or Welch's ANOVA that evaluates Digital Literacy differences between SES groups.

i). Normality Test (Shapiro-Wilk) for Digital Literacy Scores

H_0: The Digital Literacy (DL) scores for each SES group follow a normal distribution.

H_1: The Digital Literacy (DL) scores for at least one SES group do not follow a normal distribution

Table 3: Normality Test for DL

Normality Test (Shapiro-Wilk)		
	W	p
Digital Literacy	0.972	0.060

The Shapiro-Wilk test was performed to determine if DL scores are normally distributed. The Shapiro-Wilk test produced a W-statistic value of 0.972 with a p-value of 0.060. With a p-value above 0.05 we cannot reject the null hypothesis so the DL scores remain consistent with normality. The data meets the normality assumption which permits the application of parametric tests including One-Way ANOVA for further analysis.

The Shapiro-Wilk test produced a W-statistic value of 0.972 along with a p-value of 0.060. The null hypothesis stays unrefuted because the p-value exceeds 0.05. The dataset shows no significant departure from normality so it can be treated as approximately normal.

ii). Homogeneity of Variances Test (Levene's Test) for Digital Literacy Scores

H_0: The variances of Digital Literacy (DL) scores are equal across all SES groups.

H_1: The variances of Digital Literacy (DL) scores are not equal across all SES groups.

Table 4: Levene's Test for Homogeneity of Variances in DL

Homogeneity of Variances Test (Levene's)				
	F	df1	df2	p
Digital Literacy	4.62	2	83	0.013

The researcher performed Levene's test to verify whether DL scores demonstrate homogenous variances across different SES groups. The test results included an F-statistic value of 4.62 along with a p-value of 0.013. Here the rejection of the null hypothesis occurs because the p-value falls below the threshold of 0.05 which shows that group variances differ significantly. Due to the observed heterogeneity of variances, a standard One-Way ANOVA becomes unsuitable while Welch's ANOVA serves as a viable alternative because it adjusts for unequal variances.

The Levene's test produced an F-statistic value of 4.62 along with a p-value result of 0.013. The result of the p-value being lower than 0.05 leads us to reject the null hypothesis (H_0) to accept the alternative hypothesis (H_1). The DL scores show substantial variance differences between SES groups which results in a breach of the homogeneity assumption.

The standard One-Way ANOVA could not be applied because equal variances assumption was not met which led to the application of Welch's ANOVA to handle unequal variances.

iii). Welch's One-Way ANOVA for Digital Literacy Scores

H_0: There is no significant difference in Digital Literacy (DL) scores among SES groups.

H_1: At least one SES group has a significantly different DL score.

Table 5: ANOVA Results for DL across SES Group

One-Way ANOVA (Welch's)				
	F	df1	df2	p
Digital Literacy	268	2	16.9	< .001

The analysis employed Welch's ANOVA because Levene's test revealed that the assumption of homogeneity of variances was violated. The statistical analysis revealed a strong SES effect on DL scores which yielded an F value of 268 and degrees of freedom $df1 = 2$ and $df2 = 16.9$ with a p-value less than 0.001. The p-value shows significant evidence below the 0.05 threshold which leads us to reject the null hypothesis and confirms significant differences in DL scores between SES groups. Statistical analysis requires a post hoc test like Games-Howell to reveal which specific groups show significant differences.

All comparison tests produced p-values below 0.001 showing statistically significant differences in DL scores between SES groups. Because the p-values of all comparisons showed values less than 0.05 we reject the null hypothesis (H_0) and accept the alternative hypothesis (H_1). Each socio-economic group shows significant differences in DL scores compared to the others which verifies that SES has a strong influence on DL levels. Discarding H_0 confirms that people from lower SES groups display significantly lower DL levels when compared to those from higher SES groups.

iv). Games-Howell Post Hoc Test for DL Scores

Table 6: Comparison of DL Scores across different SES Groups

Games-Howell Post-Hoc Test – DL score				
		Lower	**Upper Lower**	**Lower Middle**
Lower	Mean difference	—	-0.785	-1.507
	p-value	—	< .001	< .001
Upper Lower	Mean difference		—	-0.722
	p-value		—	< .001
Lower Middle	Mean difference			—
	p-value			—

To identify significant differences between SES groups in DL scores, Games Howell post hoc test was performed after Welch's ANOVA. These results show that all pairwise comparisons are statistically significant ($p < 0.001$). In particular, the Lower SES group is found to have scores significantly lower than the scores of Upper Lower groups (Mean Difference = -0.785, $p < 0.001$) and Lower Middle SES group (Mean Difference = -1.507, $p < 0.001$). Likewise, the Upper Lower SES group has significantly lower DL scores compared to the Lower Middle SES group (Mean Difference = -0.722, $p < 0.001$).

Games-Howell post hoc tests revealed statistically significant differences between all SES groups for DL scores (all p-values < 0.001). Findings showed that farmers from lower Socio-Economic Status (SES) backgrounds had much lower levels of digital literacy compared to those from higher SES groups, exemplifying the socio-economic digital divide in agriculture technology adoption.

The findings of the study show substantial DL score differences among SES groups which support previously established research on the digital divide. People from lower SES backgrounds encounter challenges such as restricted technology access and inadequate digital skills that prevent them from fully engaging in digital age activities. Research demonstrates that both age and education level along with income and household structure serve as primary determinants of digital literacy and foster digital societal divides (Urbancikova *et al.* 2017) [17]. Experts identify the digital divide as a fundamental human rights and social justice concern which maintains existing social, economic and political inequities (Urbancikova, N. *et al.*, 2021). The results highlight the necessity of specific programs to improve digital skills among low SES groups for enhanced digital participation equity.

7. Findings and Discussion

This part of the research paper outlines the findings and show directions how they may be put to use. The study was conducted to analyze the relationship of SES with DL of farmers in Surguja and Surajpur districts of Surguja division and the barriers they encounter in using modern smart agricultural methods.

i). Key Findings

Findings indicated that there is a correlation between SES and DL. It was found that farmers belonging to higher SES groups digitally ventilated better as compared to those belonging to lower socioeconomic strata. The Welch's ANOVA test revealed strong statistical difference. F = 268, p = 0.001 and Games-Howell post hoc test indicated that all SES groups differed significantly ($p < 0.001$ for all comparisons).

Another major observation is that the majority of farmers in the region studied had low-level education, unstable employment, low income which could have limited their exposure to the digital world. Such limitations are termed as socio-economic and these constraints make it difficult for farmers to adopt new technologies like smart farming which integrates IoT-based sensors, mobile applications, and precision agricultural tools.

ii). Discussion

These results correspond with the prior studies that suggest members of lower SES groups do not have adequate access to and are unable to use digital technologies. Their limited education hinders their capacity to comprehend and manipulate digital devices, while their finances make it difficult for them to purchase smart farming tools.

The results emphasize the need for the government's digital literacy policies and financial and training workshops directed toward farmers. If the gaps are not mitigated, the gap between digital technology and agriculture intervention will increase, and will leave a large number of farmers stranded in the transition to technology-oriented farming. It is mandatory to fill this gap so that no farmer is deprived of the development that modern farming offers irrespective of their SES situation.

8. Recommendations

The gap between SES and DL can be alleviated by implementing these recommendations:

i). Digital Literacy Training Programs:

- Conduct workshops and training sessions to onboard farmers to digital tools use in farming.
- Create more user-friendly mobile applications integrated with vernacular language to increase ease of use.

ii). Financial Support and Subsidies:

- Support low-income farmers with subsidized smartphones, tablets, and internet access.
- Provide government support for purchasing smart tools for agriculture through loans or grants.

iii). Integrating digital literacy in agricultural extension services:

- Help farmers adopt ICT-based smart farming through farmer training and teaching agricultural officers ICT solutions.
- Facilitate peer learning where more digitally skilled farmers help farmers with lower skills.

iv). Improving rural connectivity and Infrastructure:

- Increase coverage of the internet and mobile networks to remote farming areas.
- Work with private firms and NGOs to upgrade rural digital infrastructure.

These measures can address the gaps in digital literacy for farmers from lower SES groups to help them use smart agricultural practices. This will lead to greater productivity, improved livelihoods, and support rural farming community development.

9. Conclusion

The author set out to examine the link between SES and DL for farmers of Surguja Division with a focus on how SES affects the use of smart agricultural technology. Based on the findings of the study, all the respondents confirm that SES affects DL as farmers of higher SES have more skills regarding the use of the internet, compared to those of lower SES who find it difficult to utilize the digital devices.

This analysis was confirmed statistically as Welch's ANOVA reported a considerable difference ($F = 268$, $p < 0.001$) in DL scores for different SES groups. Further post-hoc analysis with the Games-Howell test confirmed all SES groups differ significantly from each other ($p < 0.001$ for all comparisons). These results suggest that low education attainment, low household income and high mobility of employment are hindering most farmers from adopting and utilizing smart farming technologies.

Ultimately, results of the analysis reveal that the farmers from various socio-economic backgrounds have varying levels of digital literacy. The fewer digital skills and tools possessed by the farmers from the lower SES groups suggests they struggle with technology adoption. This enhances the gap that already exists within the agriculture sector, as education, income, and occupation greatly influence the level of digitization access and usage. To overcome this gap, more focused measures like financial aid, infrastructure investment, and most importantly, digital literacy interventions are necessary to ensure all farmers can effectively engage with digitized agriculture.

In any case, this research draws attention to the inequality of low SES farmers in regards to modern farming tools and digital skills which makes adoption very challenging and, as a result, relies on the financial situation of the farmers which is often poor. Addressing these inequalities is essential for the development of agriculture and rural areas.

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